CONTENTS

This page intentionally blank

ACRONYMS

AC	Administrative Control
AIHA	American Industrial Hygiene Association
AIS	Air Intake Shaft
ALARA	As Low As Reasonably Achievable
ANS	American Nuclear Society
ANSI	American National Standard Institute
ARF	Airborne Release Fraction
ARMS	Area Radiation Monitors
ASME	American Society of Mechanical Engineers
BLM	Bureau of Land Management
BR	Breathing Rate
Bq	Becquerel
C&C	Consultation and Cooperation
CA	Controlled Area
CAO	Carlsbad Area Office (DOE)
CAM	Continuous Air Monitor
CCDF	Complimentary Cumulative Distribution Function
CCTV	Closed Circuit Television
CD	Containers Damaged
CEDE	Committed Effective Dose Equivalent
CFR	Code of Federal Regulations
CH	Contact Handled
Ci	Curie
CI	Container Inventory
CMR	Central Monitoring Room
CMS	Central Monitoring System
D&D	Decontamination and Decommissioning
DAC	Derived Air Concentration
DBA	Design Basis Accident
DBE	Design Basis Earthquake
DBT	Design Basis Tornado
DCF	Dose Conversion Factor
DOE	Department of Energy
DOE-EM	Department of Energy, Office of Environmental Restoration
DOI	Department of Interior
DOP	Dioctylphthalate
DOT	Department of Transportation
DR	Damage Ratio
ECO	Engineering Change Order
EEG	Environmental Evaluation Group
EEGL	Emergency Exposure Guidance Level
EFB	Exhaust Filter Building
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
ERPG	Emergency Response Planning Guideline
ESH	Environment, Safety, and Health
ERT	Emergency Response Team

ACRONYMS

FAS	Fixed Air Sampler
FEP	Features, Events, and Processes
FGE	Fissile Gram Equivalent
FEIS	Final Environmental Impact Statement
FLIRT	First Line Initial Response Team
FMEA	Failure Mode and Effects Analysis
FSEIS	Final Supplement Environmental Impact Statement
FY	Fiscal Year
GM	General Manager
GPDD	General Plant System Design Description
HAZOP	Hazard and Operability Study
HEP	Human Error Probability
HEPA	High Efficiency Particulate Filter
HVAC	Heat, Ventilation, and Air Conditioning
ICRP	International Commission on Radiological Protection
ICV	Inner Containment Vessel
IDLH	Immediately Dangerous to Life and Health
LCO	Limiting Condition for Operation
LCS	Limiting Control Setting
LPF	Leakpath Factor
LPU	Local Processing Unit
LWA	Land Withdrawal Act
MAR	Material at Risk
MDC	Minimum Detectable Concentrations
MEI	Maximally Exposed Individual
MgO	Magnesium Oxide
MOC	Management and Operating Contractor
MOI	Maximally Exposed Off-site Individual
MRF	Material Release Fraction
MSDS	Material Safety Data Sheet
MSHA	Mine Safety and Health Administration
NFPA	National Fire Protection Agency
NIST	National Institute of Science and Technology
NMBMMR	New Mexico Bureau of Mines and Mineral Resources
NMDG&F	New Mexico Department of Game and Fish
NRB	Nuclear Review Board
NRC	Nuclear Regulatory Commission
NVP	Natural Ventilation Pressure
OHP	Operational Health Physics
ORNL	Oak Ridge National Laboratory
ORR	Operational Readiness Review
OSHA	Occupational Safety and Health Administration
PABX	Private Automatic Branch Exchange
PA	Public Address or Performance Assessment
PEL	Permissible Exposure limit
PE-Ci	Plutonium Equivalent Curie
ppmv	Parts per Million Volume
PSM	Process Safety Management

ACRONYMS

Pu	Plutonium
QA	Quality Assurance
QAPD	Quality Assurance Program Description
QC	Quality Control
RADCON	Radiological Control
RBP	Radiological Baseline Program
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man
REMS	Radiation Effluent Monitoring System
RF	Respirable Fraction
RFAR	Radio Fire Alarm Reporter
RH	Remote Handled
RBA	Radiological Buffer Area
RMA	Radioactive Material Area
RMS	Radiation Monitoring System
ROD	Record of Decision
RWP	Radiation Work Permit
SAR	Safety Analysis Report
SCR	Silicon Controlled Rectifier
SDD	System Design Descriptions
SEIS	Supplement Environmental Impact Statement
SH	Salt Handling Shaft
SOP	Standard Operating Procedure
SL	Safety Limit
SNL	Sandia National Laboratory
SPDV	Site and Preliminary Design Validation
SPEGL	Short-term Public Exposure Guidance Level
SR	Surveillance Requirement
SRS	Savannah River Site
SSC	System, Structure, and Component
STD	Standard
Sv	Sievert
SWB	Standard Waste Box
TDOP	Ten Drum Overpack
TDS	Total Dissolved Solids
TEDE	Total Effective Dose Equivalent
TLD	Thermoluminescent Detector
TLV-C	Threshold Limit Value-Ceiling
TLV-STEL	Threshold Limit Value-Short Term Exposure Limit
TLV-TWA	Threshold Limit Value-Time Weighted Average
TRUPACT	Transuranic Package Transporter
TRU	Transuranic
TSC	Technical Support Contractor
TSR	Technical Safety Requirements
U/G	Underground
UBC	Uniform Building Code
UPS	Uninterruptible Power Supply
USGS	United States Geological Survey

ACRONYMS

USQ	Unreviewed Safety Questions
VOC	Volatile Organic Compound
WAC	Waste Acceptance Criteria
WACC	Working Agreement for Consultation and Cooperation
WHB	Waste Handling Building
WIPP	Waste Isolation Pilot Plant
WWIS	WIPP Waste Information System

GLOSSARY OF TERMS

ABNORMAL CONDITION. Any deviation from normal conditions that adversely affects or potentially adversely affects the safety performance of the facility.

ACCEPTABLE KNOWLEDGE. An EPA term which includes process knowledge and results from previous testing, sampling, and analysis associated with the waste. Acceptable knowledge includes information regarding the raw materials used in a process or operation, process description, products, and associated wastes. Acceptable knowledge documentation includes the site history and mission, site-specific processes or operations, administrative building controls, and all previous and current activities that generate a specific waste.

ACCIDENT. An unplanned sequence of events that results in undesirable consequences.

ACCIDENT ANALYSIS. For the purposes of implementing the USQ order, the term accident analysis refers to those bounding analyses selected for inclusion in the SAR. The accident analysis is the systematic development of numerical estimates of the expected consequence and frequency of potential accidents.

ACTINIDE. An element in the actinide series beginning with element 89 and continuing through element 103. All the transuranic nuclides considered in this document are actinides.

ACTIVE INSTITUTIONAL CONTROL. (1) Controlling access to a disposal site by any means other than passive institutional controls, (2) performing maintenance operations or remedial actions at a site, (3) controlling or cleaning up releases from a site, or (4) monitoring parameters related to disposal system performance (40 CFR § 191.12).

ACTIVITY. A measure of the rate at which a material emits nuclear radiation, usually given in terms of the number of nuclear disintegrations occurring in a given length of time. The unit of activity used in this document is the curie (Ci).

ADMINISTRATIVE CONTROLS. Provisions relating to organization and management, procedures, record keeping, assessment, and reporting necessary to ensure the safe operation of the facility.

AIR DISPERSION FACTOR. The ratio of the average concentration of a hazardous constituent released into the atmosphere to its maximum concentration at or beyond the unit boundary.

AIR IMMERSION. The pathway of direct external dose from a passing cloud of dispersed radioactive material.

AIR LOCK. An intermediate chamber between zones of different static pressure.

ALARA. As Low As Reasonably Achievable; radiation protection program for minimizing personnel exposures.

ALPHA PARTICLE. A positively charged particle emitted in the radioactive decay of certain radionuclides. Made up of two protons and two neutrons bound together, it is identical to the nucleus of a helium atom. It is the least penetrating of the three common types of radiation; alpha, beta, and gamma radiation, but has the highest ionization factor.

GLOSSARY OF TERMS

AMERICIUM-241. A transuranic element resulting from the beta decay of plutonium-241.

ATMOSPHERIC DISPERSION. Movement of a contaminant due to the cumulative effect of the random motions of air.

AUTHORIZATION BASIS. Those aspects of the facility design basis and operational requirements relied upon by DOE to authorize operation. The authorization basis is described in the SAR and other safety analyses.

BACKFILL. Material placed around the waste containers, partially filling the open space in the disposal room.

BARRIER. "[A]ny material or structure that prevents or substantially delays movement of water and/or radionuclides toward the accessible environment. For example, a barrier may be a geologic structure, a canister, a waste form with physical and chemical characteristics that significantly decrease the mobility of radionuclides, or a material placed over and around waste, provided that the material or structure substantially delays movement of water or radionuclides" (40 CFR § 191.12). Barriers also prevent or delay the movement of hazardous constituents.

BETA PARTICLE. A negatively charged particle emitted in the radioactive decay of certain radionuclides; a free electron.

BECQUEREL. A unit in the International System of Units (SI), of measurement of radioactivity equal to one transformation per second.

BRINE. Saline water containing calcium (Ca), sodium (Na), potassium (K), chlorides (Cl), and minor amounts of other elements.

BOUNDING. Producing greater consequences than other scenarios; or would bound the remainder of scenarios.

CANISTER. As used in this document, a container, usually cylindrical, for remotely handled TRU waste. The waste will remain in this canister during and after burial. A canister affords physical containment but not shielding; shielding is provided during shipment by a cask.

CARCINOGEN. An agent capable of producing or inducing cancer.

CARCINOGENICITY. The ability of a substance to cause the development of cancerous growths in living tissue. Such substances are usually grouped in two classifications: (1) those that are known to induce cancer in man or animals either by operational exposure in industry or by ingestion in feedstuffs and (2) those that have been found to cause cancer in animals under experimental conditions.

CASK. A massive shipping container providing shielding for highly radioactive materials and holding one or more canisters.

GLOSSARY OF TERMS

CENTRAL MONITORING ROOM (CMR). A room at the WIPP facility equipped to monitor alarm functions and provide reliable communications.

CENTRAL MONITORING SYSTEM (CMS). A computer system that monitors the WIPP facility instrumentation; operated from the Central Monitoring Room.

COMMITTED EFFECTIVE DOSE EQUIVALENT (CEDE). The sum of the committed dose equivalents to various organs or tissues in the body from radioactive material taken into the body, each multiplied by the tissue-specific weighting factor. Expressed in terms of rem (or sievert).

CONCENTRATION. The amount of a substance contained in a unit quantity (mass or volume) of a sample.

CONSERVATIVE. As a term used with predictions or estimates, “conservative” means one in which the uncertain inputs are used in a way that overestimates an adverse impact.

CONSEQUENCE. The direct, undesirable result of an accident sequence.

CONSULTATION AND COOPERATION AGREEMENT. An agreement that affirms the intent of the Secretary of Energy to consult and cooperate with the State of New Mexico with respect to State public health and safety concerns. The term “Agreement” means the July 1, 1981, Agreement for Consultation and Cooperation, as amended by the November 30, 1984, “First Modification,” the August 4, 1987, “Second Modification,” and the March 22, 1988, modification to the Working Agreement.

CONTACT-HANDLED WASTE. Transuranic waste with a surface dose rate not greater than 200 millirem per hour.

CONTAINER INVENTORY. The amount of radioactive or hazardous material within a container or source.

CREEP. A very slow, usually continuous, time-dependent movement of soil or rock; refers to the geologic phenomenon experienced as the gradual flow of salt under compressive loading.

CREEP CLOSURE. Closure of underground openings, especially openings in salt, by plastic flow of the surrounding rock under lithostatic pressure.

CRITICALITY. A state in which a self-sustaining nuclear chain reaction is achieved.

DECOMMISSIONING. Actions taken upon abandonment of the repository to reduce potential environmental, health, and safety impacts, including repository sealing as well as activities to stabilize, reduce, or remove radioactive materials or demolish surface structures.

DECOMMISSIONING PHASE. The term “decommissioning phase” means the period of time beginning with the end of the disposal phase and ending when all shafts at the Waste Isolation Pilot Plant repository have been backfilled and sealed.

GLOSSARY OF TERMS

DEFENSE IN DEPTH. Defense in depth is a safety design concept or strategy that shall be applied at the beginning and maintained throughout the facility design process. This safety design strategy is based on the premise that no one layer of protection is completely relied upon to ensure safe operation.

DEFENSE WASTE. Nuclear waste deriving from the manufacture of nuclear weapons and the operation of naval reactors. Associated activities, such as the research carried on in the weapons laboratories, also produce defense waste.

DESIGN BASIS. The set of requirements that bound the design of the structure, systems, or components of the facility.

DESIGN BASIS EARTHQUAKE (DBE). An earthquake that is the most severe design basis accident of this type and that produces the vibratory ground motion for which safety class items are designed to remain functional. The DBE is the most severe credible earthquake that could occur at the WIPP site as described in Chapter 2. DBE SSCs shall be designed to withstand a free-field horizontal and vertical ground acceleration of 0.1g, based on a 1,000-year recurrence period, and retain their safety functions.

DESIGN BASIS TORNADO (DBT). A tornado that is the most severe design basis accident of that type applicable to the area under consideration. The DBT is the most severe credible tornado that could occur at the WIPP site as described in Chapter 2. DBT SSCs shall be designed to withstand the highest winds generated by this tornado (183 mi/h [293 km/h]), based on a 1,000,000-year recurrence period, and retain their safety function.

DESIGN LIFE. The design life of components or systems generally refers to the estimated period of time that the component or system is expected to perform within specifications before the effects of aging result in performance deterioration or a requirement to replace the component or system.

DISPOSAL. See Land Disposal.

DISPOSAL FACILITY. A facility or part of a facility into which hazardous waste is intentionally placed and in which hazardous waste will remain after closure.

DISPOSAL PHASE. The term “disposal phase” means the period of time during which transuranic waste is disposed of at the Waste Isolation Pilot Plant, beginning with the initial emplacement of transuranic waste underground for disposal and ending when the last container of transuranic waste is emplaced underground for disposal.

DISPOSAL ROOM. An excavated cavity in the Waste Isolation Pilot Plant underground in which transuranic waste will be emplaced during disposal operations.

DISPOSAL SYSTEM. For purposes of defining the PA conceptual model, the disposal system is defined as the combination of engineered and natural barriers and other assurances that isolate waste after disposal, or the more general features, events, and processes that are capable of affecting performance of the disposal unit.

GLOSSARY OF TERMS

DOSE. A general term used for brevity in place of dose equivalent, effective dose equivalent, committed effective dose equivalent, etc.

DOSAGE. The concentration-time profile for exposure to toxicological hazards.

DOSE CONVERSION FACTOR. A numerical factor used in converting radionuclide uptake (curies) in the body to the resultant radiation dose (rem).

DOSE EQUIVALENT. The product of absorbed dose in rad in tissue, a quality factor, and all other modifying factors at the location of interest. Expressed in rem.

DOSE RATE. The radiation dose delivered per unit time (rem per hour).

DRIFT. A horizontal passageway in a mine.

EFFECTIVE DOSE EQUIVALENT (EDE). The sum of the products of the dose equivalent received by specified tissues of the body and tissue-specific weighting factor. Expressed in rem.

EFFLUENT. Wastewater or airborne emissions discharged into the environment.

EMPLACEMENT. At the Waste Isolation Pilot Plant, the placing of radioactive wastes in the repository.

ENGINEERED BARRIERS. Backfill, seals, and any other man-made barrier components of the disposal system.

EVENT. A phenomenon that occurs instantaneously or within a short time interval relative to the time frame of interest.

EVENT TREE. A logic model that graphically portrays the combinations of events and circumstances in an accident scenario.

EXCLUSIVE USE AREA. This 277-acre area is surrounded by a five-strand barbed wire fence and is restricted for the use of DOE, its contractors and subcontractors in support of the WIPP project. This area is posted against trespass and is excluded from use by the general public. However, public access to the LWA (16 section) area up to the Exclusive Use Area is allowed for grazing purposes (see Figure 5.2-1 and the WIPP Land Management Plan).

FACILITY. Any equipment, structure, system, or component, or activity that fulfills a specific purpose. For the purpose of implementing *DOE Standard 3009*-94, the definition most often refers to buildings, and other structures, their functional systems and equipment, and other fixed systems and equipment installed therein to delineate a facility (*DOE Standard 3009*-94).

FAULT TREE. A tree-like cause-and-effect diagram of hypothetical events. Analysis of fault trees is used to investigate failures in a system or concept.

FILTER BANK. An arrangement of air filters in series and/or parallel.

GLOSSARY OF TERMS

FISSILE. Describes a nuclide that undergoes fission on absorption of neutrons of any energy, in particular, slow neutrons provided the effective thermal neutron production cross section exceeds the effective thermal neutron absorption cross section.

FREQUENCY. The number of occurrences per unit time at which observed events occur or are predicted to occur.

GAMMA RADIATION. Short-wavelength electromagnetic radiation emitted in the radioactive decay of certain radionuclides; high-energy photons.

GAS GENERATION MODEL. A computational model that can simulate and/or predict the rate and quantity of gases generated by waste transformation processes in a disposal room of the decommissioned repository.

GAS GENERATION RATE. The combined gas production rate from all species of gases produced as a result of transuranic waste transformations such as corrosion, microbial degradation, and/or radiolysis at any given time. The rate of gas production throughout the history of the repository is expected to vary depending on repository conditions with respect to humidity, total or partial brine inundation, competitive reactions that absorb specific gases, and the ability of the repository to retain the gases generated. The term is also applied to individual gases.

GENERATOR AND/OR STORAGE SITES. Refers to the Department of Energy sites nationwide where transuranic wastes are generated and/or stored as a result of activities associated with nuclear weapons production.

GROUNDWATER. Water below the land surface in a zone of saturation.

GROUNDSHINE. The pathway of direct external dose received from radioactive material that has deposited on the ground after being dispersed from the accident site.

GROUT. A mortar or cement slurry (of high water content) used to plug potential fluid-flow paths in geologic or engineered structures.

HAZOP. Hazard and Operability Study. A systematic method in which process hazards and potential operating problems are identified using a series of guide words to investigate process deviations.

HAZARD. A source of danger (i.e., material, process, energy source) with the potential to cause illness, injury, or death, loss of use, or loss of property.

HAZARD ANALYSIS. The determination of material, system, process, and plant characteristics that can produce undesirable consequences, followed by the assessment of hazardous situations associated with a process or activity. Largely qualitative techniques are used to pinpoint weaknesses in design or operation of the facility that could lead to accidents. The SAR Hazards Analysis examines the complete spectrum of potential accidents that could expose members of the public, onsite workers, facility workers, and the environment to hazardous materials.

GLOSSARY OF TERMS

HAZARDOUS CONSTITUENT. Those chemicals identified in Appendix VIII of 40 CFR Part 261.

HAZARDOUS MATERIAL. Any solid, liquid, or gaseous material that is toxic, explosive, flammable, corrosive, or otherwise physically or biologically threatening to health. Candidate hazards include radioactive materials and hazardous chemicals.

HAZARDOUS WASTE. A hazardous waste as defined in 40 CFR § 261.3.

HEADSPACE GASES. The free gas volume at the top of a closed container (between the container lid and the waste inside the container) or containment, such as a drum or bin, containing TRU-mixed or simulated waste. The gas may be generated from biological, chemical, or radiolytic processes; this would include contributions from volatile organic compounds (VOCs) present in the waste.

HEPA FILTER. A high-efficiency particulate air filter usually capable of 99.7 percent efficiency as measured by a standard photometric test using 0.3-micron droplets (aerodynamic equivalent diameter) of dioctylphthalate (DOP).

HORIZON. In geology, an interface indicative of a particular position in a stratigraphic sequence. For instance, the waste-emplacement horizon in the Salado Formation at the Waste Isolation Pilot Plant is the level about 650 meters (2,150 feet) deep where openings are mined for waste disposal.

HUMAN ERROR. Any action (or lack thereof) that exceeds some limit of acceptability where the limits of human performance are defined by the system. Includes actions by designers, operators, or managers that may contribute to or result in accidents.

HUMAN FACTORS. A discipline concerned with designing machines, operations, and work environments to match human capabilities, limitations, and needs.

IDLH. Immediately Dangerous to Life and Health represents a maximum airborne concentration from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.

IMMEDIATE WORKER. A worker directly involved in the operation of the facility or process (handling waste containers) when an accidental release occurs.

IN SITU. In the natural or original position. The phrase is used in this document to distinguish in-place experiments, rock properties, and so on, from those measured in the laboratory.

INTERNAL ACCIDENT. Accidents initiated by process systems or human actions under the control of a given facility.

INITIATING EVENT. The first event in an event sequence that can result in an accident unless engineered protection systems or human actions intervene to prevent or mitigate the accident.

INJECTION WELL. A well into which fluids are injected.

GLOSSARY OF TERMS

INSTITUTIONAL CONTROLS. Human actions to control a waste management facility such as the WIPP. Institutional controls are described as "active" and "passive." Active institutional controls are defined in 40 CFR § 191.12 as: (1) controlling access to a disposal site by any means other than passive institutional controls, (2) performing maintenance operations or remedial actions at a site, (3) controlling or cleaning up releases from a site, or (4) monitoring parameters related to disposal system performance. Passive institutional controls are defined in 40 CFR §191.12 as: (1) permanent markers placed at a disposal site, (2) public records and archives, (3) government ownership and regulations regarding land or resource use, and (4) other methods of preserving knowledge about the location, design, and contents of a disposal system.

INTENSITY, EARTHQUAKE. A measure of the effects of an earthquake on humans and structures at a particular place. Not to be confused with magnitude.

INTERNATIONAL SYSTEM OF UNITS. The version of the metric system which has been established by the International Bureau of Weights and Measures and is administered in the United States by the National Institute of Standards and Technology. The abbreviation for this system is "SI".

ISOTOPE. An atom of a chemical element with a specific atomic number and atomic weight. Isotopes have the same number of protons, but different number of neutrons.

LAND DISPOSAL. Emplacement in or on the land, except in a corrective action management unit, and includes, but is not limited to, placement in a landfill, surface impoundment, waste pile, injection well, land treatment facility, salt dome formation, salt bed formation, underground mine or cave, or placement in a concrete vault, or bunker intended for disposal purposes.

LAND WITHDRAWAL ACT. Public Law 102-579, as amended by Public Law 104-201 (H.R. 3230, 104th Congress--1996), which withdraws the land at the Waste Isolation Pilot Plant site from "entry, appropriation, and disposal"; transfers jurisdiction of the land from the Secretary of the Interior to the Secretary of Energy; reserves the land for activities associated with the development and operation of the Waste Isolation Pilot Plant; and includes many other requirements and provisions pertaining to the protection of public health and the environment.

LIKELIHOOD. A measure of the expected probability or frequency of an events occurrence.

LIMITING CONDITION FOR OPERATION. The lowest functional capability or performance levels of safety-related structures, systems, or components.

LONG TERM. Refers to the 10,000 years after shaft sealing for which performance assessment calculations and models assess the behavior of the repository with respect to compliance with 40 CFR Part 191 and 40 CFR § 268.6.

LOWER EXPLOSIVE LIMIT. The lower limit of flammability of a gas or vapor at ordinary ambient temperatures expressed in percent of the gas or vapor in air by volume. This limit is assumed constant for temperatures up to 120 °C (250 °F).

GLOSSARY OF TERMS

MAGNESIUM OXIDE (MgO). A white powder that (depending on the method of preparation) may be light and fluffy, or dense; melting point 2800 ^{0}C; insoluble in acids, slightly soluble in water.

MAGNITUDE, EARTHQUAKE. A measure of the total energy released by an earthquake. Not to be confused with intensity.

MARKER BEDS (MB). MBs are well-defined layers of rock that mark distinct divisions in major geological strata or geological time frames.

MAXIMALLY EXPOSED INDIVIDUAL (MEI). A hypothetical member of the public who is exposed to a release of radionuclides in such a way that the individual will receive the maximum dose from such a release. Review of the WIPP Land Management Plan (LMP) indicates that public access to the WIPP 16-section area up to the exclusive use area shown is allowed for grazing purposes, and up to the DOE off limits area" for recreational purposes. Although analyses are traditionally conducted for a maximally exposed off-site individual (MOI) at the facility site boundary, in accordance with DOE Order 6430.1A, Section 1300-3.2, the location of the MEI is located at the "closest point of public access," or the WIPP "exclusive use area." The location of the MEI is also consistent with guidance for the implementation of 40 CFR 191, Subpart A.

Exposure to the MEI is greatest at the Exclusive Use Area (closest distance a member of the public may get to the release point due to LMP access restrictions) due to the dispersion model chosen for accident analysis. As discussed in detail in SAR Section 5.2, the release is a non-plume release (vent release as defined in NRG 1.145), not subject to plume lofting or fumigation conditions. The dose to an individual is therefore greatest at the closest allowable access distance to the point of release.

MEAN. The average value. For a given set of *n* values, the mean is the sum of their values divided by *n*.

MEDIAN. The median of a set of data is the value such that half of the observations are less than that value and half are greater than that value.

MERCALLI INTENSITY. A scale of measurement of earthquake intensity.

MITIGATE. To take practicable means to avoid or minimize release of hazardous or radioactive material or consequences to a hypothetical individual or population,

MITIGATION. Equipment and/or procedures designed to interfere with accident propagation and/or reduce accident consequences

MIXED WASTE. Mixed waste contains both radioactive and hazardous components, as defined by the Atomic Energy Act and the Resource Conservation and Recovery Act, respectively.

NASH DRAW. A shallow valley, approximately 5 mi (8.1 km) wide, open to the southwest located to the west of the WIPP site.

GLOSSARY OF TERMS

NONINVOLVED WORKER. An onsite worker not involved in the operation of the facility when a release occurs. For accident analysis consequence assessment, the maximally exposed noninvolved worker is assumed to be located at a distance of 100 meters from each release point due to restrictions on dispersion modeling used in this safety analysis at close-in distances (< 100 meters).

NORMAL CONDITIONS. All activities associated with the facility mission carried out within defined process conditions, performance in accordance with procedures, etc.

NORMAL OPERATION. All normal conditions that frequency estimation techniques indicate occur with a frequency greater than 0.1 events per year.

OFF-SITE. A position located at or beyond the WIPP Site Boundary.

OFF LIMITS AREA. An area consisting of approximately 1454 acres which is posted in accordance with 10 CFR Part 860 and has been designated as such in the Federal Register. This area is managed by an off-limits policy which allows DOE to authorize the use of the area as they determine the need. Public access to the WIPP LWA (16 section) area up to the Off Limits Area is allowed for recreational purposes (see Figure 5.2-1 and the WIPP Land Management Plan).

ON-SITE. A position located within the WIPP Site Boundary.

OVERPACK. A container put around another container. In the WIPP, overpacks would be used on damaged or otherwise contaminated drums, boxes, and canisters that it would not be practical to decontaminate.

PACKAGE. In the regulations governing the transportation of radioactive materials, the packaging together with its radioactive contents as presented for transport.

PACKAGING. A shipping container without its contents.

PANEL. A group of several underground rooms connected by drifts. Within the Waste Isolation Pilot Plant, a panel consists of seven rooms connected by drifts at each end.

PARTICULATES. Solid particles small enough to become airborne.

PASSIVE INSTITUTIONAL CONTROLS. "(1) [P]ermanent markers placed at a disposal site, (2) public records and archives, (3) government ownership and regulations regarding land or resource use, and (4) other methods of preserving knowledge about the location, design, and contents of a disposal system" (40 CFR § 191.12).

PERFORMANCE ASSESSMENT. A term used to denote quantitative activities carried out to evaluate the long-term ability of the Waste Isolation Pilot Plant to effectively isolate the waste, to ensure long-term health and safety of the public by complying with 40 CFR § 268.6, and to supply data/information to the compliance analysis for demonstrating regulatory compliance. The final analysis of compliance will consist of a qualitative assessment of the quantitative results of the performance assessment.

GLOSSARY OF TERMS

PLUTONIUM. A metallic, radioactive element, symbol Pu, atomic number 94, in the actinide series of elements; used as a nuclear fuel, to produce radioactive nuclides for research, and as the fissile agent in nuclear weapons.

POLYHALITE. An evaporite mineral: $K_2MgCa_2(SO_4)_4 \cdot 2H_2O$. It is a hard, nearly insoluble mineral with no economic value.

POST-CLOSURE PERIOD. A designated period of time beginning with the end of the Decommissioning Phase and extending through the end of the regulatory time frame of 10,000 years.

POTASH. A potassium compound, especially as used in agriculture or industry.

PREVENTIVE FEATURE. Any structure, systems, or component that serves to prevent the release of hazardous material in an accident scenario.

PROPERTY PROTECTION AREA. The interior core of the facility, comprised of about 34 acres and is bordered by a chain link security fence (see Figure 5.2-1).

PUBLIC. Defined in DOE-STD-3009-94 as individuals outside of the DOE Site Boundary. However, review of the WIPP Land Management Plan indicates that public access to the WIPP 16-section area up to the exclusive use area is allowed for grazing purposes, and up to the DOE off limits area" for recreational purposes. Although accident analyses consequences are traditionally conducted for a maximally exposed off-site individual (MOI) at the facility site boundary, in accordance with DOE Order 6430.1A, Section 1300-3.2, the location of the public (MEI) for accident consequence assessment in this safety analysis is at the "closest point of public access," or the WIPP "exclusive use area." The location of the MEI is also consistent with guidance for the implementation of 40 CFR 191, Subpart A.

PUBLIC LAW 96-164. The U.S. Department of Energy National Security and Military Applications of Nuclear Energy Act of 1980. Public Law 96-164 directed the Department of Energy to proceed with the design and development of the Waste Isolation Pilot Plant.

PUBLIC LAW 102-579. *See* Land Withdrawal Act.

QUALITY ASSURANCE. The planned and systematic actions necessary to provide adequate confidence that a structure, system, or component will perform satisfactorily in service.

QUALITY ASSURANCE PROGRAM PLANS (QAPP). Documents that describe the overall program plans and activities to meet the project's quality assurance goals.

QUALITY ASSURANCE PROJECT PLANS (QAPjP). Documents that ensure site-specific waste characterization activities meet the data quality objectives.

QUALITY CONTROL. Those quality assurance activities that provide a means to control and measure the characteristics of a structure, system, or component to established requirements.

RADIOLYSIS. Chemical decomposition by the action of radiation.

GLOSSARY OF TERMS

REAL-TIME RADIOGRAPHY. A nondestructive, nonintrusive examination technique that enables a qualitative (and in some cases semiquantitative) evaluation of the contents of a waste container. Real-Time Radiography utilizes x-rays to inspect the contents of the waste container and allows the operator to view events in progress (real time). Real-Time Radiography is used to examine and verify the physical form of the waste for certain waste forms, identify individual waste components, and verify the absence of certain noncompliant items, as applicable.

REASONABLE. (1) Not conflicting with reason, (2) not extreme or excessive, (3) having the faculty of reason, or (4) possessing sound judgment.

RELEASE POINT. There are two release points for the TRU and mixed wastes accidents described in the SAR, the Exhaust Filter Building exhaust to the atmosphere and the WHB HEPA filtration exhaust to the atmosphere.

REM. A common unit of dose equivalent, effective dose equivalent, etc.

REMOTE-HANDLED WASTE. Transuranic waste with a surface dose rate of 200 millirem per hour or greater. RH-TRU waste received at the WIPP may not exceed a surface dose rate of 1,000 rem per hour (Public Law 102-579, Section 7(a)(1)(A)).

REPOSITORY. The portion of the Waste Isolation Pilot Plant underground system within the Salado Formation, including the access drifts, waste panels, and experimental areas, but excluding the shafts.

REPOSITORY/SHAFT SYSTEM. The Waste Isolation Pilot Plant underground workings, including the shafts, all engineered and natural barriers, and the altered zones within the Salado Formation and overlying units resulting from construction of the underground workings.

RESERVES. Mineral resources that can be extracted profitably by existing techniques and under present economic conditions.

RISK. In accident analysis, the probability of weighted consequences of an accident defined as the accident frequency per year multiplied by the consequences.

RESOURCE CONSERVATION AND RECOVERY ACT PERMIT APPLICATION. An application, which is submitted by the owner/operator of a hazardous waste management unit to the state (if authorized by the Environmental Protection Agency) or to the Environmental Protection Agency, for a Resource Conservation and Recovery Act permit to operate the unit.

RESOURCES. Mineralization that is concentrated enough, in large enough quantity, and in physical and chemical forms such that extraction is currently or potentially feasible and profitable.

RETRIEVABLE. Describes storage of radioactive waste in a manner designed for recovery without loss of control or release of radioactivity.

ROOM. An excavated cavity within a panel in the underground. Within the Waste Isolation Pilot Plant, a room is about 33 ft (10 m) wide, 13 ft (4 m) high, and 300 ft (91 m) long.

GLOSSARY OF TERMS

SAFETY ANALYSIS. A documented process: (1) to provide systematic identification of hazards within a given DOE operation: (2) to describe and analyze the adequacy of the measures taken to eliminate, control, or mitigate identified hazards; and (3) to analyze and evaluate potential accidents and their associated risks.

SAFETY ANALYSIS REPORT. A report that documents the adequacy of safety analysis to ensure that a facility can be constructed, operated, maintained, and shutdown, and decommissioned safely and in compliance with applicable laws and regulations.

SAFETY ASSURANCE. The process of providing adequate confidence that an acceptable safety basis for the facility exists.

SAFETY BASIS. The combination of information relating to the control of hazards at a facility (including design, engineering analyses, and administrative controls) upon which the DOE depends for its conclusion that activities at the facility may be conducted safely.

SCENARIO. A combination of naturally occurring or human-induced events and processes that represent realistic future changes to the repository, geologic, and geohydrologic systems that could cause or promote the escape of radionuclides and/or hazardous constituents from the repository.

SEAL. An engineered barrier designed to isolate the waste and to impede fluid flow in the shafts.

SEISMIC RISK ZONE. A designation of a geographic region expressing the maximum intensity of earthquakes that could be expected there.

SHAFT PILLAR. The cylindrical volume of rock around a shaft from which major underground openings are excluded in order that they not weaken the shaft.

SIEVERT. The SI unit of any quantities expressed as dose equivalent. (1 Sv = 100 rem)

SITE BOUNDARY. The boundary encompassing the WIPP 10,240 acres (LWA 16 sections).

SLUDGE. Refers to de-watered contact-handled transuranic wastes containing both organic and inorganic constituents that must meet the Waste Acceptance Criteria for shipment and disposal at the Waste Isolation Pilot Plant repository. High sludges are contact-handled transuranic waste where the sludge component constitutes 50 percent or more of the waste volume; low sludges are the same type of waste containing less than 50 percent by volume of sludge.

SOURCE TERM. Source term is the quantity of radioactive or hazardous constituents available for transport or the maximum concentration of hazardous constituents in a particular phase, depending on the type of information available.

STANDARD WASTE BOX (SWB). A waste container measuring approximately 6 by 4.5 by 3 ft (1.8 by 1.4 by 0.9 m) high, with rounded ends.

GLOSSARY OF TERMS

TECHNICAL SAFETY REQUIREMENTS. Those requirements that define the conditions, safe boundaries, and the management or administrative controls necessary to ensure the safe operation of the facility and to reduce the potential risk to the public and facility workers from uncontrolled releases of radioactive or hazardous materials.

TOTAL EFFECTIVE DOSE EQUIVALENT (TEDE). The sum of the effective dose equivalent (EDE) from sources external to the body during the year, plus the committed effective dose equivalent (CEDE).

TOXICITY. The ability of a substance to cause damage to living tissue, impairment of the central nervous system, severe illness or, in extreme cases, death when ingested, inhaled, or absorbed by the skin.

TOXICOLOGICAL HAZARD. Any substance having chemical properties that pose a potential threat to the public, workers, or the environment.

TRANSURANIC NUCLIDE. A nuclide with an atomic number greater than that of uranium (92). All transuranic nuclides are produced artificially and are radioactive.

TRANSURANIC PACKAGE TRANSPORTER (TRUPACT)-II. Package designed to transport contact-handled TRU-mixed waste to the WIPP site. It is a cylinder with a flat bottom and a domed top that is transported in the upright position.

TRANSURANIC WASTE. The term "transuranic waste" means waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, except for: (1) high-level radioactive waste, (2) waste that the Secretary has determined, with the concurrence of the Administrator, does not need the degree of isolation required by the disposal regulations, or (3) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR 61.

TREATMENT. Means any method, technique, or process, including neutralization, designed to change the physical, chemical, or biological character or composition of any hazardous waste so as to neutralize such waste, or so as to recover energy or material resources from the waste, or as to render such waste non-hazardous, or less hazardous; safe to transport, store, or dispose of; or amenable for recovery, amenable for storage, or reduced in volume.

TYPE A PACKAGING. Means a packaging designed to retain the integrity of containment and shielding required by this part under normal conditions of transport as demonstrated by the tests set forth in 49 CFR § 173.465 or 173.466, as appropriate. Note: Radioactive waste is transported to WIPP in Type B packaging.

UNINTERRUPTIBLE POWER SUPPLY (UPS). A power supply that provides automatic, instantaneous power, without delay or transients, on failure of normal power. It can consist of batteries or full-time operating generators. It can be designated as standby or emergency power depending on the application. Emergency installations must meet the requirements specified for emergency.

GLOSSARY OF TERMS

VOLATILE ORGANIC COMPOUNDS (VOCs). RCRA-regulated organic compounds which readily pass into the vapor state and are present in transuranic mixed waste.

WASTE ACCEPTANCE CRITERIA. A set of conditions established for permitting transuranic wastes to be packaged, shipped, managed, and disposed of at the Waste Isolation Pilot Plant.

WASTE CHARACTERIZATION. Sampling, monitoring, and analysis activities to determine the nature of the waste.

WASTE CHARACTERIZATION PROGRAM. The processes of transuranic waste analysis to support the Part B of the Resource Conservation and Recovery Act permit application, other permits, transportation requirements, and other program requirements. These analyses include documentation of waste generation processes, visual examination of waste components, radiography analysis, and waste assay for radionuclide content. Waste matrix and headspace gas chemical analyses are also part of the characterization program.

WASTE FORM. A term used to emphasize the physical and chemical properties of the waste.

WASTE MATRIX. The material that surrounds and contains the hazardous constituents and to some extent protects them from being released into the surrounding rock and groundwater. Only material within the canister (or drum or box) that contains the waste is considered part of the waste matrix.

WASTE STORAGE/DISPOSAL. For the purposes of this Safety Analysis Report, with regard to transuranic waste: the term “storage” refers to the temporary storage of that waste above ground; and, the term “disposal” refers to that waste which has been emplaced in the underground horizon.

WORKING AGREEMENT. Appendix B of the Agreement of Consultation and Cooperation, which sets forth the working details of that Agreement.

WORST CASE. A conservative (high) estimate of the consequences of the most severe accident identified.

This page intentionally blank

WIPP Safety Analysis Report
DOE/WIPP-95-2065

CHANGE HISTORY

REVISION	AFFECTED SECTIONS/ PAGE NUMBERS	DATE	ADDITIONAL DESCRIPTION OF NATURE OF REVISIONS
0	Entire Document	11/95	Initial Issue
1	Entire Document	3/97	Annual SAR update per DOE Order 5480.23. Incorporation of resolution of external review comments on Revision 0.
2	Entire Document Except Appendices A, D, E	12/97	Annual SAR Update per DOE Order 5480.23. Incorporation of: (1) resolution of DOE Safety Evaluation Report (SER) Recommendations, (2) Defense Nuclear Facilities Safety Board (DNSFB), and external review comments, and (3) SAR changes as a result of Unreviewed Safety Question (USQ) Safety Evaluations.
3	Entire Document Except Appendices A, B, C, D	11/98	Annual SAR Update per DOE Order 5480.23. Incorporation of: (1) Unreviewed Safety Question Safety Evaluations processed up to August 19, 1998, (2) CAO comments on the FY-1997 SAR Annual Update, (3) other external review organization comments on the FY-1997 Annual Update, (4) updated safety analyses, and (5) editorial review comments received since the last WID review.
4	Entire Document Except Appendices A, B, and C.	11/99	Annual SAR Update per DOE Order 5480.23. Incorporation of: (1) Unreviewed Safety Question Safety Evaluations processed and implemented up to August 15, 1999,(2) review organization comments on the FY-1998 Annual Update, (3) updated safety analyses, 4) incorporated Change 1 to Revision 3 of the TSRs, and (5) editorial type corrections.

EXECUTIVE SUMMARY
TABLE OF CONTENTS

EXECUTIVE SUMMARY
LIST OF FIGURES

EXECUTIVE SUMMARY
LIST OF TABLES

TABLE **TITLE** **PAGE NO.**

This page intentionally blank

1.1 Facility Background and Mission

The United States Department of Energy (DOE) was authorized by Public Law 96-164[1] to provide a research and development facility for demonstrating the safe permanent disposal of transuranic (TRU) wastes from national defense activities and programs of the United States exempted from regulations by the U.S. Nuclear Regulatory Commission (NRC). The Waste Isolation Pilot Plant (WIPP), located in southeastern New Mexico near Carlsbad, was constructed to determine the efficacy of an underground repository for disposal of TRU wastes.

In accordance with the 1981 and 1990 Records of Decision (ROD),[2,3] the development of the WIPP was to proceed with a phased approach. Development of the WIPP began with a siting phase, during which several sites were evaluated and the present site selected based on extensive geotechnical research, supplemented by testing.

The site and preliminary design validation phase (SPDV) followed the siting phase, during which two shafts were constructed, an underground testing area was excavated, and various geologic, hydrologic, and other geotechnical features were investigated. The construction phase followed the SPDV phase during which surface structures for receiving waste were built and underground excavations were completed for waste emplacement.

At the conclusion of the construction phase, the DOE proposed a test phase, to be followed by the disposal phase for waste emplacement operations. The test phase was to involve the use of limited quantities of contact-handled (CH) TRU waste to conduct tests in the WIPP underground to provide data for reducing the uncertainties in the performance assessment required for compliance with the long-term waste isolation regulations of the U.S. Environmental Protection Agency (EPA), Subpart B of 40 CFR Part 191.[4] To enable the receipt of CH-TRU waste at the WIPP site for the tests the Congress enacted the WIPP Land Withdrawal Act[5] of 1992 (Public Law 102-579). The law also provided for authorizations of detailed regulatory requirements for the WIPP.

As a result of major programmatic redirection in October 1993, the WIPP test phase was modified by substituting the previously planned WIPP underground radioactive tests with laboratory tests. In conjunction, WIPP operations would proceed directly with the disposal phase CH TRU waste emplacement operations starting in mid-1998, assuming successful demonstration of compliance with applicable federal and state laws and regulations, and successful completion of the WIPP CH Operational Readiness Review (ORR). The CH ORR closely examined the safety bases of the facility and the status of attendant conformance to ensure that the facility was operationally ready and that CH waste emplacement operations would be conducted safely.

Disposal operations began in March 1999. The disposal phase currently scheduled to last 35 years,[6, 7] will consist of receiving, handling, and emplacing TRU waste in the repository for disposal, and will end when the design capacity of the repository has been reached.

The decommissioning phase, during which the repository will be prepared for permanent closure, will follow the disposal phase. Surface facilities will be decontaminated and decommissioned, underground excavations will be prepared for closure, and shaft seals will be emplaced. This phase is currently projected to last for 10 years. The post-decommissioning phase will consist of active and passive institutional controls. Active institutional controls will include activities such as control of access to the site, implemented consistent with applicable regulations and permit conditions and will continue for at least 100 years[8].

These controls will be designed to ensure that the potential for future, inadvertent human intrusion is reduced to a level that renders such intrusion unlikely.

This Safety Analysis Report (SAR) documents the safety analyses that develop and evaluate the adequacy of the WIPP CH TRU safety bases necessary to ensure the safety of workers, the public, and the environment from the hazards posed by WIPP waste handling and emplacement operations during the disposal phase and hazards associated with the decommissioning and decontamination phase.

The analyses of the hazards associated with the long-term (10,000 year) disposal of TRU and TRU mixed waste, and demonstration of compliance with the requirements of 40 CFR 191, Subpart B[4] have been addressed in detail in the WIPP Compliance Certification Application (CCA).[8] The Environmental Protection Agency (EPA) reviewed the CCA and subsequently certified that the WIPP was in compliance with the requirements in 40 CFR 191, Subpart B and C on May 13, 1998.[9] SAR Section 5.5, Long-Term Waste Isolation Assessment summarizes the assessment.

References for Section 1.1

1. Public Law 96-164, Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1980, December 29, 1979.

2. U.S. Department of Energy, 46 FR 9162, Record of Decision, Waste Isolation Pilot Plant, January 28, 1981.

3. U.S. Department of Energy, 55 FR 256892, Record of Decision, Waste Isolation Pilot Plant, June 22, 1990.

4. U.S. Environmental Protection Agency, 40 CFR 191, Environmental Radiation Protection for Management and Disposal of Spent Nuclear Fuel, High Level and Transuranic Wastes, Subpart B, Environmental Standards for Disposal, December 1993.

5. Public Law 102-579, Waste Isolation Pilot Plant Land Withdrawal Act, US Congress, October, 1992 [as amended by Public Law 104-201].

6. DOE/NTP-96-1204, Revision 0, The National Transuranic Waste Management Plan, U. S. Department of Energy, Carlsbad Area Office, September 30, 1996, Section 2.1.

7. DOE/EIS-0026-S-2, WIPP Disposal Phase Final Supplemental Environmental Impact Statement, U. S. Department of Energy, Carlsbad Area Office, September, 1997.

8. Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant, DOE/CAO-1996-2184, October 1996, Section 7.1.4.

9. EPA (U.S. Environmental Protection Agency), 1998. Criteria for the Certification and Recertification of the Waste Isolation Pilot Plant's Compliance with the Disposal Regulations: Certification Decision: Final Rule, Federal Register, Volume 63, pages 27354 through 27406, May 18, 1998, Radiation Protection Division, Washington, D.C.

This page intentionally blank

1.2 Facility Overview

1.2.1 Facility Design

The WIPP is located in Eddy County in southeastern New Mexico, 26 miles (41.6 km) east of Carlsbad as shown in Figure 1.2-1. The amount of land that has been set aside for the WIPP includes an area of 10,240 acres (41 km^2). The WIPP is located in an area of low population density with less than 30 permanent residents living within a ten-mile radius. The area surrounding the facility is used primarily for grazing, and development of potash, oil, salt, and gas resources. Development of these resources results in a transient population (non-permanent) consisting principally of workers at three potash mines that are located within ten miles of the WIPP. The largest population center nearest the WIPP is the city of Carlsbad, 26 miles (41.6 km) to the west, with approximately 25,000 inhabitants. Two smaller communities, Loving (population approximately 1300) and Malaga (population approximately 200), are located about 20 miles (32 km) southwest of the facility. As the result of the WIPP Land Withdrawal Act of 1992, no mineral resource development is allowed within the WIPP Site Boundary (with the exception of existing leases).

The WIPP is designed to receive and handle a maximum of 500,000 ft^3/yr (14,160 m^3/yr) CH TRU waste and 10,000 ft^3/yr (283 m^3/yr) remote handled (RH) TRU waste. The CH TRU waste will be contained in 55-gallon (208 L) drums, standard waste boxes (SWBs), ten drum overpacks, 85-gallon (322 L) drum overpacks, 55-gallon (208 L) drums overpacked in SWBs, and pipe containers in 55-gallon (208 L) drums. The WIPP facility is designed to have a disposal capacity for TRU waste of 6.2×10^6 ft^3 (1.76×10^5 m^3). Current design is that RH waste will be packaged in steel canisters and transported to the WIPP facility in shielded road casks. The WIPP facility has sufficient capacity to handle the 250,000 ft^3 (7,080 m^3) of RH TRU that was established in the ROD[1] as a total volume. In addition, the WIPP Land Withdrawal Act of 1992[2] limits the total RH TRU activity to 5.1×10^6 curies.

CH TRU wastes will be disposed of in the 100-acre (0.4 km^2) disposal area on a horizon located 2,150 feet (655 meters) beneath the surface in a deep, bedded salt formation. Waste will be transferred from the surface to the disposal horizon through a waste shaft using a hoisting arrangement. The disposal phase is currently scheduled to last for 35 years.[3, 4]

The Department of Energy - Carlsbad Area Office (DOE-CAO) has determined that waste emplacement will only follow a decision, by DOE and by appropriate regulatory agencies, that permanent disposal in the WIPP facility protects human health and the environment. When initiated, the placement of waste in the WIPP will be for the purpose of permanent disposal with no intent to retrieve. However, if in the future it is determined that recovery of disposed waste is required, prior to commencement of recovery operations: (1) principal design and safety criteria for structures, systems, and components (SSCs) that protect the public, workers, and the environment from hazards posed by recovery shall be developed, and (2) those hazards associated with the recovery design and process will be analyzed to address recovery.

The WIPP is divided into three basic groups: surface structures, shafts, and subsurface structures as shown in Figure 1.2-2. The WIPP surface structures (see Figure 1.2-3) accommodate the personnel, equipment, and support services required for the receipt, preparation, and transfer of waste from the surface to the underground. The surface structures are located in an area within a perimeter security fence. The primary surface operations at the WIPP are conducted in the Waste Handling Building (WHB), which is divided into the CH TRU waste handling area, the RH TRU waste handling area, and support areas. The CH TRU waste handling area includes the entrance air locks, CH Bay, a shielded holding area, and CH TRU support facilities.

The current design of the RH TRU waste handling area includes an RH Bay, cask receiving and preparation areas, hot cell complex, and a shielded cell for shielded road cask unloading, waste canister inspection, overpacking canisters, as required, and facility cask loading prior to transfer underground.

The vertical shafts extending from the surface to the underground horizon (see Figure 1.2-2) are the waste shaft, the salt handling shaft, the exhaust shaft, and the air intake shaft. These shafts are lined from the shaft collar to the top of the salt formation (about 850 ft [259 meters] below the surface), and are unlined through the salt formation. The shaft lining is designed to withstand the full piezometric water pressure associated with any water-bearing formation encountered. The waste shaft is located between the CH TRU and RH TRU areas in the WHB. It is nominally 19 feet (5.8 meters) in diameter and is serviced by a hoist utilizing a hoist cage that is primarily used for transportation of CH TRU and RH TRU wastes from the surface to underground disposal areas.

The underground areas (see Figure 1.2-4) consist of the waste disposal area, and the support area. The disposal area has four main entries (two entries for fresh air and two entries for return air) and a number of disposal rooms. The layout of the shafts and entries allows mining and disposal operations to proceed simultaneously. The first disposal panel is used to dispose waste while the next panel is being mined. Successive stages follow in a similar manner.

A typical disposal panel consists of seven disposal rooms. Each room is 33 feet (10 meters) wide, 13 feet (4 meters) high, and 300 feet (91.5 meters) long. The disposal rooms are separated by pillars of salt 100 feet (30.5 meters) wide and 300 feet (91.5 meters) long. Panel entries at the end of each of these disposal rooms are also 33 feet (10 meters) wide and 13 feet (4 meters) high and will be used for waste disposal, except for the first 200 feet (61 meters) from the main entries which are 22 feet (6.7 meters) wide by 14 feet (4.3 meters) high. This first 200 feet (61 meters) will be used for installation of panel closure systems.

1.2.2 Facility Operations

The principal operations of the WIPP involve the receipt of TRU and TRU mixed waste and emplacement in the underground salt repository for disposal (see Figure 1.2-5). Transporters carrying TRU waste arrive at the WIPP and are unloaded outside the WHB. The shipments are surveyed for external contamination prior to their movement into the WHB for unloading.

CH TRU waste will be shipped to the WIPP in Nuclear Regulatory Commission (NRC)-certified shipping packages. After the CH TRU waste shipping container is inspected for contamination, the loaded shipping container is moved into the WHB and placed on a handling dock. The container is opened, surveyed for radiation and contamination levels, and the waste containers are removed and placed on a facility pallet. This pallet is then transferred to the conveyance loading car, which is moved into the hoist cage in the waste shaft for transfer to the disposal horizon.

At the disposal horizon, the pallet is removed from the hoist cage, placed on the underground transporter, and moved to the CH TRU waste disposal room. In the disposal room, the containers are removed from the pallet and placed in the waste stack. The empty pallet is returned to the surface for reuse.

The waste received for placement in the WIPP facility must conform with the WIPP Waste Acceptance Criteria (WAC).[5] The operational philosophy at the WIPP facility is to start radiologically clean and stay radiologically clean. Consequently, any containers of waste that are found to be externally contaminated or damaged will be decontaminated or placed in a larger container (overpacked at the location contamination is found or damage occurs), or returned to the generating/shipping facility. Also, any local area of contamination will be isolated and/or decontaminated prior to continuation of the waste handling process.

Analyses in this SAR address CH TRU waste emplacement operations only. **Existing RH TRU design and operations information were retained for design configuration management purposes only (Changes to RH SSCs are evaluated through the configuration management process, for their impact on CH design and operations as evaluated in this SAR).** RH TRU waste handling and emplacement operations will be updated in future revisions of this SAR.

References for Section 1.2

1. U.S. Department of Energy, 46 FR 9162, Record of Decision, Waste Isolation Pilot Plant, January 28, 1981

2. Public Law 102-579, Waste Isolation Pilot Plant Land Withdrawal Act, October, 1992 [as amended by Public Law 104-201].

3. DOE/NTP-96-1204, Revision 0, The National Transuranic Waste Management Plan, U. S. Department of Energy, Carlsbad Area Office, September 30, 1996, Section 2.1.

4. DOE/EIS-0026-S-2, WIPP Disposal Phase Final Supplemental Environmental Impact Statement, U. S. Department of Energy, Carlsbad Area Office, September, 1997.

5. WIPP-DOE-069, TRU Waste Acceptance Criteria for the Waste Isolation Pilot Plant, Revision 5, April 1996.

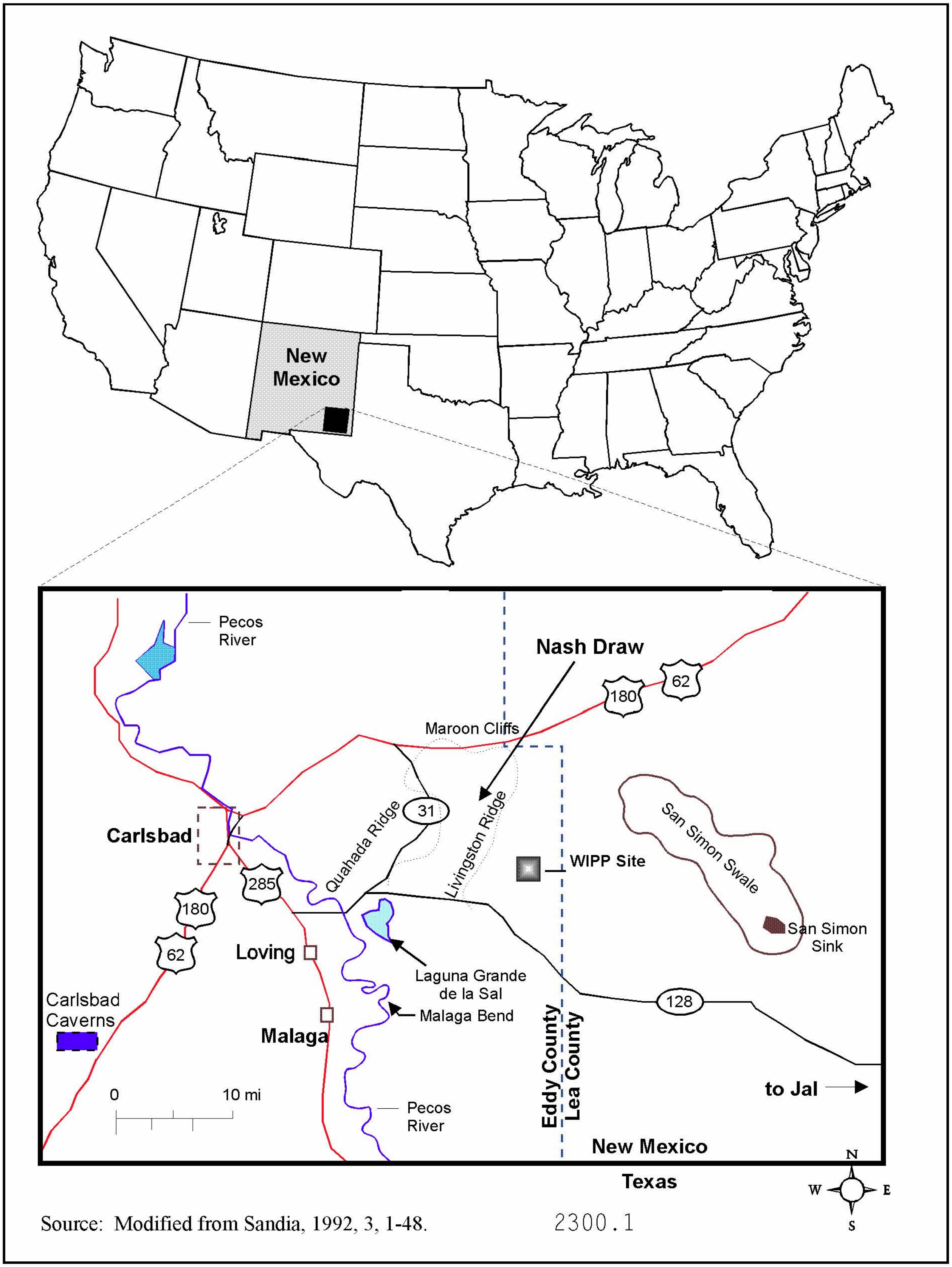


Figure 1.2-1, WIPP Location in Southeastern New Mexico

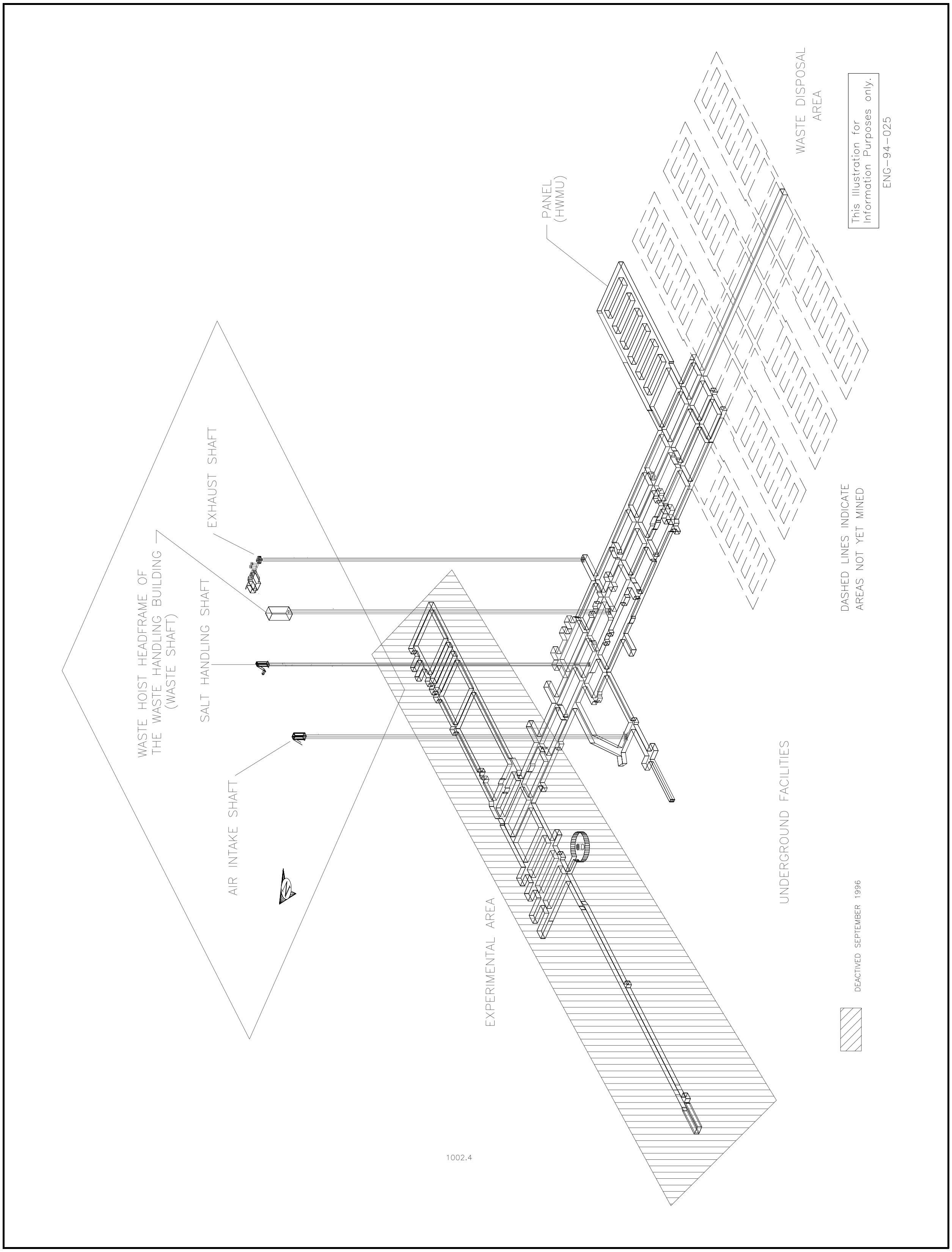


Figure 1.2-2, Spatial View of the WIPP Facility

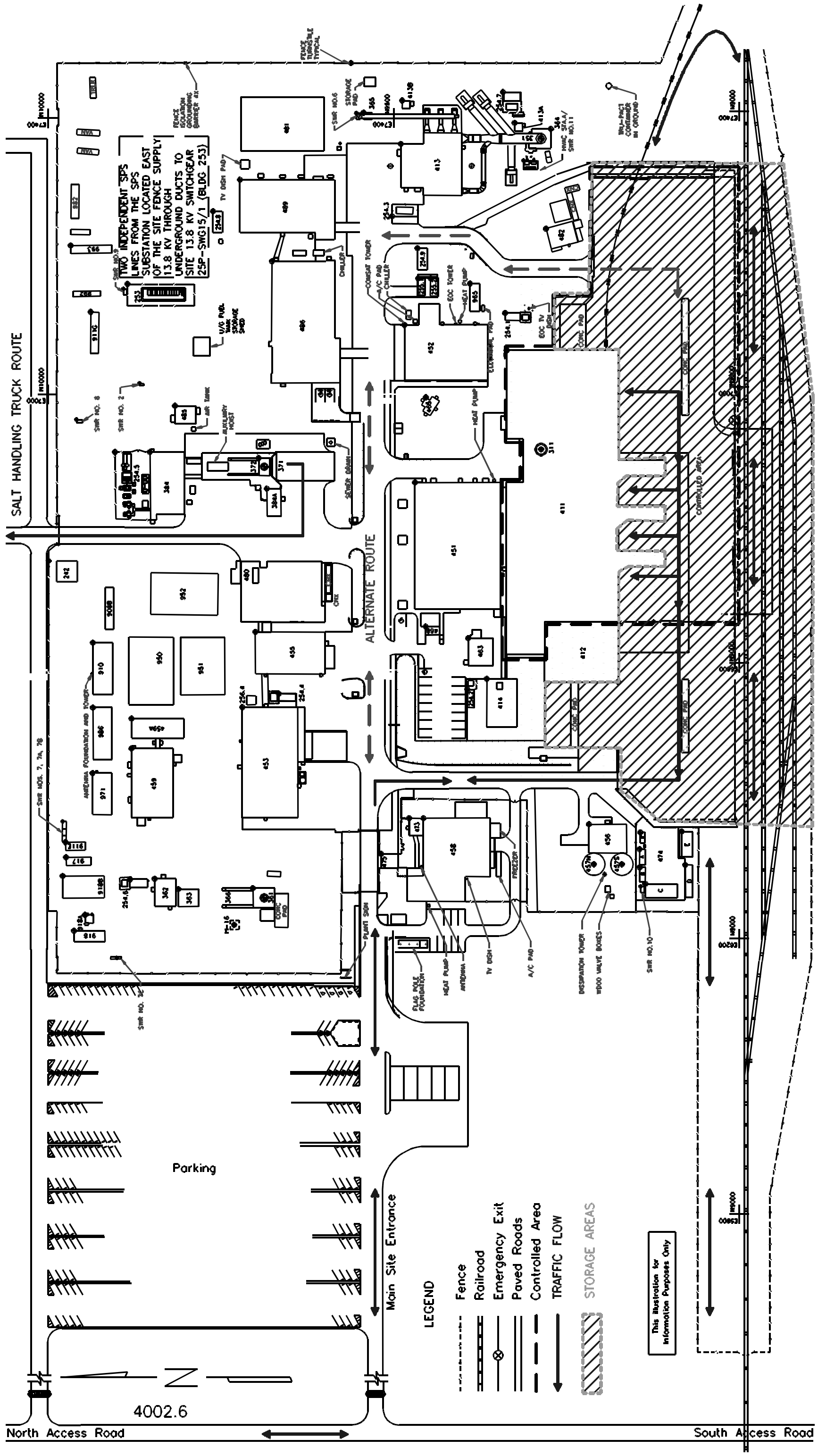


Figure 1.2-3a, WIPP Surface Structures

BLDG./ FAC. #	DESCRIPTION
242	NORTH GATEHOUSE
253	13.8 KV SWITCHGEAR 25P-SWG15/1
254.1	AREA SUBSTATION NO.1 25P-SW15.1
254.2	AREA SUBSTATION NO.2 25P-SW15.2
254.3	AREA SUBSTATION NO.3 25P-SW15.3
254.4	AREA SUBSTATION NO.4 25P-SW15.4
254.5	AREA SUBSTATION NO.5 25P-SW15.5
254.6	AREA SUBSTATION NO.6 25P-SW15.6
254.7	AREA SUBSTATION NO.7 25P-SW15.7
254.8	AREA SUBSTATION NO.8 25P-SW15.8
254.9	AREA SUBSTATION NO.9 25P-SW15.9
255.1	BACKUP GENERATOR #1 25-PE 503
255.2	BACKUP GENERATOR #2 25-PE 504
311	WASTE SHAFT
351	EXHAUST SHAFT
361	AIR INTAKE SHAFT
362	AIR INTAKE SHAFT/HOIST HOUSE
363	AIR INTAKE SHAFT/WINCH HOUSE
364	EFFLUENT MONITORING INSTRUMENT SHED A
365	EFFLUENT MONITORING INSTRUMENT SHED B
366	AIR INTAKE SHAFT HEADFRAME
371	SALT HANDLING SHAFT
372	SALT HANDLING SHAFT HEADFRAME
384	SALT HANDLING SHAFT HOISTHOUSE
384A	SALT HOIST OPERATIONS
411	WASTE HANDLING BUILDING
412	TRUPACT MAINTENANCE FACILITY
413	EXHAUST FILTER BUILDING
413A	EFFLUENT MONITORING ROOM A
413B	EFFLUENT MONITORING ROOM B
414	WATER CHILLER FACILITY & BLDG
451	SUPPORT BUILDING
452	SAFETY & EMERGENCY SERVICES FACILITY
453	WAREHOUSE/SHOPS BUILDING
455	AUXILLIARY WAREHOUSE BUILDING
456	WATER PUMPHOUSE

BLDG./ FAC. #	DESCRIPTION
457N	WATER TANK 25-D-001A
457S	WATER TANK 25-D-001B
458	GUARD AND SECURITY BUILDING
459	CORE STORAGE BUILDING
459A	SANDIA ANNEX
463	COMPRESSOR BUILDING
465	AUXILIARY AIR INTAKE
468	TELEPHONE HUT
473	ARMORY BUILDING
474	HAZARDOUS WASTE STORAGE FACILITY
474A	HAZARDOUS WASTE STORAGE BUILDING
474B	HAZARDOUS WASTE STORAGE BUILDING
474C	OIL & GREASE STORAGE BUILDING
474D	GAS BOTTLE STORAGE BUILDING
474E	HAZARD MATERIAL STORAGE BUILDING
474F	WASTE OIL RETAINER
475	GATEHOUSE
480	VEHICLE FUEL STATION
481	AUXILIARY WAREHOUSE
482	EXHAUST SHAFT HOIST EQUIP. WAREHOUSE
485	COMPRESSOR BUILDING
486	ENGINEERING BUILDING
489	TRAINING BUILDING
H-16	SANDIA TEST WELL (NOT IDENTIFIED)
908B	HBS TRAILER
910	ENVIRONMENTAL MONITORING TRAILER
911G	SANDIA OFFICES TRAILER

BLDG./ FAC. #	DESCRIPTION
917	AIS MONITORING
918	VOC TRAILER
918A	VOC AIR MONITORING STATION
918B	VOC LAB TRAILER
950	WORK CONTROL TRAILER
951	PROCUREMENT / PURCHASING
952	TRAILER (7-PLEX)
965	SAMPLE PREPARATION LAB
971	HUMAN RESOURCES TRAILER
982	TRAILER
986	PUBLICATIONS & PROCEDURES TRAILER
992	SANDIA CALIBRATION LAB TRAILER
993	SANDIA OFFICES TRAILER
SWR NO.1	SWITCHRACK NO. 1
SWR NO.2	SWITCHRACK NO. 2
SWR NO.3	SWITCHRACK NO. 3
SWR NO.6	SWITCHRACK NO. 6
SWR NO.7,7A,7B	SWITCHRACK NO. 7, 7A, 7B
SWR NO.7C	SWITCHRACK NO. 7C
SWR NO.8	SWITCHRACK NO. 8
SWR NO.9	SWITCHRACK NO. 9
SWR NO.10	SWITCHRACK NO. 10
SWR NO.11	SWITCHRACK NO. 11

4003.8

This illustration for Information Purposes Only

Figure 1.2-3b, Legend for Figure 1.2-3

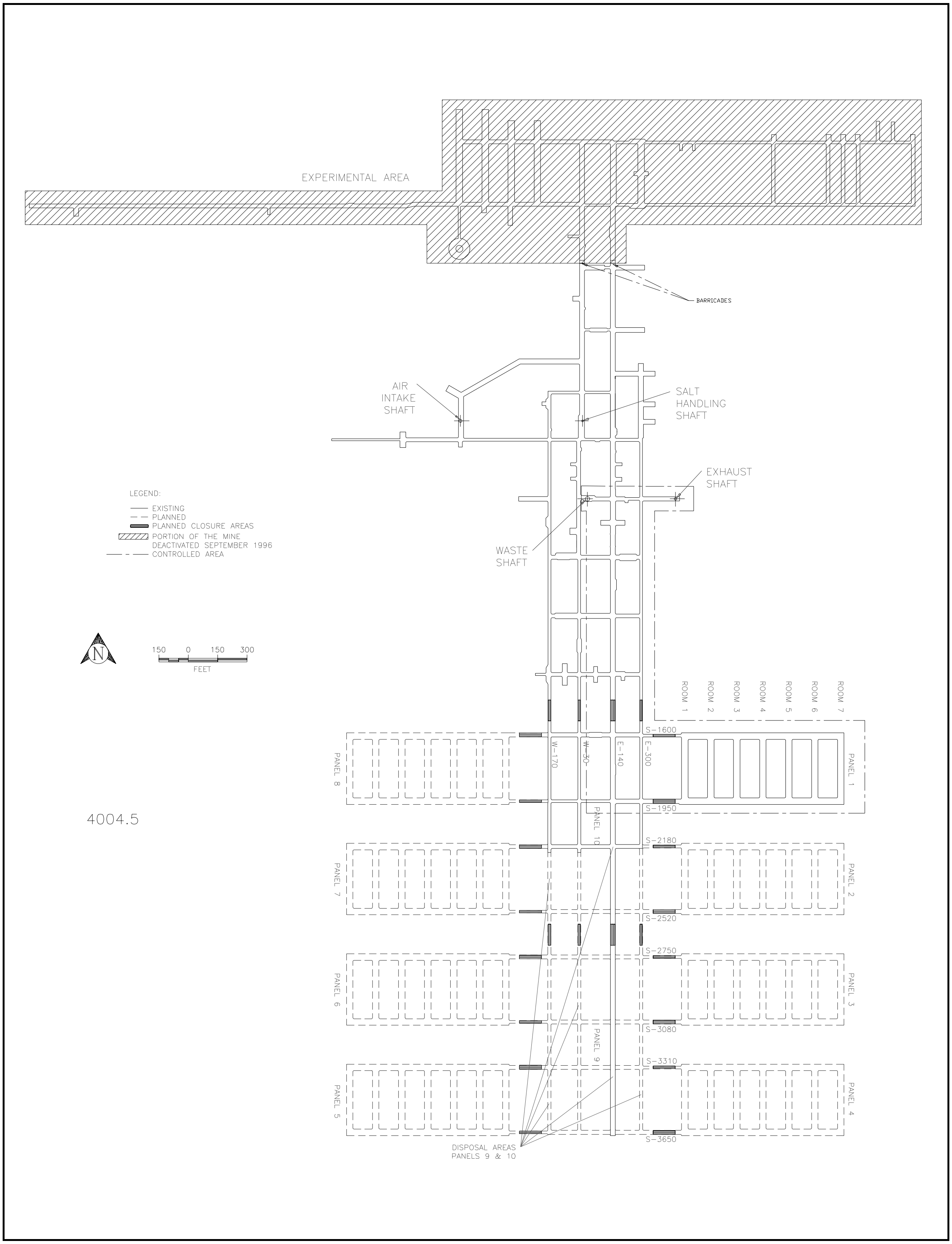


Figure 1.2-4, Underground Subsurface Areas

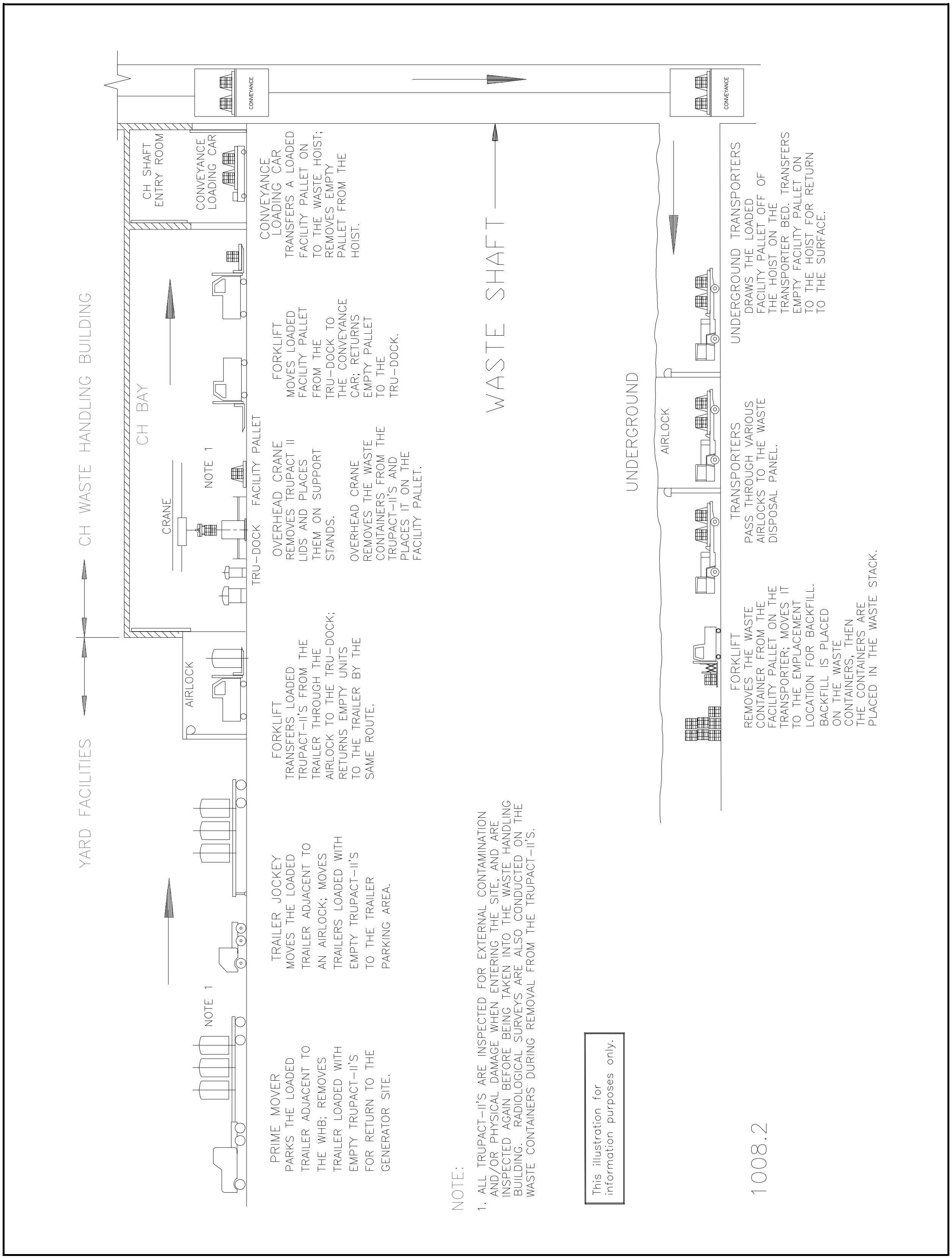


Figure 1.2-5, CH TRU Waste Emplacement Process

1.3 Safety Analysis Overview and Conclusions

1.3.1 Safety Analysis Report Strategy and Approach

The WIPP SAR, originally issued in May 1990 following approval by the Department of Energy, Office of Environmental Restoration and Waste Management (DOE-EM), was prepared to satisfy: (1) the commitments in the Working Agreement for Consultation and Cooperation[1] (WACC) (Article III, Section C and Article IV, Section K, known as the Working Agreement) between the State of New Mexico and the U.S. Department of Energy; and (2) the requirements of DOE Order 5481.1B, Safety Analysis and Review System[2] and DOE Albuquerque Operations Office AL Order DOE-AL 5481.1B.[3]

Since the original approval by DOE-EM, the WIPP SAR has been reviewed and updated: (1) annually in the Fiscal Year (FY)-92 through FY-97 updates; and (2) to ensure compliance with the requirements of DOE Orders 5480.21, Unreviewed Safety Questions,[4] 5480.22, Technical Safety Requirements,[5] 5480.23, Nuclear Safety Analysis Reports,[6] and 5480.24, Nuclear Criticality Safety.[7] Due to the cancellation of DOE Order 5481.1B, the SAR is being maintained per the requirements of DOE Order 5480.23. This SAR represents a statement and commitment by the DOE that the WIPP can be operated safely and at acceptable risk. It also represents the "Final" SAR indicating that the WIPP facility is ready to begin operating versus "Preliminary," which generally refers to a facility in the design or construction stage.

In accordance with the requirements of DOE Order 5480.23,[6] the SAR documents the safety analyses that develop and evaluate the adequacy of the safety bases. The safety bases are defined by DOE Order 5480.23[6] as:

"the combination of information relating to the control of hazards at a nuclear facility (including design, engineering analyses, and administrative controls) upon which DOE depends for its conclusion that activities at the facility can be conducted safely."

This SAR establishes and evaluates the adequacy of the WIPP CH TRU safety bases in response to plant normal and abnormal operations, and postulated accident conditions. The WIPP safety bases analyzed include; (1) the adequacy of the design basis of WIPP CH SSCs, and the application of appropriate engineering codes, standards, and quality assurance requirements, (2) the selection of principal design and safety criteria, (3) the assignment of Technical Safety Requirements (TSRs), and (4) the management, conduct of operations, and institutional dimensions of safety assurance.

Analyses in this SAR address CH TRU waste emplacement operations only. **Existing RH TRU design and operations information were retained for design configuration management purposes only (Changes to RH SSCs are evaluated through the configuration management process, for their impact on CH design and operations as evaluated in this SAR).** RH TRU hazards and accident analyses will be included in a RH TRU Preliminary Safety Analysis Report (currently scheduled for FY-99).

The following provides a summary of the specific issues as they relate to the CH TRU safety bases:

(1) Safety Analysis Report Organization

The WIPP SAR was originally structured to satisfy the specific commitments made in the WACC Agreement.[1] The WACC format is different from the 20 chapter SAR concept of DOE Order 5480.23,[6] and DOE-STD-3009-94.[8] By applying the graded approach concepts as discussed in DOE-STD-3009-94, 10 of the 20 DOE Order 5480.23 chapters were consolidated into other identified chapters. This resulted in a 10 chapter WIPP SAR format that is similar to the WACC Agreement format. This graded approach consolidation and reformatting is consistent with the discussion in DOE Order 5480.23 Attachment 1, Sections 4.f.(1)(c), and 4.f.(3)(d). SAR chapter titles are retitled to follow selected DOE-STD-3009-94 or DOE Order 5480.23 titles and to be consistent with their individual contents. The WIPP SAR format is as follows:

Chapter 1 - Executive Summary
Chapter 2 - Site Characteristics
Chapter 3 - Principal Design and Safety Criteria
Chapter 4 - Facility Design and Operation
Chapter 5 - Hazards and Accident Analysis
Chapter 6 - Derivation of Technical Safety Requirements
Chapter 7 - Radiological and Hazardous Material Protection
Chapter 8 - Institutional Programs
Chapter 9 - Quality Assurance
Chapter 10 - Decontamination and Decommissioning

Table 1.3-1 provides a correlation between the WACC Agreement SAR Format and Content requirements and the WIPP SAR format, and Table 1.3-2 provides a correlation between the SAR topics required by DOE Order 5480.23.

(2) Facility Hazard Categorization

The hazard classification categorization was determined in accordance with DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*.[9] A deterministic approach was taken without considering facility segmentation, form location or dispersibility of the material at risk. The material at risk for the determination of the categorization was defined as the maximum radiological contents of a single CH waste container as derived in Chapter 5. The WIPP Facility is classified as a Hazard Category 2 facility based on this single waste container inventory in comparison to the threshold quantities provided in Table A-1 of DOE-STD-1027-92.[9]

(3) Design and Operation

The System Design Descriptions[10] (SDDs) for the WIPP provide the design information for Chapter 3, Principal Design and Safety Criteria, and Chapter 4, Facility Design and Operation. The SDDs provide the most currently available final engineering design information on waste emplacement operations throughout the disposal phase up to the point of permanent closure. Design and operations information were also obtained from the Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant, DOE/CAO-1996-2184, October 1996.[12] Also, the criteria which define the TRU waste to be acceptable for disposal at the WIPP facility are summarized in Chapter 3 based on the *Waste Acceptance Criteria (WAC) for the Waste Isolation Pilot Plant*.[11]

WACC Agreement SAR requirements for Long Term Waste Isolation Assessment, are summarized in Chapter 5. The Long Term Waste Isolation Assessment is covered in the WIPP Compliance Certification Application (CCA).

The systematic evaluation of the human factors associated with the design and operation of the WIPP to meet the requirements of DOE Order 5480.23[6] is incorporated in Chapter 4. The evaluation determined that well established policies and procedures are in place ensuring normal and emergency procedures are implemented, adequate directions have been provided to shift personnel concerning actions to be taken in a potential accident environment, and adequate procedures are available for follow-up response. A detailed summary of the human factors evaluation is provided in Section 1.3.2.2.6.

The WIPP site description in terms of geology, hydrology, meteorology, geography, demography, nearby facilities, and cultural and natural resources are based on information provided in the Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant, DOE/CAO-1996-2184, October 1996.[12]

(4) Hazard Analysis

The WIPP CH TRU handling process was qualitatively evaluated using a Hazard and Operability Study (HAZOP)[13] (Summarized in Appendix C). This systematic approach to hazard analysis was conducted by a leader knowledgeable in the HAZOP methodology and consisted of personnel from various disciplines familiar with the design and operation of the WIPP (HAZOP Team). The HAZOP Team identified deviations from the intended design and operation of the waste handling system that could: (1) result in process slowdown or shutdown, (2) result in worker injury or fatality, and (3) result in the release of waste container radiological and nonradiological materials.

The HAZOP Team assigned a qualitative consequence and frequency ranking for each deviation. A hazard evaluation ranking mechanism utilized the frequency and the most significant consequences to separate the low risk hazards from high risk hazards that may warrant additional quantitative analysis of consequences to the maximally exposed individual (MEI), noninvolved worker, and immediate worker. Based on this ranking approach HAZOP deviations whose combined hazard rank were identified to be of moderate or high risk (see Table 1.3-3) were selected for quantitative analysis in Section 5.2 to: (1) verify and document the basis for the qualitative frequency and consequence assignments in the HAZOP, and (2) identify the need for safety (safety-class or safety-significant) SSCs and Technical Safety Requirements (TSRs).

The HAZOP replaces previous hazards analyses in existing documentation including the Final Environmental Impact Statement (FEIS),[14] Final Supplement Environmental Impact Statement (SEIS),[15] WIPP Fire Hazards and Risk Analysis,[16] and Failure Modes and Effects Analyses (FMEAs), for the purposes of identifying initiating events for quantitative accident analysis in Section 5.2. However, these documents were reviewed to ensure that all hazards associated with CH TRU waste handling were identified in the HAZOP. A detailed summary of the hazards analysis results is provided in Section 1.3.2.2.1.

Since the performance of the HAZOP, an update of the WIPP Fire Hazards Analysis[17] has been performed to meet the requirements of DOE O 420.1.[18] The updated Fire Hazards Analysis confirms the previous evaluation that the frequency of room or structural fire, as an accident in the Waste

Handling Building (WHB) resulting in a direct release of radioactive material from the waste containers engulfed in the fire, is beyond extremely unlikely (<1E-06/yr).

(5) Defense in Depth

A defense in depth section identifies layers of defense against the abnormal and accidental release of radiological and nonradiological hazardous materials. The WIPP approach provides three layers of defense which include conservative design of the facility's SSCs, protection against anticipated operational occurrences and unlikely events, and passive features that may be on line continuously or automatically/manually activated.

The ultimate safety objective of the first, or primary layer of WIPP defense in depth is **accident prevention**. The reduction of risk (as the product of frequency and consequence) to both workers and the public from WIPP CH TRU waste handling and emplacement operations is primarily achieved by reducing the frequency of occurrence of postulated abnormal events or accidents. The conservative design of the facility's SSCs, with operations conducted by trained/qualified personnel to the standards set forth in approved procedures, provides the first layer. Specific preventative measures are identified in Appendix C for each postulated deviation as identified in the HAZOP, and in Table 1.3-3 for each deviation considered for quantitative accident analysis.

The second layer of defense in depth provides protection against anticipated and unlikely operational events that might occur in spite of the protection afforded by the first layer of defense. The second defense layer is characterized by detection and protection systems, and controls that: (1) indicate component, system, or process performance degradation created by compromises of the first layer, and (2) provide adequate mitigation and accommodation of the consequences of those operational accidents which may occur.

The third layer of defense in depth supplements the first two layers by providing protection against extremely unlikely operational, natural phenomenon, and external events. These events represent extreme cases of failures and are analyzed in Section 5.2.3 using conservative assumptions and calculations to assess the radiological and nonradiological effects of such accidents on the MEI, noninvolved worker, and immediate worker to verify that a conservative design bases has been established. A detailed summary of the WIPP defense-in-depth strategy is provided in Section 1.3.2.2.7.

(6) Accident Analysis

The accident analyses utilize currently available DOE Orders, standards and guidance as documented in DOE-STD-3009-94[8] and DOE-STD-1027-92[9], for determination of safety of the public, worker, and the environment. This SAR provides an analysis of the potential hazards that may exist at the WIPP at the level of analytical effort based on the magnitude of the hazards and the complexity of the CH TRU waste operations conducted at the WIPP. The accidents selected for quantitative analysis are considered "Derivative Design Basis Accidents," (DBAs) as defined in DOE Standard 3009-94. These derivative DBAs are used to estimate the response of WIPP SSCs to "the range of accident scenarios that bound the envelope of accident conditions to which the facility could be subjected" in order to evaluate accident consequences.

The principal purpose of the accident analysis is to evaluate the derivative DBAs for the purposes of identifying safety (safety-class or safety-significant) SSCs and TSRs necessary to maintain accident consequences resulting from these derivative DBAs to within the accident risk evaluation guidelines.

For the purposes of establishing safety SSCs, the consequences of these accidents are analyzed to a noninvolved worker conservatively assumed to be 328 ft (100 meters) from each release point, and to the MEI located at the WIPP Exclusive Use Area. An evaluation of operational accidents "beyond" the derivative design basis is conducted by evaluating the accident scenarios in response to the bounding conditions as derived from the WIPP Waste Acceptance Criteria (WAC).[11] For simplicity, the term "derivative" is dropped for the remainder of this chapter; DBA refers to derivative DBAs.

DOE Standard 3009-94 states that use of a lower binning threshold such as 1E-06/yr is generally appropriate, but should not be used as an absolute cutoff for dismissing physically credible low frequency operational accidents without an evaluation of preventative or mitigative features. As such, DBAs identified in this section whose frequency are less than 1E-06/yr (beyond extremely unlikely) are also analyzed quantitatively for the sole purpose of providing perspective on the risk associated with the operation of the facility. The results of these analyses are found in the respective accident evaluation in Section 5.2.3.

An assessment of immediate worker accident consequences is also conducted for the operational waste handling scenarios whose frequency is greater than 1E-06/yr (waste container breaches due to drop or impact), that may be initiated by waste handling equipment failure or directly through human error by a worker performing a waste handling operation. Again, accidents whose frequency are less than 1E-06/yr (beyond extremely unlikely) are also analyzed quantitatively in the respective accident evaluation in Section 5.2.3 for the sole purpose to provide perspective of the risk to the immediate worker associated with the operation of the facility. The immediate worker is that individual directly involved with the waste handling operation for which the accident is postulated. As discussed in Sections 5.1.2.1.2 and 5.1.7, the assessment of immediate worker consequences will ensure that the maximum allowable radionuclide inventory, in conjunction with the other layers of defense in depth, will preclude worker risk from being unacceptable.

The models and assumptions used in the analysis for determining the amount of radioactivity released to the environment and the extent of exposure to the MEI, noninvolved worker, and immediate worker are provided in Section 5.2. Activity releases to the environment are given for each postulated accident. Committed Effective Dose Equivalents (50 yr CEDE) were calculated for what are considered to be hypothetical individuals located: (1) at the WIPP Exclusive Use Area boundary (MEI) and the site boundary (16 Section Boundary), (2) at 328 feet (100 m) from each release point (noninvolved worker), and (3) within the immediate area of the accident (immediate workers). The meteorological conditions under which these doses are evaluated are discussed in Section 5.2.1.

In evaluating hypothetical accidents, a level of conservatism is used in the safety analysis assumptions to provide consequences which result in postulated releases that are overestimated rather than underestimated. The level of conservatism in each of the safety analysis variables is consistent with DOE-STD-3009-94 and its draft appendix. Although draft documents are not necessarily appropriate for reference in this SAR, the draft appendix provides reasonable guidance for consideration and use. The level of conservatism chosen, bounding the full range of possible scenarios (although several of those scenarios are considered to be beyond extremely unlikely), provides reasonable assurance that when considering the variability in waste form, TRU activity content, and radionuclide distributions that: (1) the safety envelope of the facility is defined, (2) the design of the facility is adequate in response to the accident scenarios analyzed, and (3) the Technical Safety Requirements (TSRs) assigned will provide for the protection of the public, the worker, and the environment. A detailed summary of the accident analysis frequency and consequence results is provided in Sections 1.3.2.2.2 and 1.3.2.2.3.

Analyses in this SAR address CH TRU waste emplacement operations only. Existing RH TRU design and operations information were retained for design configuration management purposes only (Changes to RH SSCs are evaluated through the configuration management process, for their impact on CH design and operations as evaluated in this SAR). RH TRU hazards and accident analyses will be included in a RH TRU Preliminary Safety Analysis Report, currently scheduled for FY-1999.

(7) Verification of Design

The hazard and accident analysis results are used to indicate whether safety (safety-class or safety-significant) SSCs are required for the WIPP to prevent or mitigate accidental radiological or nonradiological consequences to the MEI and noninvolved worker to within the risk evaluation guidelines.

Section 5.2.4.1, Evaluation of the Design Basis, discusses in detail: (1) the identification of defense-in-depth SSCs, (2) the evaluation of safety-class and safety significant SSCs, and (3) the applicability of functional and performance requirements and controls. A detailed summary is provided in Section 1.3.2.2.5.

(8) Technical Safety Requirements

Technical Safety Requirements (TSRs) are developed based on the requirements provided in DOE 5480.22,[5] Technical Safety Requirements (TSRs). Based on the requirements and the results of the hazard and accident analysis, no Safety Limits, Operational Limits, or Surveillance Requirements are defined for the WIPP. Supporting the first layer of defense in depth (the prevention of accidents), WIPP TSR Administrative Controls (ACs) are established as follows:

- To maintain the design, quality, testability, inspectability, maintainability, and accessibility of the facility, TSR ACs are required relating to: (1) configuration and document control, (2) maintenance, (3) quality assurance, and (4) geotechnical monitoring. These ACs are important to ensure the frequency of events and the availability of the operating and design conditions remain as analyzed in Section 5.2.3.

- To ensure that the facility operations are conducted by trained and certified/qualified personnel in a controlled and planned manner, TSR ACs are required relating to: (1) facility operations chain of command and responsibilities, (2) facility staffing requirements, (3) procedures, (4) staff qualifications, (5) conduct of operations, and (6) training. These ACs are important to ensuring the low frequency of the accidents analyzed in Section 5.2.3, in particular to those waste handling accidents where human error is the major contributor to the likelihood of the accident initiating event (CH3, CH4, and CH9).

- To ensure that hazards are limited within the bounds assumed in Section 5.2, or that the occurrence of a deviation from the assumed hazard bounds are at an acceptably low frequency, TSR ACs are required relating to: (1) waste characteristics (Waste Acceptance Criteria), (2) waste container integrity, and (3) criticality safety. The TSR AC for waste characteristics limits the radionuclide content of each waste container, restricts the fissile content of the containers, and restricts the presence of waste characteristics unacceptable for management at the WIPP facility. Container integrity ensures the robustness reflected in the waste release analyses, while criticality safety is a designed in-storage and handling configuration that ensures (in conjunction with waste characteristics) that active criticality control is not required.

Supporting the second and third layers of defense in depth, WIPP TSR ACs are identified which establish programs for radiation protection (including radiation monitoring equipment and airborne radioactivity monitoring), and emergency management. Basic elements and requirements defined for TSR AC programs are enforced by the associated implementing WIPP procedures.

(9) Protection of Immediate Workers From Accidents

The HAZOP[13] for the CH TRU Waste Handling System identified a number of waste handling process hazards that could potentially lead to events resulting in immediate worker injury or fatality, or exposure to radiological and nonradiological hazardous materials.

The HAZOP Team identified a significant number of existing preventative safeguards that lower the likelihood of occurrence of each deviation, substantially reducing the risk of injury or fatality to workers. The HAZOP Team concluded, consistent with the first layer of defense in depth, substantial safeguards currently exist at the WIPP to prevent or reduce the likelihood of such deviations from occurring. Identified preventative safeguards generally include the following:

- Facility and equipment design, application of appropriate design classification and applicable design codes and standards,
- Programs relating to configuration and document control, quality assurance, and preventative maintenance and inspection,
- Administrative controls including the WIPP WAC, waste handling procedures and training, and the WIPP Emergency Plan and associated procedures.

Consistent with: (1) Paragraph 6 of Attachment 1 of DOE Order 5480.22, Technical Safety Requirements, (2) the defense-in-depth philosophy discussed in Section 5.1.6, and (3) the philosophy of Process Safety Management (PSM), as published in 29 CFR 1910.119, Process Safety Management of Highly Hazardous Chemicals,[21] reduction of the risk to workers from accidents is accomplished at the WIPP primarily by identifying controls to **prevent the event from happening**. (note: Compliance with 29 CFR 1910.119 is not required by WIPP. However, the WIPP philosophy of reduction of accident risk discussed in this section, is consistent with this standard.) As stated in paragraph 6 of Attachment 1 of DOE Order 5480.22, “The TSRs are not based upon maintaining worker exposures below some acceptable level following an uncontrolled release of hazardous material or inadvertent criticality; rather the risk to workers is reduced through the reduction of the frequency and potential impact of such events.”

Consistent with this statement, in conjunction with the defense-in-depth philosophy described in the previous section, total risk is evaluated in this SAR by: (1) performing engineering analyses in the form of event tree/fault tree analysis to identify systems, structures, components, processes, or controls that contribute most to the accident phenomena frequency for the purposes of verifying their adequacy or identifying improvements to reduce the accident frequency and therefore risk, and (2) evaluating human error as an initiating event.

Section 5.2.3 evaluates the accident dose consequences to immediate workers from operational waste container handling accidents whose frequency is greater than 1E-06/yr and may be initiated by waste handling equipment failure or directly through human error by a worker performing a waste handling operation. These accidents include crane failure, and waste container drops or puncture in the Waste Handling Building and the underground. The immediate worker is that individual directly involved with the waste handling operation for which the accident is postulated. This evaluation will ensure that the maximum allowable radionuclide inventory, in conjunction with the other layers of defense in depth, will preclude worker risk from being unacceptable. A detailed summary of the evaluation of the WAC maximum allowable radionuclide inventory is provided in Section 1.3.2.4. Releases from such accidents are conservatively assumed to be instantaneous, and, although procedures dictate that workers exit the area immediately, such accidents present an immediate risk due to the inhalation of airborne radionuclides to the worker performing the waste handling operation.

To evaluate the risk to immediate workers from extremely unlikely operational accidents such as roof fall in the underground and waste hoist failure, the direction of resources in this SAR is focused on the evaluation of system/facility reliability (accident prevention) than on an in-depth evaluation of radiological consequences to an immediate worker and post accident mitigative systems and controls. This evaluation is conducted in the event tree/fault tree analysis in Appendix D, and the accident scenario and evaluation of design adequacy descriptions for each applicable accident in Section 5.2.3.

The risk to workers from extremely unlikely process inherent events such as spontaneous ignition, is a result of the failure of the WIPP WAC to restrict waste elements (such as the presence of pyrophorics) that may cause the initiating event. Again, the direction of resources is focused more on the evaluation of the adequacy of the WAC certification process to prevent this type of accident, rather than on the evaluation of a survivable, specified radiological consequence for which mitigative SSCs or administrative controls may be derived. This evaluation is conducted in the event tree/fault tree analysis in Appendix D, and discussed in Section 5.1.2, and the accident scenario descriptions for CH1 and CH7 in Section 5.2.3. In addition to these fault tree analyses, human error as an initiating event has been evaluated in the WIPP Human Factors Evaluation.

As derived from the WIPP HAZOP, the risk to immediate workers from severe natural phenomenon (design basis earthquake and/or tornado), is dominated by worker fatality due to the energetic phenomenon during the event, as opposed to a specified radiological dose for which additional mitigative SSCs or administrative controls may be derived. This SAR is focused more on the evaluation of the existing facility design when subjected to the severe natural phenomenon (to reduce the likelihood of worker fatality, as well as breach of waste containers), rather than on the evaluation of radiological consequences to an immediate worker. This evaluation is conducted in the accident scenario and evaluation of design adequacy descriptions for each applicable accident in Section 5.2.3.

Due to the importance of these preventative features in the WIPP defense-in-depth safety approach, and for providing worker protection from accidents, TSR ACs are assigned in Chapter 6 and required in the WIPP TSR Document (Attachment 1 to the SAR).

(10) Waste Acceptance Criteria

The WIPP WAC[11] provides the initial set of criteria in Section 3.1 for use in the hazards and accident analyses. The waste accepted for placement in the WIPP facility must conform with the WIPP WAC unless an exception to the WAC has been approved as a result of examination in relation to the SAR. Based on the hazards and accident analyses presented in Chapter 5, specific waste characteristics used in the development of the safety analysis, are required in Chapter 6 to be incorporated as WAC Operations and Safety Requirements. A TSR AC for Waste Characteristics require that the safety analysis criteria be incorporated into the WAC.

Estimates of the radiological waste container inventory for safety analysis calculations were established from a June, 1996 query of the *WIPP Transuranic Waste Baseline Inventory Report* (BIR)[19] database, examining the radionuclide inventory by final waste form, stored waste volume, and waste site. The data reported by the generator sites for 569 individual waste streams was organized by the waste stream, final waste form, and radionuclide concentration (expressed in terms of PE-Ci/equivalent 55 gallon (208 L) drums).

Past WIPP safety analyses established a waste container radionuclide inventory (CI) for use in accident analysis calculations based: (1) strictly on the weapons grade mix (Pu-52 distribution), or (2) based on an average or representative waste container content. Additionally, an arbitrarily chosen radionuclide inventory of 1000 PE-Ci was previously used for bounding accident analysis consequence calculations, and established as the WIPP WAC Pu-239 Equivalent Activity Operations and Safety limit.

Past safety analysis consequence calculations were performed predicated on the WIPP WAC Operations and Safety requirement that waste materials be immobilized if >1% by weight is particulate material <10 microns in diameter, or if > 15 % by weight is particulate material < 200 microns in diameter. However, deletion of this constraint is desirable due to the risk and cost associated with characterizing the size distribution of deposited radionuclide surface contamination on combustible and noncombustible solids. This SAR has evaluated a reasonable range of CIs for "untreated" (not solidified, vitrified, or overpacked) CH TRU waste. Based on a maximum reasonable CI, used in conservative safety analysis with updated airborne release and respirable fractions and the radionuclide limitations for untreated waste derived below, the potential dose consequences due to inhalation by immediate workers, the noninvolved worker, and the MEI from operational accidents with frequencies greater than 1E-06/yr are within the risk evaluation guidelines in Section 5.2.2. As a result, immobilization is no longer required as a WAC criterion.

In conjunction with this goal, the establishment of the radionuclide CI for use in accident analysis calculations must also involve: (1) an evaluation of existing safety analysis orders and guidance documents to establish the appropriate level of conservatism for the CI for safety analysis calculations, (2) consideration of the projected waste inventory in Appendix A and the desire to encompass as much of the Pu-239 and Pu-238 operations waste as possible with the least design or operational impacts to both the waste generator and the WIPP, and (3) evaluation of the existing WAC transportation constraints (nuclear criticality (Pu-239 FGE) and Thermal Power (<40 watts per TRUPACT-II) criteria).

The adequacy of the WIPP facility design, and operational administrative controls (the maximum CI derived below, and elimination of the immobilization requirement as a WAC criterion) is evaluated, based on the accident results in Section 5.2, in detail in Section 5.2.4, and summarized in Section 1.3.2.4.

The source term equation radiological CI used in the accident analyses, is based on the analyses in Section 5.1.2. DOE-STD-3009-94 and its draft appendix state that the source term material at risk (MAR = CI * containers damaged, CD) should “represent a reasonable maximum for a given process or activity, as opposed to artificial maximums unrepresentative of actual conditions.” Additionally, Section A.3.1 of the draft appendix to DOE-STD-3009-94, states that documentation may be used to “back off” of bounding estimates of the MAR. Consistent with this statement, based on the data found in Appendix A (as discussed in Section 5.1.2.1), since CH TRU waste operations accidents may result in more than one container damaged in a postulated accident (CD > 1), for safety analysis calculation purposes it is conservatively assumed that one waste container contains the maximum radionuclide inventory and the remaining waste containers each contain an average radionuclide inventory.

As described in Section 5.1.2.1, the maximum drum radionuclide inventory is 80.0 PE-Ci and the maximum SWB radionuclide inventory is 130 PE-Ci. For accident scenarios which involve single waste containers (CD = 1), it is conservatively assumed that the waste container contains the maximum radionuclide inventory. The value CD is determined in each specific accident scenario.

As described in Section 5.1.2.1, the maximum drum radionuclide inventory used to formulate the MAR that is not solidified, vitrified, or overpacked is 80.0 PE-Ci, and the maximum SWB radionuclide inventory that is not solidified, vitrified, or overpacked is 130 PE-Ci. As a defense-in-depth approach to prevent potential unacceptable dose consequences to the MEI, noninvolved worker, and immediate worker (the primary receptor of concern for evaluation of the adequacy of the immobilization criterion) from high PE-Ci untreated waste, the WAC requires that waste containers exceeding the 80 PE-Ci (drums) or 130 PE-Ci (SWBs) values must be overpacked (drum within a SWB or TDOP), or solidified or vitrified (thus immobilized) prior to acceptance at WIPP. Solidification and vitrification both greatly inhibit the release of the waste form should a container be breached during an accident. Overpacking provides an additional barrier that will greatly reduce the frequency of breach during accidents. These two factors, combined with the low percentage of high activity TRU waste volume that currently exists in the inventory, are judged to make the risks associated with high PE-Ci waste forms small compared to those estimated for the "reasonable maximum" MAR.

As discussed above, the WIPP WAC Thermal Power TRUPACT-II requirement limits the maximum total PE-Ci for a TRUPACT-II shipment of Pu-238 waste to approximately 1,117 PE-Ci. Therefore, the WAC Pu-239 Equivalent Activity Operations and Safety maximum allowable waste container radionuclide inventory of 1,100 PE-Ci for overpacked waste and 1,800 PE-Ci for solidified/vitrified is established.

The adequacy of these assumptions and the WIPP CH TRU facility design basis are evaluated in detail based on the accident results in Section 5.2.4, and summarized in Section 1.3.2.4. Receipt of waste for disposal at WIPP that does not meet the applicable Operations and Safety Requirements of the WIPP WAC will first require the performance of an Unreviewed Safety Question Determination (USQD) in accordance with the requirements of DOE Order 5480.21, Unreviewed Safety Questions.[4]

(12) Programs and Procedures

It is the firm commitment of the WIPP management that occupational radiological exposures are kept As Low As Reasonably Achievable (ALARA). This policy, as reflected in administrative programs and procedures established in accordance with 10 CFR 835[22] and the WIPP Radiation Safety Manual,[23] ensures that the safety basis of the WIPP facility will maintain individual occupational radiation exposures to ALARA. As part of normal operations activities at the WIPP, the waste containers (having met the WIPP WAC) are closely inspected and surveyed for radiation, contamination, and damage before transfer to the underground repository. Most significantly, the cleanliness of containers is required to not be in excess of the DOE's free release limits (20 disintegrations per minute (dpm) alpha per 100 cm^2, or 200 dpm beta/gamma per 100 cm^2) prior to shipment from the generator sites. (See Chapter 7 for the basis for radiological and hazardous material protection limits.) WIPP normal operations do not entail any planned or expected releases of airborne radioactive materials which may present an internal occupational radiological hazard to workers, or present a hazard from the airborne pathway to the off-site public.

The institutional programs provide an inclusive strategy to support the safe operation of the facility through implementation of programs and procedures. These programs and procedures fulfill the objectives of radiological protection, project management system, safety management policies and programs, procedures and training, initial testing, in service equipment monitoring, maintenance, operational safety, quality assurance, emergency preparedness, and decontamination/decommissioning.

1.3.2 Safety Analysis Conclusions and Assessment of the CH Design Basis

1.3.2.1 Safety Analysis Overview

Safety analysis was performed for the WIPP to ensure that: 1) potential hazards are systematically identified, 2) unique and representative hazards that may develop into accidents are evaluated, 3) applicable reasonable measures to eliminate, control, or mitigate the accidents are taken, and 4) safety (safety-class or safety-significant) SSCs and accident specific TSRs, based on comparison of accident consequences to the MEI and noninvolved worker to the off-site and on-site risk evaluation guidelines respectively, are identified.

The predicted waste (radioactive/chemical content) to be received in 55-gallon (208 L) drums and SWBs at the WIPP was conservatively estimated based on data[19] from the generating sites, process knowledge, and limiting criteria provided in the WAC.[11] These estimates provided bounding container inventories used in the determination of potential consequences from postulated accidents.

Hazards associated with the facility processes were evaluated through a systematic hazard analysis process. The analysis encompassed the waste receipt, handling and disposal of CH TRU waste in the WIPP. The hazards analysis involved a multi-step process which included: 1) identification of the potential hazards associated with the CH TRU waste handling process, 2) characterization of the waste expected at the WIPP, and 3) a hazard evaluation in the form of a HAZOP[13] for the CH TRU waste handling process. This multi-step process provided a comprehensive examination of the potential hazards which may require quantitative evaluation in the accident analysis.

The major hazard associated with the CH TRU waste handling process is associated with the radiological and nonradiological hazardous materials within the waste containers. Hazards associated with mining operations are considered standard industrial hazards governed by Occupational Safety and Health Administration (OSHA) and Mine Safety and Health Administration (MSHA) regulations and are considered only when they may be an initiating event leading to the accidental release of radiological or nonradiological hazardous materials. Waste handling operations at the WIPP do not involve high temperature and pressure systems, electromagnetic fields or the use of toxic material in large quantities outside of the waste containers. Therefore, for the purposes of establishing an inventory of radiological and nonradiological material, only that material contained in the waste containers was considered, with the dispersive forces being mechanical damage to the containers, or chemical reaction within the containers.

The hazard analysis process identified potential accident scenarios in the categories of: 1) operational accidents (caused by initiators internal to the facility), 2) natural phenomena events (e.g., earthquakes, tornadoes), and 3) external events (caused by man made initiators external to the facility). These potential accident scenarios were then qualitatively ranked in terms of consequence to the public and relative probability to determine unique and representative accidents for further quantitative analysis see Table 1.3-3.

Review of the WIPP Land Management Plan[24] indicates that public access to the WIPP 16-section area up to the exclusive use area shown in Figure 5.2-1 is allowed for grazing purposes, and up to the DOE off limits area" for recreational purposes. In accordance with DOE Order 6430.1A,[20] Section 1300-3.2, the location of the MEI is located at the "closest point of public access," or the DOE “exclusive use area. "The location of the MEI is also consistent with guidance for the implementation of 40 CFR 191,[26] Subpart A. Calculations are also performed in Appendix E for a member of the public at the site boundary for reference purposes.

Although prevailing winds are towards the northwest at the WIPP Site, the closest distance to the exclusive use area (without regard to direction) from the exhaust shaft vent and the WHB vent was used in the dose assessment calculations. The closest distance to the exclusive use area boundary from the exhaust shaft vent lies south at approximately 935 ft (285 meters) and the closest distance to the exclusive use area boundary from the WHB lies southeast at approximately 1150 ft (350 meters) (Figure 5.2-2).

The noninvolved worker is assumed to be a worker not directly involved with the waste handling operation for which the accident is postulated. The maximally exposed noninvolved worker is assumed to be located at a distance of 328 ft (100 meters) from each release point due to the restrictions on dispersion modeling used in this safety analysis, at close-in distances.

A summary of the noninvolved worker and MEI radiological and toxicological consequences of analyzed accidents and comparison to risk evaluation guidelines is presented in Tables 1.3-4, 5, 6, and 1.3-7. Off-site risk evaluation guidelines based on ANSI/ANS-51.1[25] are adopted by the WIPP to compare accidental releases from postulated events to the MEI based on estimated frequency of occurrence. Noninvolved worker dose consequences are compared to on-site risk evaluation guidelines developed from available supporting DOE and ANSI guidance. DOE-CAO adopts the same conceptual approach used for the on-site risk evaluation guidelines as for the off-site (public) dose.

However, on-site risk evaluation guidelines are greater than those for the public as DOE-CAO accepts the basic premise that entry onto the site implies acceptance of a higher degree of risk than that associated with the off-site public. This assumption is not considered remiss with regards to safety assurance because the on-site risk evaluation guidelines do not result in any acute health effects noticeable to exposed individuals at frequencies greater than 1.0E-4 event per year and would not result in any acute life-threatening effects.

The methodology for verifying the annual occurrence frequencies, qualitatively estimated in the HAZOP, of operational initiating events is based on the evaluation of process inherent events (spontaneous ignition), equipment failures, and human error. Appendix D contains the detailed assessment of occurrence frequencies of the accidents evaluated in this section. The occurrence frequencies for process events are estimated based on existing references and engineering judgement. The occurrence frequencies for equipment failures and human errors are based on information from other DOE sites with similar operations, and from generic industry data bases when available, applicable, and appropriate.

Equipment failure rates and human error probabilities were combined with WIPP specific operational data to obtain WIPP specific initiating event occurrence frequencies. A detailed event tree/fault tree analysis for each postulated accident is included in Appendix D. The event trees include the analysis of failure of associated preventative and mitigative systems and develops the annual occurrence frequency for both mitigated and unmitigated accident sequences. The annual occurrence frequencies derived from the event tree/fault tree analysis are not intended to represent detailed probabilistic calculations requiring sensitivity or uncertainty analysis. The annual occurrence frequencies derived from the event tree/fault tree analysis are used to provide reasonable assurance that an accident frequency is in a specific qualitative frequency range (i.e. extremely unlikely) or " bin " for the purposes of selecting an appropriate risk evaluation consequence guideline.

For the purposes of establishing safety (safety-class or safety-significant) preventative and mitigative SSCs, an iterative process is performed. The safety (safety-class or safety-significant) iterative process (see Section 3.1.3) initially involves comparing the "unmitigated" accident consequences to the MEI and noninvolved worker (with associated "unmitigated" accident frequency from the event tree analyses in Appendix D) to the off-site and on-site risk evaluation guidelines respectively. The process is continued taking credit for additional preventative/mitigative SSCs until the risk evaluation guidelines are met. Systems required to keep estimated consequences below the risk evaluation guidelines are designated as safety (safety-class or safety-significant) SSCs.

The assessment of the immediate worker accident consequences is based on the evaluation of operational waste handling scenarios (waste container breaches), whose frequency is greater than 1E-06/yr, that may be initiated by waste handling equipment failure or directly through human error by a worker performing a waste handling operation. The immediate worker is that individual directly involved with the waste handling operation for which the accident is postulated. Although procedures dictate that workers exit the area immediately, such accidents present an immediate risk due to the inhalation of airborne radionuclides to the worker performing the waste handling operation. As discussed in Sections 5.1.2.1.2 and 5.1.7, the assessment of immediate worker consequences provides quantitative information in evaluating the adequacy of the WIPP defense-in-depth features (identified in the qualitative HAZOP) in keeping worker dose from accidents as low as reasonably achievable. No current risk evaluation guidelines exist for the assessment of accident consequences to immediate workers. Therefore, in the absence of guidelines, and for conservatism, the on-site radiological guidelines were used as a reference point for the assessment of consequences to immediate workers and the evaluation of the adequacy of the WIPP defense-in-depth features.

1.3.2.2 Safety Analysis Conclusions

1.3.2.2.1 Hazards Analysis Results

The HAZOP Team concluded that:

- Safeguards currently exist at the WIPP to prevent or reduce the frequency of such deviations from occurring. Identified safeguards include facility and equipment design, procedures, training, preventative maintenance and inspection, and administrative controls including the WIPP WAC (see Table 1.3-3, and Appendix C).

- Mitigation exists to reduce the consequences of any postulated deviation to acceptable levels. Identified mitigation includes confinement/ventilation systems and associated HEPA filtration systems (see Table 1.3-3, and Appendix C).

As qualitatively concluded from this HAZOP, the design of the WIPP CH TRU Waste Handling System is sufficient to ensure the safety of the public, workers and the environment. The HAZOP Team identified no substantial recommendations for the WIPP management to consider to reduce the severity or frequency of any of the postulated deviations.

Based on the results of the HAZOP (Table 1.3-3), operational events are binned into two major accident categories (fire and breach of waste container). Since breach of waste containers may occur due to drop or vehicle impact, accidents involving both of these breach mechanisms are evaluated. Accidents involving waste container drops are further evaluated based on the energy involved due to drop height. Due to the differences in release and dispersion mechanisms possible, accidents of each category are evaluated in the above ground and underground areas of the facility. Operational, Natural and External initiating events that require further evaluation as determined by the hazard analysis are listed below:

1. Operational Events

   Fires

   - CH1 Spontaneous Ignition (Drum) in the WHB
   - CH7 Spontaneous Ignition (Drum) in the Underground

   Waste Container Breaches

   - CH2 Crane Failure in the WHB
   - CH3 Puncture of Waste Containers by Forklift in the WHB
   - CH4 Drop of Waste Containers by Forklift in the WHB
   - CH5 Waste Hoist Failure
   - CH9 Drop of Waste Containers by Forklift in the Underground
   - CH11 Underground Roof Fall

2. Natural Events

   - CH6 Seismic Event
   - CH10 Tornado Event

3. External Events

   - CH8 Aircraft Crash

The WIPP is classified as a Hazard Category 2 facility based on bounding estimates of a single waste container inventory of radiological material. The safety analysis utilized this category as a preliminary indication of the level of detail that should be contained in the SAR. In addition to the category, the level of detail was also determined by the level of complexity and potential hazards which may exist during operation of the facility.

1.3.2.2.2 Accident Analysis Frequency Results

As shown in Section 5.2.3, the quantitative frequency analysis for each accident produced the following grouping of accidents:

Unlikely Range (10^{-2}/year > frequency > 10^{-4}/year)

CH2, Crane Failure in the Waste Handling Building (WHB)

CH3, Puncture of Waste Containers in the Waste Handling Building

CH4, Drum Drop in WHB

CH9, Drum Drop in the Underground

Extremely Unlikely Range (10^{-4}/year > frequency > 10^{-6}/year)

CH7, Spontaneous Ignition in the Underground (For the population of drums < 8 PE-Ci)

Beyond Extremely Unlikely Range (10^{-6}/year > frequency)

CH1, Spontaneous Ignition in The Waste Handling Building

CH5, Waste Hoist Failure

CH7, Spontaneous Ignition in the Underground (For population of drums > 8 PE-Ci/drum)

CH11, Roof Fall

For all accidents, the quantitative frequency analysis has verified that the qualitative frequency ranges assigned for these scenarios in the Hazard and Operability Study (HAZOP) were either correctly or conservatively assigned. The unmitigated release frequency is as derived from the event tree (Appendix D) for the associated scenario, and includes: (a) the likelihood of the initiating event, and (b) the conditional likelihood of waste container damage/failure as derived from test data.

Additional quantitative frequency analyses in the form of event/fault tree analyses were performed to identify SSCs, or processes that contribute most to the accident phenomena frequency for the purposes of verifying their adequacy or identifying improvements to reduce the accident frequency and therefore risk to immediate workers (as well as to the MEI and noninvolved worker). Specific accidents evaluated in this manner were: (1) CH1 and CH7, Spontaneous Ignition in the WHB and Underground, (2) CH2, Crane Failure in the WHB, (3) CH5, Waste Hoist Failure, and (4) CH11, Roof Fall in the Underground. With the exception of the Waste Handling Building 6-ton bridge crane (CH2) and spontaneous ignition in drums containing <8 PE-Ci/ drum in the underground (CH7), the event tree/fault tree analyses indicate that the unmitigated frequency of the identified accidents occurring are beyond extremely unlikely (frequency<1E-06/yr).

1.3.2.2.3 Accident Analysis Consequence Results

Based on the CH accident source term and release mechanism analyses presented in Section 5.2.3, for scenarios with a frequency greater than 1E-06/yr (CH2, CH3, CH4, and CH9), the calculated unmitigated accident consequences to the noninvolved worker, and MEI, were found to be well below the selected accident risk evaluation guidelines for the extremely unlikely range (See Tables 1.3-4, 1.3-5, 1.3-6, and 1.3-7). The worst-case consequences are obtained from CH3, with an estimated 3.8 rem (38 mSv) to the noninvolved worker (100 m [328 ft]) (4% of 100 rem [1 Sv] on-site guideline), and 440 mrem (4.4 mSv) to the MEI at the exclusive use area (2% of 25 rem [250 mSv] off-site guideline). It should be noted that: (1) **the MEI unmitigated consequences for scenarios with a frequency greater than 1E-06/yr (CH2, CH3, CH4, and CH9), are also well within the value of 500 mrem (5 mSv) temporary annual dose limit for normal operations derived from DOE Order 5400.5**, and (2) the noninvolved worker unmitigated consequences are within the 5 rem (50 mSv) annual dose limit for workers for normal operations. The unmitigated release frequency for the worst-case consequences is as derived from the event tree (Appendix D) for the associated scenario, and includes: (a) the likelihood of the initiating event, (b) the conditional likelihood of waste container damage/failure as derived from test data, and (c) the conditional likelihood of the worst-case CI from Table A-5 of Appendix A.

Additionally, the accident analysis evaluation of the unmitigated consequences at 100 m confirms the WIPP facility hazard categorization classification as a Hazard Category 2 facility. The calculated 100 m (noninvolved worker) consequences for CH2, CH3, and CH9 exceed the 1 rem criteria established in DOE-STD-1027-92 as the basis for the Category 2 threshold values.

The worst-case consequences to the immediate worker from CH3 are estimated to be 32 rem (320 mSv). No current risk evaluation guidelines exist for the assessment of accident consequences to immediate workers. Therefore, in the absence of guidelines, and for conservatism, the on-site radiological guidelines were used as a reference point for the assessment of consequences to immediate workers and the evaluation of the adequacy of the WIPP defense-in-depth features. The consequences to the immediate worker from CH3 are also well within the on-site risk evaluation guidelines. Therefore, no specific additional worker protection engineering or administrative controls (such as respiratory protection, more stringent maximum waste container inventory, or additional WAC controls such as immobilization), beyond those already qualitatively identified as providing defense-in-depth for the immediate worker, are needed based on the quantitative consequence assessment results.

For scenarios with a frequency less than 1E-06/yr (CH1, CH5, CH7, and CH11), the calculated unmitigated accident consequences to the noninvolved worker, and MEI were also found to be below the selected accident risk evaluation guidelines. The worst-case noninvolved worker and MEI consequences are obtained from CH5, with an estimated 60 rem (600 mSv) to the noninvolved worker (100 m [328 ft]) (60% of 100 rem [1 Sv] on-site guideline) and 9 rem (90 mSv) to the MEI at the exclusive use area (36% of 25 rem [250 mSv] off-site guideline). Risk evaluation guidelines are not identified for events with frequency < 1E-06/yr, however, the 25 rem (250 mSv) risk evaluation guideline for the extremely unlikely range (25 rem siting criteria in DOE Order 6430.1A) is used for evaluating the risk associated with these scenarios. It should be noted that the MEI (exclusive use area) unmitigated consequences for all accidents analyzed, regardless of frequency, were found to be well below 25 rem (250 mSv) risk evaluation guideline.

The worst-case calculated dose to an immediate worker is from CH5 with an estimated 500 rem (5 Sv). Although the immediate worker dose for CH5 exceeds the on-site risk evaluation guidelines for the extremely unlikely range, no specific additional worker protection engineering or administrative controls are identified. The risk associated with this potential exposure is deemed acceptable for the following reasons:

- The conservatism in the risk evaluation guidelines as discussed in Section 5.2.2, as well as the application of the on-site guidelines to the immediate worker,

- Consistent with Section 1.3.1 (9), Protection of Immediate Workers From Accidents, the very low frequency of this scenario is primarily due to the design changes and identification of administrative controls which significantly enhance the system safety and reliability. As identified in EEG-59,[28] the performance of preoperational tests are of paramount importance to system reliability (for the waste hoist, as well as other WIPP SSCs), and as such, is a primary element of the first layer of WIPP defense in depth. Section 8.3.4 discusses the elements of preoperational checks as required by the conduct of operations program, and a TSR AC is derived in Chapter 6 for inclusion in the WIPP Technical Safety Requirements,

- The conservatism inherent in all of the accident analysis source term variables used to estimate the above consequences,

- The existing elements for protection of the worker discussed in detail in Section 5.1.7.

1.3.2.2.4 Comparison to Standards of 40 CFR 61 and 40 CFR 191

As required by Working Agreement for Consultation and Cooperation,[1] signed by the U.S. DOE and the State of New Mexico, July 1981, this SAR will document DOE's ability to comply with the provisions of 40 CFR 191, Subpart A.[26] Paragraph 191.03(b) of 40 CFR 191 Subpart A specifies that the combined annual dose equivalent to any member of the public in the general environment resulting from the discharge of radioactive material and direct radiation from the management and storage of TRU waste shall not exceed 25 millirems (0.25 mSv) to the whole body and 75 millirems (0.75 mSv) to any critical organ. In addition, paragraph 61.92 of 40 CFR 61 Subpart H[27] specifies that emissions of radionuclides to the ambient air from DOE facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr (0.10 mSv/yr).

WIPP normal operations do not involve or entail any planned or expected releases of airborne radioactive materials to the workplace or the environment. Waste containers accepted for disposal at the WIPP are required to meet the 10 CFR 835 external contamination limits. To insure compliance, the containers are surveyed both prior to release from the generator sites and as the TRUPACT-II containers are opened at the WIPP. Since radioactive material remains in the waste containers unless an accident occurs, there will be no emissions of radionuclides to the ambient air during normal WIPP waste handling, and the public will not be subjected to direct radiation. Therefore, the public is expected to receive a negligible dose during normal operations. As a result of the above arguments, it may be concluded that the WIPP will be operated in compliance with the release standards of 40 CFR 191 Subpart A[55] and 40 CFR 61 Subpart H.[56] Effluent sampling will be conducted to demonstrate compliance with the annual release limits in those standards.

As shown in this SAR for WIPP, only accidents have the capability of producing a dose to the public. For accidents, 40 CFR 191, Subpart A does not require demonstration of compliance with the release standards. However, the following discussion provides a comparison of the calculated dose consequences to the release standards. As the provisions of 40 CFR 191 Part A guidance impose no restrictions on systems that may be considered in the evaluation of dose to the public, comparison of the WIPP accident analysis results to the standards in paragraph 191.03(b) include the availability and effectiveness mitigation systems that are expected to be in operation should an accident occur. As shown in the accident analysis, these systems are not required in order to meet the safety criteria established by DOE Orders. However, the plant design and operating procedures do provide them for defense in depth and additional assurance that releases that might result from accidents will be as low as reasonably achievable. As shown in Appendix E, based on a decontamination factor of 1E-06 provided by the waste handling building and underground HEPA filtration systems, **the worst-case mitigated accident doses to the maximally exposed individual for all accidents analyzed, regardless of occurrence frequency, will be much less than the annual release limits imposed by 40 CFR 191 Subpart A and 40 CFR 61, Subpart H.**

1.3.2.2.5 Evaluation of the Design Basis

The accident analyses indicate that safety (safety-class or safety-significant) SSCs are not required for the WIPP to mitigate any MEI or noninvolved worker accident radiological and nonradiological consequence to below risk evaluation guideline levels.

Secondary confinement is required to remain functional (following DBAs) to the extent that the guidelines in DOE Order O 420.1,[18] Section 4.1.1.2, Design Requirements, are not violated. The risk evaluation guidelines developed in this safety analysis report were used in the absence of definitive criteria in DOE Order 6430.1A[20] and DOE safety analysis orders or guidance documents for evaluation of secondary confinement. As stated above, the MEI (exclusive use area) and noninvolved worker unmitigated consequences were found to be well below the selected risk evaluation guidelines, including accidents whose frequency is $<$1E-06/yr, and as such, secondary confinement is not required. However, existing Design Class II and IIIA secondary confinement SSCs, while not required to mitigate the consequences of an accident from exceeding the risk evaluation guidelines, support the second layer of the WIPP defense-in-depth philosophy. A TSR AC is derived in Chapter 6 to ensure that these secondary confinement defense-in-depth SSCs are operating as required for each WIPP mode of operation as specified in Table 6-2.

As discussed in the accident scenarios in Section 5.2.3, there is no credible physical mechanism by which the **operational** accidents analyzed in the WHB or the underground will also disable the respective ventilation or HEPA filtration systems. No releases are postulated requiring ventilation or HEPA filtration for the DBE and DBT scenarios. If waste container breach occurs in the WHB during a credible operational accident (CH2, CH3, CH4), the release to the outside environment is mitigated by the permanently installed continuously on-line two-stage HEPA filter. For credible accident scenarios in the underground (CH9), shift of the underground ventilation system may occur manually (it is assumed that the CMR operator will be notified or be aware of the accident and actuate the shift to filtration), or automatically.

With regard to DBE and DBT scenarios, no release scenarios are expected to be initiated during the DBE or DBT, primarily due to the DBE/DBT design of the WHB structure including tornado doors and specific waste handling equipment such as the WHB 6-ton bridge crane and waste hoist. As such, the WHB ventilation and filtration systems are not required to mitigate the consequences of the DBE or DBT scenarios.

Based on criteria in Chapter 3, Section 3.1.3.2, the factors that lead to designation of a component as Safety Significant are:

- SSCs whose preventive or mitigative function is necessary to keep hazardous material exposure to the noninvolved worker below on-site risk evaluation guidelines,

- SSCs that prevent acute worker fatality or serious injury from hazardous material release that is outside the protection of standard industrial practice, OSHA regulation, or mine safety regulation (MSHA) (e.g. potentially explosive waste containers).

As concluded from the WIPP SAR Section 5.2, Accident Analysis, none of the analyzed scenarios (note: all scenarios are analyzed without regard for occurrence frequency) resulted in noninvolved worker consequences exceeding the on-site risk evaluation guidelines. Therefore, there are no SSCs that are considered Safety Significant due to the need to prevent or mitigate noninvolved worker consequence.

The HAZOP identified two potential scenarios related to WIPP waste handling operations, that could result in worker fatality: (1) potentially explosive waste containers, and (2) waste hoist failure while transporting personnel. With regard to explosive waste containers, SAR Section 5.2.3.1 evaluates such scenarios as beyond extremely unlikely. These events are effectively controlled through rigorous application of the preventive function provided by the WAC administrative control, and as such, preventive or mitigative SSCs are not evaluated or required.

With regard to the waste hoist failure scenario, the consequences involving waste hoist failure while transporting waste containers were evaluated in SAR Chapter 5. Based on the analysis, Safety SSCs are not applicable for that scenario. Personnel **and** waste containers will not be transported simultaneously. Failure of the waste hoist while transporting personnel does not constitute a process related accident involving radioactive materials and as such is considered a standard industrial hazard associated with standard mining operations. Hoisting operations are required to comply with the requirements of 30 CFR 57 and the New Mexico Safety Code for all Mines. As such, Safety Significant SSCs are not designated for failure of the waste hoist while transporting personnel.

Specific SSCs that fulfill a defense-in-depth safety function are: (1) the waste handling equipment such as the WHB 6-ton TRUDOCK bridge crane, adjustable center of gravity lift fixture (ACGLF), electric forklifts, facility pallets (including tie-downs and stretch wrap), waste-hoist, underground transporter, the Loron/BRUDI attachments, and (2) WIPP confinement SSCs including waste containers, Waste Handling Building (WHB) and underground structure, and WHB and underground HVAC and filtration systems. With regard to waste handling equipment, in each instance their reliability and functionality are important to the prevention of damage to the waste containers (first layer of defense in depth). As such, their designation as defense-in-depth SSCs ensures that they are designed, maintained, and operated to prevent failure resulting in an accident. WIPP confinement SSCs (WHB and underground HVAC and filtration systems, and WHB and underground structure) support the second layer of defense in depth. All other WIPP SSCs are considered as balance of plant.

Table 1.3-8 provides a summary of: (1) the preventive and mitigative defense-in-depth safety functions for each accident analyzed quantitatively in Chapter 5 of the SAR, and (2) the safety features that fulfill those safety functions, and whether they are fulfilled by preventive and mitigative SSCs or administrative controls.

DOE-STD-3009-94, requires that for Safety (Safety Class or Safety Significant) SSCs, a SAR define the SSC safety function and functional requirements, performance requirements (system evaluation), and controls (TSRs). Since Safety SSCs are not defined for WIPP, these requirements are not applicable to the WIPP SAR.

Specific WIPP SSCs are classified as Defense-in-Depth SSCs, based on the above functional classification results. Rather than the WIPP SAR specify functional requirements and performance criteria for those defense-in-depth SSCs, the applicable System Design Descriptions (SDDs) describe their intended safety functions, and specify the requirements for design, operation, maintenance, testing, and calibration.

As discussed in detail in SAR Chapter 6, based on application of the criteria in DOE Order 5480.22 for the selection of safety and operational limits, and the fact that Safety Class and Safety Significant SSCs are not selected for WIPP, TSR Safety Limits (SLs), Limiting Conditions for Operation (LCOs), and Surveillance Requirements are not required. TSR ACs assigned for features discussed above that play a role in supporting the WIPP defense-in-depth approach are derived in SAR Chapter 6. Table 6-1 provides a summary of defense-in-depth safety features, applicable TSR controls, and implementing WIPP documents.

Based on the fact that TSR Operational Limits and Surveillance Requirements are not defined for WIPP, operability definitions for Defense-in-Depth SSCs are not required in the SAR. SSCs are required in the TSR to be operated as required during each facility mode as described in Table 6-2, to support the overall WIPP defense-in-depth strategy.

It is therefore concluded from the hazards and accident analyses in this SAR that the design basis of the WIPP CH TRU waste handling system is adequate in response to postulated range of CH TRU normal operations and accident conditions for the facility.

1.3.2.2.6 Evaluation of Human Factors

A systematic inquiry of the importance to safety of reliable, correct, and effective human-machine interactions, considering the mission of the WIPP facility and the physical nature of the radioactive wastes that it will receive was conducted. The specific human errors that can contribute to accidental releases of hazardous materials were evaluated as an integral part of each hypothesized accident. Based on the analysis of those accidents and the discussion below, it can be concluded that the WIPP waste acceptance criteria for transuranic wastes, facility design, and operational controls provide high confidence that all potential releases can be contained with passive safety features that eliminate the need for human actions requiring sophisticated human-machine interfaces.

To provide additional support for the conclusion that no detailed human factor evaluation of human-machine interfaces is required, a scoping assessment of the effectiveness of the human-machine interfaces that support important design functions of the Table 4.1-1 Design Class II and IIIA systems was performed. It can be seen that most of the Design Class II and IIIA WIPP systems and equipment do not require human actions to initiate or sustain their function relative to the release of radiological or nonradiological waste materials. In most cases these functions are accomplished with automatic passive mechanisms designed to provide containment for the waste materials.

Functions allocated to automatic passive mechanisms or automatic active systems may be influenced by human error during maintenance. However, using the graded approach, human-machine interfaces for maintenance activities at WIPP are judged to be adequate because they are deliberate, and there is ample opportunity to discover errors and correct them with no adverse safety consequences.

The ability of the staff to accomplish their responsibilities in potential accident environments was evaluated. The limited magnitude of the hazard and the lack of dispersal driving forces provide very high confidence that the staffing and training presented in those sections will enable the staff to perform their responsibilities in potential accident environments.

The magnitude of hazardous materials that can be involved in an accident leading to a release is very limited. The radioactive material is delivered to the site in closed containers, and the waste handling operations are designed to maintain that integrity throughout the entire process required to safely emplace those containers in the site's underground waste disposal rooms. Inventory limits on individual containers ensure that heat generated by radioactive decay can be easily dissipated by passive mechanisms. Finally, only a limited number of waste containers have the possibility of being breached as a result of any one accident initiating event. As a result, the consequences of unmitigated releases from all accidents hypothesized in Chapter 5, including those initiated by human error, do not exceed the risk evaluation guidelines.

The facility has no complex system requirements to maintain an acceptable level of risk. The facility is designed to minimize the presence and impact of other energy sources that could provide the heat or driving force to disperse hazardous materials. **When something unusual happens during normal operations, such as support systems becoming unavailable, waste handling can be simply stopped and personnel evacuated until an acceptable operating condition is reestablished.**

Should an initiating event occur that breaches the waste containers, the plant design permits the immediate cessation of activity and isolation of the area where the breach occurs. Once isolation is achieved, there is no driving force within the waste or waste handling area that could result in a release of the waste material. Consequently, sufficient time is available to thoroughly plan and prepare for the remediation process prior to initiating decontamination and recovery actions.

Human factors considered in this SAR are limited to that time necessary to properly emplace the transuranic waste designated for disposal at WIPP. The operations will be straightforward, proceduralized, and consistent. Moreover, they will continue for only the period of time needed to complete the disposal process. Once a panel is filled and closed off, the natural properties of the salt and the location of the mine combine to provide passive isolation of the waste from the environment. The potential for human intrusion after the facility closure is beyond the scope of the human factors evaluation considered here.

1.3.2.2.7 Defense in Depth

In spite of the foregoing favorable safety characteristics of the WIPP, a defense-in-depth safety philosophy is employed in establishing the safety commitments and objectives of the WIPP.

The WIPP defense-in-depth safety approach provides layers of defense against release of radiological and nonradiological hazardous materials to the environment. The WIPP approach provides three layers of defense against releases. Each successive layer provides an additional measure of the combined defense strategy. These layers are defined as follows:

1) The ultimate safety objective of the first, or primary layer of WIPP defense in depth is **accident prevention**. The reduction of risk (as the product of frequency and consequence) to both workers and the public from WIPP CH TRU waste handling and emplacement operations is primarily achieved by reducing the frequency of occurrence of postulated abnormal events or accidents. The conservative design of the facility's SSCs, with operations conducted by trained/qualified personnel to the standards set forth in approved procedures, provides the first layer.

   The occurrence frequency for each postulated deviation as identified in the HAZOP, and in Table 1.3-3 for each deviation considered for quantitative accident analysis is primarily derived from process inherent events, equipment failure and human error. To reduce the frequency of equipment failure, the facility design, fabrication, and construction were undertaken in accordance with applicable codes and standards, based on the design classification of SSCs established in Chapter 4. Extensive pre-operational tests were conducted to verify SSCs perform their design function. This is followed up presently by in-service and pre-operational checks and inspections, and preventive maintenance and quality assurance programs. The WIPP employs configuration management change control and modification retest to ensure quality throughout facility life. For hazards associated with underground operations, a substantial array of ground control planning and practices, support systems, instrumentation, monitoring, and evaluation exist to reduce the frequency of potential underground accidents. Technical Safety Requirement (TSR) Administrative Controls (ACs) are assigned in Chapter 6 and required in the WIPP TSR Document (Attachment 1 to the SAR) to ensure that the high level of design is maintained throughout the facility lifetime.

Additionally, as identified in the HAZOP, accident prevention for process inherent events such as spontaneous ignition, is achieved administratively through the WAC (as discussed in detail in Section 5.1.2.2) which restricts waste elements (such as the presence of pyrophorics) which may be initiating events for accidents. In addition, the following provide administrative controls to prevent the risk from postulated accidents from being unacceptable: (1) WAC limits on the radionuclide and fissile content of each waste container, (2) waste container integrity provisions ensure the robustness reflected in the waste container accident release analyses, and (3) criticality safety is a designed in-storage and handling configuration that ensures (in conjunction with waste characteristics) that active criticality control is not required.

Prevention of human error as an initiating event is achieved by the extensive training and qualification programs, operational procedures, and conduct of operations programs. TSR ACs are derived in Chapter 6 and required in the WIPP TSR Document (Attachment 1 to the SAR) to ensure that these programs are maintained, and operations continue to be conducted with highly qualified and trained personnel using current approved procedures.

2) The second layer of defense in depth provides protection against anticipated and unlikely operational events that might occur in spite of the protection afforded by the first layer of defense. The second defense layer is characterized by detection and protection systems, and controls that: (1) indicate component, system, or process performance degradation created by compromises of the first layer, and (2) provide adequate mitigation and accommodation of the consequences of those operational accidents which may occur.

   Specific mitigative features are identified in Appendix C for each postulated deviation as identified in the HAZOP, and in Table 1.3-3 for each deviation considered for quantitative accident analysis. In general, the WHB and underground radiation monitoring systems and HEPA filtration systems, and the WIPP emergency management program provide this layer of defense in depth. In addition, the WIPP Human Factors Evaluation, determined that well established policies and procedures are in place ensuring normal and emergency procedures are implemented, adequate directions have been provided to shift personnel concerning actions to be taken in a potential accident environment, and adequate procedures are available for follow up response. TSR ACs are assigned in Chapter 6 and required in the WIPP TSR Document (Attachment 1 to the SAR) supporting the second level of defense in depth. Programs supporting defense in depth as required by the TSRs, are discussed in detail in Chapters 7, 8, and 9.

3) The third layer of defense in depth supplements the first two layers by providing protection against extremely unlikely operational, natural phenomenon, and external events. These events represent extreme cases of failures and are analyzed in Chapter 5 using conservative assumptions and calculations to assess the radiological and nonradiological effects of such accidents on the public to verify that a conservative design bases have been established. These accidents include sustained waste container internal fire, waste hoist failure, and roof fall in the underground.

TSR ACs assigned for features discussed above that are of major significance to the WIPP defense-in-depth approach are derived in Chapter 6.

1.3.2.3 Analysis of Beyond the Design Basis

1.3.2.3.1 Operational Events

An evaluation of operational accidents "beyond "the derivative design basis accident (BDBA) is conducted to provide perspective of the residual risk associated with the operation of the facility. As discussed in DOE-STD-3009-94, beyond DBAs are simply those accidents with more severe conditions or equipment failure. The operational scenarios analyzed in this section as "beyond the design basis" take into consideration the effect of the WIPP Waste Acceptance Criteria Pu-239 Equivalent Activity, and Thermal Power Criteria on the assumed accident scenario material at risk (MAR) and accident consequences of the most credible accident sequences. Based on the analyses in Section 5.2.3, the operational accident scenarios involving potential consequences to the noninvolved worker, MEI, and immediate worker, whose frequency is greater than 1E-06/yr are: (1) CH2, Crane Failure in the Waste Handling Building (WHB), (2) CH3, Puncture of Waste Containers in the Waste Handling Building, (3) CH4, Drum Drop in WHB, and (4) CH9, Drum Drop in the Underground.

The source term MAR developed in Section 5.2.3 is based on the waste container inventory derived in Section 5.1.2.1.2. The analyses assumed that based on the data in Appendix A, that: (1) one waste container contains a maximum radionuclide inventory, and (2) the remaining waste containers contain an average radionuclide inventory of 8 PE-Ci (Table A-1 lowest bin upper cutoff). The 8 PE-Ci average bounds 86 percent of the volume for all waste forms, including the predominant heterogeneous, uncategorized metal, and combustible waste forms, and bounds over 96 percent of the volume of uncategorized metals, chosen in Section 5.2.1.1 as the waste form for waste container breach/impact analyses. For accident scenarios which involve single waste containers, it was conservatively assumed that the waste container contains a maximum radionuclide inventory.

As discussed in Section 5.1.2.1.2, the WIPP WAC Thermal Power TRUPACT-II requirements, limit the decay heat from all CH-TRU waste to 40 watts per TRUPACT-II. Using the Pu-238 "heat source" distribution in Table A-4 of Appendix A, calculations indicate that the maximum total PE-Ci for a shipment of Pu-238 waste is approximately 1,117 PE-Ci. The analyses of beyond the design basis considers the effect, and thus the residual risk, on the accident consequences evaluated for CH2, CH3, CH4, and CH9 of a hypothetical TRUPACT-II shipment of **untreated** (not solidified or vitrified) Pu-238 waste with each drum at 80 PE-Ci. Receipt of fourteen drums each at 80 PE-Ci is plausible, considering the above thermal wattage limit PE-Ci equivalent of 1,117 PE-Ci (14 drums x 80 PE-Ci approximately equals 1,117 PE-Ci). However, based on the data presented in Table A-5 of Appendix A, as a result of the conditional likelihood of receiving such a shipment, the on-site and off-site risk evaluation guidelines for the extremely unlikely range are used for the consequence evaluation.

As shown in Appendix E Tables E-13, E-14, E-23, E-24, E-29, E-30, E-43, and E-44, the analysis of CH2, CH3, CH4, and CH9 with each damaged drum at 80 PE-Ci, indicates that the highest immediate worker consequences are obtained from CH3 and CH9. The radiological consequences of CH3 are discussed here assuming that each drum involved in the scenario is at 80 PE-Ci. The same assumptions regarding waste form combustible and noncombustible composition, damage ratio, airborne release fraction, and respirable fraction are assumed. Substitution of these values into the consequence calculations for CH3, indicate doses of approximately 12 rem (120 mSv) to the noninvolved worker (12% of the 100 rem (1 Sv) on-site risk evaluation guideline for the extremely unlikely range), and 1.4 rem (14 mSv) (6% of 25 rem (250 mSv) off-site risk evaluation guideline for the extremely unlikely range) to the MEI. The noninvolved worker and MEI doses therefore remain well within the risk evaluation guidelines. The estimated dose to an immediate worker for the CH3 beyond design basis scenario approaches (70 rem [700 mSv]), but does not exceed the on-site risk evaluation guideline of 100 rem (1.0 Sv) for the extremely unlikely range (Table E-62).

Thus, no significant risk is incurred to the immediate worker, noninvolved worker, or MEI considering the beyond design basis most credible operational accident scenarios above involving a maximally loaded TRUPACT-II shipment of untreated Pu-238 heat source waste, with each drum at 80 PE-Ci.

1.3.2.3.2 Natural Phenomenon

As discussed in Section 3.4.3 of DOE-STD-3009, natural phenomenon beyond design basis accidents are defined by a frequency of occurrence less than that assumed for the DBA. Since the DBT is defined with a 10^6 yr return period, and the DBE as a 10^3 yr return period, the most credible beyond DBA natural phenomenon event is an earthquake with a vertical ground acceleration of greater than 0.1 g (considered extremely unlikely).

For the evaluation of beyond the design basis earthquake, DBE SSCs: (1) the WHB structure, and (2) WHB 6-ton bridge crane, are assumed to fail resulting in a release of radioactive material. It is assumed that the bridge crane fails while removing a load from a TRUPACT II (CH2). The WHB structure is also assumed to fail resulting in some damage to the seven facility pallets (196 drums or 28 SWBs) of waste that may be stored in the CH Bay for a period of up to 5 days awaiting transfer to the underground. It is conservatively assumed that one-half of the drums in storage are breached by the falling WHB structure debris, with an DR equivalent to that from the heights associated with drops from the third layer of the waste stack (DR=0.025). This equivalent to 14 times the consequences of the CH2 accident (0.31 rem [3.1 mSv]) or 4.3 rem (43 mSv) to the MEI.

Combining this with the MEI consequences of CH2 (0.3 rem [3 mSv]), the total MEI (exclusive use area) consequence from the postulated beyond DBE is 4.6 rem (460 mSv) (20% of 25 rem [250 mSv] off-site risk evaluation guideline for the extremely unlikely range). The combined consequences to the noninvolved worker are 41 rem (410 mSv) (41% of the 100 rem [1.0 Sv] on-site guideline). Therefore, the radiological risk associated with a greater than 0.1 g earthquake is considered acceptable.

1.3.2.4 Assessment of WIPP Waste Acceptance Criteria (WAC)

1.3.2.4.1 WAC Pu-239 Equivalent Activity Operations and Safety Requirement

Based on the beyond design basis accident analysis results in Section 5.2.4.2 (using conservative assumptions, and in conjunction with elimination of the WAC Revision 4.0,[29] Immobilization Criteria), the estimated radiological consequences for CH3, Puncture in the Waste Handling Building, to the immediate worker, approach the on-site accident risk evaluation guidelines. Therefore, the 80 PE-Ci for drums and 130 PE-Ci for SWBs derived in Section 5.1.2.1.2, are established as the WAC[11] Pu-239 Equivalent Activity Operations and Safety maximum allowable waste container radionuclide inventories for untreated CH TRU waste. The establishment of the 80 and 130 PE-Ci values, provides an defense-in-depth based approach to ensure that the estimated immediate worker accident consequences from untreated CH TRU waste remain acceptable.

Waste containers exceeding these values must be overpacked or treated (solidified, or vitrified) prior to acceptance at WIPP. Such a defense-in-depth approach, focuses on the prevention of potential higher dose consequences to the immediate worker from high PE-Ci untreated waste containers by reducing: (1) the conditional likelihood of waste container breach, and the damage ratio (DR) term of the source term equation (Equation 5-1) for overpacked containers (drums overpacked in SWBs or ten-drum overpacks), and (2) the combined airborne release fraction (ARF) and respirable fraction (RF) for solidified or vitrified waste containers. The CH1 and CH7 sustained internal waste container fire scenarios were evaluated in Section 5.2.3 to be beyond extremely unlikely. Therefore, for the evaluation of solidification, vitrification, and overpacking options, these scenarios are not evaluated.

The WIPP WAC Thermal Power TRUPACT-II requirements, limit the decay heat from all CH-TRU waste to 40 watts per TRUPACT-II. Using the Pu-238 "heat source" distribution in Table A-4 of Appendix A, calculations indicate that the maximum total PE-Ci for a TRUPACT-II shipment of Pu-238 waste is approximately 1,117 PE-Ci.

The acceptability of the WAC Pu-239 Equivalent Activity Operations and Safety maximum allowable waste container radionuclide inventory of 1,100 PE-Ci for overpacked and 1,800 PE-Ci for solidified/ vitrified waste, established in Section 5.1.2.1.2 is verified by evaluating the most credible worst-case accident scenarios involving the largest potential consequences for each scenario of interest to the noninvolved worker, MEI, and immediate worker.

However, the consequences of accident scenarios CH2 and CH3 are evaluated in Appendix E (Tables E-9, E-10, E-11, E-12, E-19, E-20, E-21, E-22, E-57, E-58, E-59, and E-60) assuming that the accidents involve highly loaded (1,100 PE-Ci) overpacked (untreated waste within a 55-gallon (208 L) drum overpacked within a SWB or TDOP), and (1,800 PE-Ci) solidified/vitrified waste containers. The consequences of CH2 and CH3 for solidified/vitrified waste, are discussed here due to the differences in breaching mechanisms, and the release fractions identified in Section 5.2.1.1. It is conservatively assumed that seven solidified waste containers are breached as a result of crane failure (CH2), and two are breached as a result of puncture (CH3), with one drum in each scenario at 1,800 PE-Ci. As discussed in Section 5.2.1.1, the damage ratio for CH2 scenario is conservatively assumed to be the same as for untreated waste (DR = 1E-02), and for CH3, DR = 0.01. The ARF x RF for solids that undergo brittle fracture (e.g. aggregate, glass) due to crush-impact forces is given by Equation 5-1 of DOE-HDBK-3010-94.[30] Applying this equation for solidified waste forms to the drop of waste container from heights equal to or less than 3 meters (5 ft $<$ h $<$ 10 ft), the calculated ARF x RF = 1.64E-05.

Comparing this factor with that obtained for contaminated noncombustible materials which are subjected to impact and breach of the waste container for solids that do not undergo brittle fracture (Section 5.2.1.1), solidification offers a two order magnitude reduction in respirable airborne radioactive material for the bounding scenarios analyzed in this SAR.

Substitution of these values into the consequence calculations for CH2 and CH3 (Tables E-9, E-11, E-19, E-21, E-57, and E-59), indicate worst-case consequences to the immediate worker for CH3, and are thus summarized here. The doses to the immediate worker (2.1 rem [21 mSv]), noninvolved worker (0.25 rem [2.5 mSv]), and MEI (0.03 rem [0.3 mSv]), are well within the risk evaluation guidelines (for the extremely unlikely range) despite the higher PE-Ci loading. Based on the data presented in Table A-5 of Appendix A, as a result of the conditional likelihood of receiving such a shipment, the risk evaluation guidelines for the extremely unlikely range are used for the consequence evaluation. Therefore, although a higher PE-Ci limit is allowed, the effects of vitrifying, or solidifying waste containers results in a significant reduction in the release of respirable airborne radioactivity and thus risk to the receptors of concern.

To determine the acceptability of overpacking a drum of untreated waste within a SWB or TDOP, the radiological consequences of CH2 and CH3 are again evaluated assuming that multiple drums are breached, one in each scenario at 1,100 PE-Ci (Tables E-10, E-12, E-20, E-22 E-58, and E-60). As discussed in Section 5.2.1.1, the DR for overpacked noncombustible solids (drum within a SWB or

TDOP) for drops less than 10 ft (3 m) is 2.5E-04, and the DR for punctures of heavy waste containers (overpacked noncombustible solids, drum within a SWB or TDOP) is 1E-02. CH3 therefore results in a worst-case source term and as such, the consequences of CH3 are analyzed here. The ARF and RF for noncombustible solids are 1E-03 and 1.0 respectively. Substitution of these values into the consequence calculations for CH3, indicate doses of approximately 9 rem (90 mSv) to the noninvolved worker, 1 rem (10 mSv) to the MEI, and 77 rem (770 mSv) to the immediate worker. The MEI, noninvolved worker, and immediate worker doses therefore remain well within the risk evaluation guidelines (for the extremely unlikely range). Based on the data presented in Table A-5 of Appendix A, as a result of the conditional likelihood of receiving such a shipment, the risk evaluation guidelines for the extremely unlikely range are used for the consequence evaluation.

The WAC Pu-239 Equivalent Activity Operations and Safety limits defined above, when analyzed in conjunction with conservative safety analysis assumptions, and existing stored waste information: (1) provides a reasonable degree of assurance that the safety envelop of the facility has been defined, and (2) ensures that the risk to immediate workers, noninvolved workers, and the MEI remain well within the risk evaluation guidelines.

1.3.2.4.2 WAC Revision 4.0 Immobilization Criteria

Section 3.3.1.6 of WAC Rev.4[29] stated that immobilization will minimize the quantity of radioactive material that is available for dispersion or inhalation in event of the failure of a waste package.

The types of accidents of SAR concern involve contaminated combustible and non-combustible material packaged in robust containers (drums and standard waste boxes), that are opened and/or fail due to drops and/or punctures. The release fractions for drops and/or punctures of drums used in the SAR analyses for the case of surface contamination on solid, noncombustible surfaces are obtained from DOE-HDBK-3010-94.[30] Section 5.1, page 5-4 of DOE-HDBK-3010-94 states, “the airborne release fractions and respirable fractions for these types of accidents are based on reasoned judgement that suspension under these circumstances will be bounded by suspension postulated for debris impacting powders in cans.”

Therefore, in conjunction with the use of conservative waste container radionuclide inventories and damage ratios for heterogeneous or uncategorized metals, conservatism is provided in the calculation of potential radiological consequences from untreated CH TRU waste to the MEI, noninvolved worker, and immediate worker. The estimated consequences were found to be within the on-site and off-site accident risk evaluation guidelines for all receptors of concern. As such, based on the accident consequence analysis in this SAR, no additional criteria are required to immobilize **untreated** (not solidified or vitrified) waste forms (up to a maximum allowable value of 80 PE-Ci for drums and 130 PE-Ci for SWBs) to minimize the quantity of radioactivity available for release.

Section 5.0 of DOE-HDBK-3010-94 discusses the difficulty in characterizing the size distribution of deposited radionuclide contamination. The handbook states that for surface contamination of combustible and noncombustible materials, it is not expected that defensible bases exist for assuming an original source respirable fraction, as the WAC Rev. 4 criteria required. Therefore, (1) since the use of 80 PE-Ci for a drum radionuclide inventory and the inherent conservatism in the derivation and use of the bounding release fractions produce acceptable dose consequences to the worker, noninvolved worker, and MEI, and (2) considering the difficulty in characterizing waste particle size distributions for the waste forms identified in the BIR, the elimination of the WAC immobilization criteria for “untreated waste” up to the values of 80 PE-Ci for drums and 130 PE-Ci for SWBs is warranted.

As discussed in the preceding discussion on maximum allowable waste container radionuclide inventories, however, waste containers exceeding these values will be overpacked, solidified, or vitrified (thus immobilized) as a defense-in-depth approach to limiting the consequences of potential accidents. Immobilization is therefore based on a more readily quantifiable variable (PE-Ci) (i.e., it is measurable and verifiable in all waste forms) than on the percentage of respirable particulates.

References for Section 1.3

1. Working Agreement for Consultation and Cooperation, signed by the U.S. DOE and the State of New Mexico, July 1981 and subsequent revisions.

2. U.S. Department of Energy, DOE Order 5481.1B, Safety Analysis and Review System, September 23, 1986.

3. U.S. Department of Energy, DOE-AL Order 5481.1B, Albuquerque Operations Office, Safety Analysis and Review System, January 1, 1988.

4. U.S. Department of Energy, DOE Order 5480.21, Unreviewed Safety Questions, December 21, 1991.

5. U.S. Department of Energy, DOE Order 5480.22, Technical Safety Requirements, February 25, 1992.

6. U.S. Department of Energy, DOE Order 5480.23, Nuclear Safety Analysis Reports, April 30, 1992.

7. U.S. Department of Energy, DOE Order 5480.24, Nuclear Criticality Safety, August 12, 1992.

8. U.S. Department of Energy, DOE-STD-3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports, July 1994.

9. U.S. Department of Energy, DOE-STD-1027-92, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, 1992.

10. Waste Isolation Pilot Plant General Plant System Design Description (GPDD), Rev. 2, April 1997.

11. WIPP-DOE-069, TRU Waste Acceptance Criteria for the Waste Isolation Pilot Plant, Rev.5, April 1996.

12. *Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant*, DOE/CAO-1996-2184, October 1996.

13. WCAP-14312, Hazard and Operability Study for CH TRU Waste Handling System, Waste Isolation Pilot Plant, Westinghouse Waste Isolation Division, April 1995.

14. DOE/EIS-0026, Final Environmental Impact Statement, Waste Isolation Pilot Plant, 2 Vols, U.S. Department of Energy, Carlsbad, N.M., 1980.

15. DOE/EIS-0026-FS, Final Supplement Environmental Impact Statement, Waste Isolation Pilot Plant, U.S. Department of Energy, Carlsbad, N.M., 1990.

16. DOE/WIPP 91-031, WIPP Fire Hazards and Risk Analysis, May 1991.

17. DOE-WID-96-2176, Revision 0, WIPP Fire Hazards Analysis Report, August, 1996.

18. DOE Order O 420.1 Chg. 2, Facility Safety, October 1996.

19. DOE/CAO95-1121, U.S. Department of Energy Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report (TWBIR), Revision 2, December 1995.

20. DOE Order 6430.1A, General Design Criteria, Division 13, Special Facilities, April 1989.

21. 29 CFR 1910-119, Process Safety Management of Highly Hazardous Chemicals.

22. 10 CFR 835, Occupational Radiation Protection.

23. WP 12-5, WIPP Radiation Safety Manual, March 1997.

24. DOE/WIPP 94-026, Waste Isolation Pilot Plant Land Management Implementation Plan, August 1994.

25. ANSI/ANS-51.1, American National Standards Institute, Standard Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants.

26. 40 CFR 191, Environmental Radiation Protection for Management and Disposal of Spent Nuclear Fuel, High-Lead and Transuranic Wastes, Subpart A, Environmental Standards for Management and Storage.

27. 40 CFR 61, National Emission Standards for Hazardous Air Pollutants, Subpart H, National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities.

28. EEG-59, An Analysis of the Annual Probability of Failure of the Waste Hoist Brake System at the Waste Isolation Pilot Plant, Environmental Evaluation Group, New Mexico, November, 1995.

29. WIPP-DOE-069, Rev. 4, TRU Waste Acceptance Criteria for the Waste Isolation Pilot Plant, December 1991.

30. DOE-HDBK-3010-94, Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities, December 1994.

Table 1.3-1, Consultation and Cooperation (WACC) Agreement/SAR Correlation 1 of 5

WACC Topic		SAR Section	
Chapter 1 - Introduction and General Description			
1.1	Location	1.1	Facility Background and Mission
1.2	Mission	1.1	Facility Background and Mission
1.3	Organization	1.4	Organizations
1.4	Facilities - both surface and underground	1.2.1	Facility Design
1.5	Operations - including retrieval	1.2.2	Retrieval operations deleted. Disposal-phase operations are discussed with no intent to retrieve.
1.6	Research and Development programs	Deleted - SAR only addresses disposal phase	
Chapter 2 - Site Characteristics			
2.1	Geography and Demography	2.1	Geography and Demography of the Area Around the WIPP Facility.
2.2	Nearby Industrial, Transportation and Military Facilities	2.2	Nearby Industrial, Transportation and Military Facilities
2.3	Meteorology	2.5	Meteorology
2.4	Surface Hydrology	Deleted per CAO direction.	
2.5	Subsurface Hydrology	Deleted per CAO direction.	
2.6	Regional Geology	Deleted per CAO direction.	
2.7	Site Geology	Deleted per CAO direction.	
2.8	Vibratory Ground Motion	2.8	Vibratory Ground Motion
2.9	Surface Faulting	Deleted per CAO direction.	
2.10	Stability of Subsurface Materials and Foundations	Deleted per CAO direction.	
2.11	Slope Stability	2.5.2.5	Topography

Table 1.3-1, Consultation and Cooperation (WACC) Agreement/SAR Correlation 2 of 5

WACC Topic		SAR Section	
Chapter 3 -	**Principal Design Criteria**		
3.1	Definition of Mission	1.1	Facility Background and Mission
	Waste Characterization	5.1.2	CH Waste Characterization
	Repository Functions	3.1	General Design Criteria
	Storage Capacities	3.1.1	TRU Waste Criteria
	Retrievability	Deleted	
	By-Products	3.1.2	Facility By-Products
3.2	Structural and Mechanical Design	3.2	Structural Design Criteria
3.3	Safety Protection Criteria		
	Confinement	3.3.1	Confinement Requirements
	Handling	3.1	General Design Criteria
	Emplacement	3.1	General Design Criteria
	Retrieval	Deleted	
	Fire	3.3.2	Fire Protection
	Explosion	3.3.2	Fire Protection
	Radiological	3.3.3	Radiological Protection
	Criticality	3.3.3.4	Nuclear Criticality Safety
	Mine Safety	3.3.4	Industrial and Mining Safety
3.4	Design Classification	3.1.3	Design Classification of Structures, Systems, and Components
3.5	Decommissioning	3.1.4	Decontamination and Decommissioning
	Decontamination	3.1.4	Decontamination and Decommissioning
	Backfilling	Deleted	
	Sealing	3.1.4	Decontamination and Decommissioning
	Record Maintenance	3.1.4	Decontamination and Decommissioning
	Site Markers	3.1.4	Decontamination and Decommissioning

Table 1.3-1, Consultation and Cooperation (WACC) Agreement/SAR Correlation 3 of 5

WACC Topic		SAR Section	
Chapter 4 -	**Plant Design**		
4.1	Location Details	4.1	Summary Description
4.2	Surface Facilities	4.2.1	Surface Facilities
	Waste Building Handling	4.2.1.1	Waste Handling Building
	Support Functions	4.2.1.2 4.2.1.3 4.2.1.4 4.2.1.5	Exhaust Filter Building Water Pumphouse Support Building Support Structures
4.3	Shafts and Subsurface Facilities	4.2.2 4.2.3	Shaft and Hoist Facilities Subsurface Facilities
	Shafts	4.2.2	Shaft and Hoist Facilities
	Storage	4.2.3	Subsurface Facilities
	Experimental Areas	4.2.3	Subsurface Facilities
4.4	Service and Utility systems	4.3 4.4 4.5 4.6 4.7	Process Description Confinement Systems Safety Support Systems Utility and Auxiliary Systems Radioactive Waste (Radwaste) and Hazardous Waste Management
	Ventilation	4.4.1 4.4.2	Confinement Ventilation Systems
	Electrical	4.6.1	Electrical System
	Fire Protection	4.5.1	Fire Protection System
	Waste Water	4.6.3 4.6.4 4.7	Domestic Water System Sewage Treatment System Radioactive Waste (Radwaste) and Hazardous Waste Management
	Salt Handling	4.3.5	Underground Mining Operations
	Radwaste	4.7	Radioactive Waste (Radwaste) and Hazardous Waste Management
	Transportation	2.2.7	Land Transportation
	Alarms	4.5.2	Plant Monitoring and Communications
	Maintenance	8.3.5	Maintenance Program

Table 1.3-1, Consultation and Cooperation (WACC) Agreement/SAR Correlation 4 of 5

WACC Topic		SAR Section	
	Compressed Air	4.6.2	Compressed Air
	Underground Fuel	4.2.3.1	General Design
4.5	Emplacement and Retrieval	4.3	Retrieval Deleted
4.6	Underground Excavation Equipment	Deleted -	Standard Industrial (MSHA) Hazard
Chapter 5 -	**Process Description**		
5.1	Contact-handled (CH) waste handling	4.3.1	CH TRU Waste Handling System
5.2	Remote-handled (RH) waste handling	4.3.2	RH TRU Waste Handling System
5.3	Experimental handling	Deleted - SAR only addresses disposal phase	
5.4	Plant Generated Radwaste	4.7	Radioactive Waste (Radwaste) and Hazardous Waste Management
5.5	General process		
	Instrumentation	4.5.2	Plant Monitoring and Communications
	Criticality Safety	5.1.4	Nuclear Criticality
	Waste Logging	4.3.4	WIPP Waste Information System
5.6	Underground excavation	4.3.5	Underground Mining Operations
5.7	Control room	4.5.2.1	Central Monitoring System
5.8	Analytical Sampling	7.1.4.2.1 7.2.4	Effluent Sampling/Monitoring and Environmental Monitoring Environmental Monitoring
5.9	Retrievability of All Waste Forms	Deleted	
Chapter 6 -	**Radiation Protection**		
6.1	As low as reasonably achievable (ALARA)	7.1.2 7.2.3.1	ALARA Policy and Program ALARA Policy
6.2	Radiation Sources	7.1.3.1.3.2	Direct Radiation Sources
6.3	Radiation protection	7.1.3	Radiological Exposure Control
6.4	On-site dose assessment	7.1.4.1 7.2.2.2	On-site Dose Assessment On-site Exposure Assessment
6.5	Radiological control program	7.1.1	Radiological Control Program and Organization
6.6	Off-site dose assessment	7.1.4.2 7.2.2.1	Off-site Dose Assessment Off-site Exposure Assessment

Table 1.3-1, Consultation and Cooperation (WACC) Agreement/SAR Correlation 5 of 5

WACC Topic		SAR Section	
Chapter 7 -	**Accident Analysis**		
7.1	Accident classifications	5.2	CH TRU Accident Analysis
7.2	Source terms and analytical methods	5.2	CH TRU Accident Analysis
7.3	Accident descriptions and actual analyses	5.2	CH TRU Accident Analysis
Chapter 8 -	**Long Term Waste Isolation Assessment**	5.5	Long-Term Waste Isolation Assessment
8.1	Identification of potential communication modes	5.5	Long-Term Waste Isolation Assessment
8.2	Modeling methods	5.5	Long-Term Waste Isolation Assessment
8.3	Consequence analyses	5.5	Long-Term Waste Isolation Assessment
Chapter 9 -	**Conduct of Operations**		
9.1	Organizational structure	8.1.3	Organizational Structure, Responsibilities, and Interfaces
9.2	Acceptance tests	8.3.3	Initial Test Program
9.3	Training	8.2.4	Training Program
9.4	Operating procedures	8.2.3	Procedures Program
9.5	Security		Deleted
9.6	Emergencies	8.5	Emergency Preparedness Program
Chapter 10 -	**Operating Limits and Controls**		
10.1	Design limits	Chapter 3	
10.2	Operating limits and surveillance requirements	6.4	Derivation of WIPP TSRs
10.3	Design features	Not Required by 5480.22	
10.4	Administrative controls	6.4.5	Administrative Controls
10.5	Guidelines for the operating organization	6.4.5	Administrative Controls
Chapter 11 - Quality Assurance		Chapter 9 - Quality Assurance	

Table 1.3-2, DOE Order 5480.23/SAR Correlation 1 of 1

DOE Order 5480.23 Topic	SAR Section
Chapter 1 - Executive Summary	Chapter 1 - Executive Summary
Chapter 2 - Applicable Statutes, Rules, and Departmental Orders	Chapter 1 - Executive Summary
Chapter 3 - Site Characteristics	Chapter 2 - Site Characteristics
Chapter 4 - Facility Description and Operation	Chapter 4 - Facility Design and Operation
Chapter 5 - Hazards Analysis and Classification of the Facility	Chapter 5 - Hazards and Accident Analysis
Chapter 6 - Principal Health and Safety Criteria	Chapter 3 - Principal Design and Safety Criteria
Chapter 7 - Radioactive and Hazardous Material Waste Management	Chapter 4 - Facility Design and Operation
Chapter 8 - Inadvertent Criticality Protection	Chapter 5 - Hazards and Accident Analysis
Chapter 9 - Radiation Protection	Chapter 7 - Radiological and Hazardous Material Protection
Chapter 10 - Hazardous Material Protection	Chapter 7 - Radiological and Hazardous Material Protection
Chapter 11 - Analysis of Normal, Abnormal, and Accident Conditions	Chapter 5 - Hazards and Accident Analysis
Chapter 12 - Management, Organization, Institutional Safety	Chapter 8 - Institutional Programs
Chapter 13 - Procedures and Training	Chapter 8 - Institutional Programs
Chapter 14 - Human factors	Chapter 4 - Facility Design and Operation
Chapter 15 - Initial Testing, In service Surveillance, Maintenance	Chapter 8 - Institutional Programs
Chapter 16 - Technical Safety Requirements	Chapter 6 - Derivation of Technical Safety Requirements
Chapter 17 - Operational Safety	Chapter 8 - Institutional Programs
Chapter 18 - Quality Assurance	Chapter 9 - Quality Assurance
Chapter 19 - Emergency Preparedness	Chapter 8 - Institutional Programs
Chapter 20 - Decontamination and Decommissioning	Chapter 10 - Decontamination and Decommissioning

Table 1.3-3, HAZOP Accident Scenario Ranking **Page 1 of 3**

Accident	Scenario	# Node	Deviation	Consequence	Qualitative Consequence Ranking (Table 5.1-6)	Qualitative Frequency Ranking (Table 5.1-5)	Risk	Prevention/Mitigation
CH1	Fire/spontaneous ignition	07 TRUPACT II internal condition	Fire in TRUPACT II	Minor radioactive materials released	**3**	**3**	**9**	Prevention: Type A container, Waste container integrity, QA, Reinstall ICV lid, Building Construction, Stable drum history, TRUPACT II integrity, Vented drums, WAC criteria. Mitigation: Reinstall ICV lid, WHB HEPA filtration and fire suppression systems, Emergency response plan and teams.
CH2	Crane failure/breach	08 Transfer of payload from TRUDOCK to facility pallet	Failure of lifting equipment	Negligible radioactive materials released	**2**	**3**	**6**	Prevention: Type A container, Crane fail safe design, QA, Operator training & qualification, PM program, Procedures, Stretch wrapping, WAC criteria, Hoisting **&** rigging practices, two operators, pre-op checks, waste container integrity. Mitigation: Building Exhaust HEPA filtered, Emergency response plan and teams.
CH2	Crane failure/breach	08 Transfer of payload from TRUDOCK to facility pallet	Failure to secure load	Negligible radioactive materials released	**2**	**3**	**6**	Prevention: Type A container, Fail safe design, QA, Operator training & qualification, Preoperational checks on equipment, PM program, Procedures, Stretch wrapping, WAC criteria, Hoisting & rigging practices, Two operators, Waste container integrity. Mitigation: Building Exhaust HEPA filtered, Emergency Response Plan and teams .
CH3	Fork lift mishap/puncture	09 Transfer facility pallet to conveyance car	Fork lift improper engagement of load	Negligible radioactive materials released	**2**	**3**	**6**	Prevention: Forklift design, QA, Adequate lighting, Operator training & qualification, Pre-op checks, PM program, Procedures, Spotters, WAC criteria, Type A container, Drum integrity, Waste container integrity. Mitigation: Building Exhaust HEPA filtered, Emergency response plan and teams.
CH4	Fork lift mishap/breach	09 Transfer facility pallet to conveyance car	Moving accident	Negligible radioactive materials released	**2**	**3**	**6**	Prevention: Type A container, Operator training & qualification, PM program, Stretch wrapping, Spotters, Tie-down strapping, WAC criteria, Procedures, Pre-op checks, QA, Drum integrity, Waste container integrity. Mitigation: Building Exhaust HEPA Filtered, Emergency Response Plan and Teams.

Table 1.3-3, HAZOP Accident Scenario Ranking **Page 2 of 3**

Accident	Scenario	# Node	Deviation	Consequence	Qualitative Consequence Ranking (Table 5.1-6)	Qualitative Frequency Ranking (Table 5.1-5)	Risk	Prevention/Mitigation
CH4	Fork lift mishap/breach	09 Transfer facility pallet to conveyance car	Mislocation on the conveyance car	Negligible radioactive materials released	**2**	**3**	**6**	Prevention: Type A container, QA, Air lock doors interlocked, Local alarms, Operator training & qualification, Restricted access, Robust doors & walls, Stretch wrapping, Spotters, WAC criteria, Procedures, Tie-down strapping, Waste container integrity, PM program, Pre-op checks. Mitigation: HEPA filtration, Emergency response plan and teams.
CH4	Car/breach	10 Transfer conveyance car load onto the waste cage	Moving accident	Negligible radioactive materials released	**2**	**3**	**6**	Prevention: Type A container, QA, Operator training & qualification, Procedures, Stretch wrapping, Spotters, Strapped containers, WAC criteria, Waste container integrity, PM program, Pre-op checks. Mitigation: HEPA filtration, Emergency response plan and teams.
CH5	Hoist failure/breach	11 Waste hoist	Waste hoist drop	Minor radioactive materials released	**3**	**1**	**3**	Prevention: Brake testing, Cable NDT exams, Acoustics exam for failed parts, Control system has elevation check mechanisms, Four independent valve failures required to fail brakes, Brakes checked with full power, Catch gear, Cage fails up, Maintenance procedures & program, Mine rescue equipment, MSHA inspections, Preoperational checks, Qualified personnel, Redundant brakes & controls, Sump under shaft, Six hoist ropes each capable of holding load, inspections, Training and qualification, Weekly inspections, annual vendor inspection, visual inspection of structural steel assemblies, QA. Mitigation: HEPA, Emergency response plan and teams.
CH6	Seismic	15 Natural events	Seismic event	Negligible radioactive materials released	**2**	**1**	**2**	Prevention: Drum integrity, DBE qualified Class II and IIIA SSCs, TRUPACT II integrity, WAC criteria, Type A containers, QA. Mitigation: Shutdown procedure, Emergency response plan and teams.

Table 1.3-3, HAZOP Accident Scenario Ranking **Page 3 of 3**

Accident	Scenario	# Node	Deviation	Consequence	Qualitative Consequence Ranking (Table 5.1-6)	Qualitative Frequency Ranking (Table 5.1-5)	Risk	Prevention/Mitigation
CH7	Spontaneous ignition	27 Drum fire	Drum fire	Minor radioactive materials released	**3**	**3**	**9**	Prevention: Type A container, Waste container integrity, Reinstall ICV lid, Building Construction, Stable drum history, TRUPACT II integrity, Vented drums, WAC criteria. Mitigation: HEPA filtration, , Emergency response plan and teams.
CH8	Crash/fire/breach	16 External events	Aircraft crashes into WHB	Minor radioactive materials released	**3**	**1**	**3**	Prevention: Flight patterns, Remote location. Mitigation: Emergency response plan and teams.
CH9	Fork lift mishap/breach	23 Life of facility	Floor distortion	Negligible radioactive materials released	**2**	**3**	**6**	Prevention: Drift inspections, Floor surveys, MSHA inspections, Forklift design, Type A containers, Procedures, Training. Mitigation: Ventilation flow, Emergency response plan and teams, HEPA filtration.
CH10	Tornado	15 Natural events	Tornado	Negligible radioactive materials released	**2**	**2**	**4**	Prevention: CMR monitors weather conditions, DBT qualified Design Class II and IIIA SSCs, Drum integrity, Procedural guidance for personnel protection, TRUPACT II integrity, WAC criteria, Type A containers. Mitigation: Emergency response plan and teams.
CH11	Roof fall/breach	22 Storage room	Roof collapse during emplacement	Negligible radioactive materials released	**2**	**3**	**6**	Prevention: Inspections & assessments, Ground control, Mine instrumented and monitored, MSHA inspections, Predictive monitoring, Pre-emplacement checks, Type A containers, WAC, procedures, training. Mitigation: Emergency response plan and teams, HEPA filtration.
CH11	Roof fall	23 Life of facility	Roof collapse in life of facility area	Negligible radioactive materials released	**2**	**2**	**4**	Prevention: MSHA inspections, Shift inspections, WAC criteria, Instrumentation and monitoring, Ground control, Bi-monthly visual and instrument inspections, Procedures, Training. Mitigation: Ventilation during emplacement, HEPA filtration, Emergency response plan and teams.

NOTE: Accidents CH5, CH6, CH8, and CH11 were retained in the safety analysis due to being an external event, a natural event, or an event of significant interest.

Table 1.3-4, Summary of Noninvolved Worker and MEI Estimated Radiological Dose and Comparison to Guidelines Page 1 of 1

Accident	Unmitigated Release Freq/yr [1, 2]	On-site /Off-site Guidelines (rem)	Type of Release	Receptor Dose (CEDE-rem)			Receptor Dose % of Guidelines [(Dose/Guidelines)*100]		
				100 m (Noninvolved Worker)	Exclusive Use Area Boundary (MEI)	Site Boundary	100 m (Noninvolved Worker)	Exclusive Use Area Boundary (MEI)	Site Boundary
CH2 Crane Failure in WHB	Extremely Unlikely	100/25	Drums/mitigated	2.7E-06	3.1E-07	2.1E-08	<1%	<1%	<1%
			Drums/unmitigated	2.7E+00	3.1E-01	2.1E-02	2.7%	1.2%	<1%
			SWBs/mitigated	1.1E-06	1.3E-07	8.5E-09	<1%	<1%	<1%
			SWBs/unmitigated	1.1E+00	1.3E-01	8.5E-03	1.1%	<1%	<1%
CH3 Puncture in WHB	Extremely Unlikely	100/25	Drums/mitigated	3.8E-06	4.4E-07	3.0E-08	<1%	<1%	<1%
			Drums/unmitigated	3.8E+00	4.4E-01	3.0E-02	3.8%	1.8%	<1%
			SWBs/mitigated	1.3E-06	1.6E-07	1.1E-08	<1%	<1%	<1%
			SWBs/unmitigated	1.3E+00	1.6E-01	1.1E-02	1.3%	<1%	<1%
CH4 Drop in WHB	Extremely Unlikely	100/25	Drums/mitigated	8.6E-07	1.0E-07	6.8E-09	<1%	<1%	<1%
			Drums/unmitigated	8.6E-01	1.0E-01	6.8E-03	<1%	<1%	<1%
			SWBs/mitigated	1.3E-07	1.6E-08	1.1E-09	<1%	<1%	<1%
			SWBs/unmitigated	1.3E-01	1.6E-02	1.1E-03	<1%	<1%	<1%
CH9 Drop in U/G	Extremely Unlikely	100/25	Drums/mitigated	2.7E-06	4.4E-07	2.1E-08	<1%	<1%	<1%
			Drums/unmitigated	2.7E+00	4.4E-01	2.1E-02	2.7%	1.8%	<1%
			SWBs/mitigated	1.1E-06	1.8E-07	8.4E-09	<1%	<1%	<1%
			SWBs/unmitigated	1.1E+00	1.8E-01	8.4E-03	1.1%	<1%	<1%

Notes: (1) Listed accidents are those whose unmitigated frequency, as derived in Appendix D, is $>10^{-6}$/yr. The consequences of beyond extremely unlikely accidents may be found in the respective accident scenario.

(2) The unmitigated release frequency is as derived from the event tree (Appendix D) for the associated scenario, and includes: (a) the likelihood of the initiating event, (b) the conditional likelihood of waste container damage/failure as derived from test data, and (c) the conditional likelihood of the worst-case CI from Table A-5 of Appendix A.

100 rem = 1 Sv

Table 1.3-5, Summary of Immediate Worker Estimated Radiological Dose and Comparison to Guidelines[1] Page 1 of 1

Accident	No-Mitigation Release Freq/yr[2]	Type of Release	Noninvolved Worker Guidelines (rem)	Receptor Dose (CEDE-rem)	Receptor Dose % of Guidelines
CH2 Crane Failure in WHB	Extremely Unlikely	Drums/no-mitigation	100	1.1E+01	11.0%
		SWBs/no-mitigation	100	4.5E+00	4.5%
CH3 Puncture in WHB	Extremely Unlikely	Drums/no-mitigation	100	3.2E+01	32.0%
		SWBs/no-mitigation	100	1.1E+01	11.0%
CH4 Drop in WHB	Extremely Unlikely	Drums/no-mitigation	100	3.6E+00	3.6%
		SWBs/no-mitigation	100	5.6E-01	<1.0%
CH9 Drop in U/G	Extremely Unlikely	Drums/no-mitigation	100	2.2E+01	22.0%
		SWBs/no-mitigation	100	8.8E+00	8.8%

Notes:
(1) Listed accidents are those whose no-mitigation frequency, as derived in Appendix D, is $>10^{-6}$/yr. The consequences of beyond extremely unlikely accidents may be found in the respective accident scenario.
(2) The no-mitigation release frequency is as derived from the event tree (Appendix D) for the associated scenario, and includes: (a) the likelihood of the initiating event, (b) the conditional likelihood of waste container damage/failure as derived from test data, and (c) the conditional likelihood of the worst-case CI from Table A-5 of Appendix A.

1 REM = .01 Sv

Table 1.3-6, Summary of Noninvolved Worker and MEI Nonradiological Concentrations and Comparison to Guidelines **Page 1 of 2**

Accident	Unmitigated Release Freq./yr [1]	Type of Release	Compound	Concentrations (mg/m³)			% of Guidelines	% of Guidelines
				100 m (Noninvolved Worker)	Exclusive Use Area (MEI)	On-site/Off-site Guidelines (mg/m³) (Table 5.2-2)	100 m (Noninvolved Worker)	Exclusive Use Area (MEI)
CH2 Crane Failure in WHB	Unlikely	Drums/unmitigated	Methylene Chloride	7.3E+00	8.6E-01	21,000/870	<1.0%	<1.0%
			Carbon Tetrachloride	1.4E+01	1.6E+00	1,917/63	< 1.0%	2.50%
			Chloroform	7.10E-01	8.3E-02	5,000/50	< 1.0%	<1.0%
			1,1,2,2-Tetrachloroethane	3.70E-01	4.34E-02	1,505/35	<1.0%	<1.0%
		SWBs/unmitigated	Methylene Chloride	4.2E+00	4.9E-01	21,000/870	<1.0%	<1.0%
			Chloroform	4.1E-01	4.7E-02	5,000/50	<1.0%	<1.0%
			1,1,2,2-Tetrachloroethane	2.12E-01	2.5E-02	1,505/35	<1.0%	<1.0%
			Carbon Tetrachloride	7.7E+00	9.0E-01	1,917/63	<1.0%	1.40%
CH3 Puncture in WHB	Unlikely	Drums/unmitigated	Methylene Chloride	4.2E+00	4.9E-01	21,000/870	<1.0%	<1.0%
			Carbon Tetrachloride	7.8E+00	9.0E-01	1,917/63	<1.0%	1.40%
			Chloroform	4.10E-01	4.7E-02	5,000/50	<1.0%	<1.0%
			1,1,2,2-Tetrachloroethane	2.10E-01	2.5E-02	1,505/35	<1.0%	<1.0%

Table 1.3-6, Summary of Noninvolved Worker and MEI Nonradiological Concentrations and Comparison to Guidelines Page 2 of 2

Accident	Unmitigated Release Freq./yr [1]	Type of Release	Compound	Concentrations (mg/m^3)			% of Guidelines	% of Guidelines
				100 m (Noninvolved Worker)	Exclusive Use Area (MEI)	On-site/Off-site Guidelines (mg/m^3) (Table 5.2-2)	100 m (Noninvolved Worker)	Exclusive Use Area (MEI)
		SWBs/unmitigated	Methylene Chloride	8.4E+00	9.8E-01	21,00/870	<1.0%	<1.0%
			Chloroform	8.1E-01	9.5E-02	5,000/50	<1.0%	<1.0%
			1,1,2,2-Tetrachloroethane	4.2E-01	4.9E-02	1,505/35	<1.0%	< 1.0%
			Carbon Tetrachloride	1.6E+01	1.8E+00	1.917/63	<1.0%	2.9%
CH4 Drop in WHB	Unlikely	Consequences same as CH3	-	-	-	-	-	-
CH9 Drop in U/G	Unlikely	Drums/unmitigated	Methylene Chloride	7.3E+00	1.2E+00	21,000/870	<1.0%	<1.0%
			Chloroform	7.1E-01	1.2E-01	5,000/50	<1.0%	<1.0%
			1,1,2,2-Tetrachloroethane	3.7E-01	6.1E-02	1,505/35	<1.0%	<1.0%
			Carbon Tetrachloride	1.36E+01	2.2E+00	1,917/63	<1.0%	3.5%
		SWBs/unmitigated	Methylene Chloride	4.2E+00	6.9E-01	21,000/870	<1.0%	<1.0%
			Chloroform	4.1E-01	6.7E-02	5,000/50	<1.0%	<1.0%
			1,1,2,2-Tetrachloroethane	2.1E-01	3.5E-02	1,505/35	<1.0%	<1.0%
			Carbon Tetrachloride	7.7E+00	1.3E+00	1,917/63	<1.0%	2.1%

NOTE: (1) No credit is taken for mitigation of solid, liquid chemicals or VOCs by HEPA filtration. The unmitigated release frequency is as derived from the event tree (Appendix D) for the associated scenario, and includes: (a) the likelihood of the initiating event, and (b) the conditional likelihood of waste container damage/failure as derived from test data.

Table 1.3-7, Summary of Immediate Worker Estimated Nonradiological Dose and Comparison to Guidelines Page 1 of 1

Accident	No-mitigation Freq/yr	Compound	Noninvolved Worker Guidelines (mg/m^3)	Drum Concentration (mg/m^3)	Drum % 0f Guidelines	SWB Concentration (mg/m^3)	SWB % of Guidelines
CH2	Unlikely	Methylene Chloride	21,000	5.49E+00	<1.0%	3.14E+00	<1.0%
		Chloroform	5,000	5.30E-01	<1.0%	3.03E-01	<1.0%
		Carbon Tet	1,917	1.01E+01	<1.0%	5.79E+00	<1.0%
		1,1,2,2-Tetrachlor.	1,505	2.78E-01	<1.0%	1.58E-01	<1.0%
CH3 Puncture in WHB	Unlikely	Methylene Chloride	21,000	3.14E+00	<1.0%	6.27E+00	<1.0%
		Chloroform	5,000	3.03E-01	<1.0%	6.06E-01	<1.0%
		Carbon Tet	1,917	5.79E+00	<1.0%	1.16E+01	<1.0%
		1,1,2,2-Tetrachlor.	1,505	1.59E-01	<1.0%	3.16E-01	<1.0%
CH4	Unlikely	Same as CH3		Same as CH3		Same as CH3	
CH9	Unlikely	Methylene Chloride	21,000	5.99E+01	<1.0%	3.42E+01	<1.0%
		Chloroform	5,000	5.78E+00	<1.0%	3.30E+00	<1.0%
		Carbon Tet	1,917	1.11E+02	5.8%	6.31E+01	3.3%
		1,1,2,2-Tetrachlor.	1,505	3.03E+00	<1.0%	1.73E+00	<1.0%

NOTE: (1) No credit is taken for mitigation of solid, liquid chemicals or VOCs by HEPA filtration. The unmitigated release frequency is as derived from the event tree (Appendix D) for the associated scenario, and includes: (a) the likelihood of the initiating event, and (b) the conditional likelihood of waste container damage/failure as derived from test data.

Table 1.3-8, Summary of Defense-In-Depth Functions and Defense-in-Depth Features Important to Accident Scenarios Page 1 of 7

Accident	Defense-In-Depth Function	Defense-in-Depth Feature	Type of Feature (SSC or AC)	Type of TSR Control
CH1 Spontaneous Ignition in WHB	• Primary Confinement	• Vented DOT Type A Waste Container or Equivalent	SSC (Passive)	Design Feature/AC 5.9.12
	• Secondary Confinement	• Waste Handling Building Structure (WHB) • WHB CH HVAC System • WHB HEPA Filters	SSC (Passive) SSC (Active) SSC (Passive)	Design Feature/AC 5.1 Design Feature/AC 5.1 Design Feature/AC 5.1
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	AC	AC 5.9.12
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	AC	AC 5.9.8
CH2 Crane Failure in WHB	• Primary Confinement	• Vented DOT Type A Waste Container or Equivalent	SSC (Passive)	Design Feature/AC 5.9.12
	• Secondary Confinement	• Waste Handling Building Structure (WHB) • WHB CH HVAC System • WHB HEPA Filters	SSC (Passive) SSC (Active) SSC (Passive)	Design Feature/AC 5.1 Design Feature/AC 5.1 Design Feature/AC 5.1
	• TRUDOCK Crane designed to prevent failure resulting in a dropped load • Adjustable Center of Gravity Lift Fixture (ACGLF) designed to prevent load from swinging	• TRUDOCK Crane Design, ACGLF Design • Configuration Control • Quality Assurance	SSC (Active) AC AC	Design Feature/AC 5.1 AC 5.9.1/5.9.13 AC 5.9.4
	• TRUDOCK Crane maintained to prevent failure resulting in a dropped load • Adjustable Center of Gravity Lift Fixture maintained to prevent load from swinging	• Preventative Maintenance	AC	AC 5.9.3
	• TRUDOCK Crane operated to prevent failure resulting in a dropped load • Adjustable Center of Gravity Lift Fixture designed to prevent load from swinging	• Pre-op Checks/Inspections (Conduct of Ops) • Operator Training and Qualifications • Waste Handling Procedures • Hoisting and Rigging Practices • Operations performed with spotter present • Document Control	AC AC AC AC AC AC	AC 5.1/5.9.7 AC 5.9.6/5.4 AC 5.9.5 AC 5.9.6 AC 5.9.6 AC 5.9.2
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	AC	AC 5.9.12
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	AC	AC 5.9.8

Table 1.3-8, Summary of Defense-In-Depth Functions and Defense-in-Depth Features Important to Accident Scenarios Page 2 of 7

Accident	Defense-In-Depth Function	Defense-in-Depth Feature	Type of Feature (SSC or AC)	Type of TSR Control
CH3 Puncture in WHB	• Primary Confinement	• Vented DOT Type A Waste Container or Equivalent	SSC (Passive)	Design Feature/AC 5.9.12
	• Secondary Confinement	• Waste Handling Building Structure (WHB)	SSC (Passive)	Design Feature/AC 5.1
		• WHB CH HVAC System	SSC (Active)	Design Feature/AC 5.1
		• WHB HEPA Filters	SSC (Passive)	Design Feature/AC 5.1
	• Waste Handling Equipment (Forklift and Attachment Design, and Facility Pallet) designed to prevent failure resulting in a punctured waste container	• Forklift and Attachments Design, Facility Pallet Design	SSC (Active)	Design Feature/AC 5.1
		• Configuration Control	AC	AC 5.9.1/5.9.13
		• Quality Assurance	AC	AC 5.9.4
	• Waste Handling Equipment maintained to prevent failure resulting in a punctured waste container	• Preventative Maintenance	AC	AC 5.9.3
	• Waste Handling Equipment operated to prevent failure resulting in a punctured waste container	• Pre-op Checks/Inspections (Conduct of Ops)	AC	AC 5.1/5.9.7
		• Operator Training and Qualifications	AC	AC 5.9.6/5.4
		• Waste Handling Procedures	AC	AC 5.9.5
		• Hoisting and Rigging Practices	AC	AC 5.9.6
		• Operations performed with spotter present	AC	AC 5.9.6
		• Document Control	AC	AC 5.9.2
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	AC	AC 5.9.12
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	AC	AC 5.9.8

Table 1.3-8, Summary of Defense-In-Depth Functions and Defense-in-Depth Features Important to Accident Scenarios Page 3 of 7

Accident	Defense-In-Depth Function	Defense-in-Depth Feature	Type of Feature (SSC or AC)	Type of TSR Control
CH4 Drop in WHB	• Primary Confinement	• Vented DOT Type A Waste Container or Equivalent	SSC (Passive)	Design Feature/AC 5.9.12
	• Secondary Confinement	• Waste Handling Building Structure (WHB) • WHB CH HVAC System • WHB HEPA Filters	SSC (Passive) SSC (Active) SSC (Passive)	Design Feature/AC 5.1 Design Feature/AC 5.1 Design Feature/AC 5.1
	• Waste Handling Equipment (Forklift and Attachments, Facility Pallet) designed to prevent failure resulting in a dropped waste container	• Forklift and Attachments Design, Facility Pallet Design • Configuration Control • Quality Assurance	SSC (Active) AC AC	Design Feature/AC 5.1 AC 5.9.1/5.9.13 AC 5.9.4
	• Waste Handling Equipment maintained to prevent failure resulting in a dropped waste container	• Preventative Maintenance	AC	AC 5.9.3
	• Waste Handling Equipment operated to prevent failure resulting in a dropped waste container	• Pre-op Checks/Inspections (Conduct of Ops) • Operator Training and Qualifications • Waste Handling Procedures • Hoisting and Rigging Practices • Operations performed with spotter present • Document Control	AC AC AC AC AC AC	AC 5.1/5.9.7 AC 5.9.6/5.4 AC 5.9.5 AC 5.9.6 AC 5.9.6 AC 5.9.2
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	AC	AC 5.9.12
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	AC	AC 5.9.8

Table 1.3-8, Summary of Defense-In-Depth Functions and Defense-in-Depth Features Important to Accident Scenarios Page 4 of 7

Accident	Defense-In-Depth Function	Defense-in-Depth Feature	Type of Feature (SSC or AC)	Type of TSR Control
CH5 Waste Hoist Failure	• Primary Confinement	• Vented DOT Type A Waste Container or Equivalent	SSC (Passive)	Design Feature/AC 5.9.12
	• Secondary Confinement	• Underground Ventilation Exhaust System	SSC (Active)	Design Feature/AC 5.1
		• Underground Ventilation Exhaust HEPA Filters	SSC (Passive)	Design Feature/AC 5.1
		• Central Monitoring System (for actuation of underground shift to filtration only)	SSC (Active)	Design Feature/AC 5.1
		• Waste Hoist and Brake System Design		
	• Waste Hoist System designed to prevent failure resulting in an uncontrolled movement of the hoist	• Configuration Control	SSC (Active)	Design Feature/AC 5.1
		• Quality Assurance	AC	AC 5.9.1/5.9.13
			AC	AC 5.9.4
	• Waste Hoist System maintained to prevent failure resulting in an uncontrolled movement of the hoist	• Preventative Maintenance		
			AC	AC 5.9.3
	• Waste Hoist System operated to prevent failure resulting in an uncontrolled movement of the hoist	• Pre-op Checks/Inspections (Conduct of Ops)		
		• Operator Training and Qualifications	AC	AC 5.9.7
		• Waste Handling Procedures		
		• Hoisting and Rigging Practices	AC	AC 5.9.6/5.4
		• Operations performed with spotter present	AC	AC 5.9.5
		• Document Control	AC	AC 5.9.6
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics		AC	AC 5.9.6
		• WIPP Waste Acceptance Criteria	AC	AC 5.9.2
	• Provide facility emergency response to the event (notification, evacuation, direct response)		AC	AC 5.9.12
		• WIPP Emergency Management Program		
			AC	AC 5.9.8
CH6 DBE	• Primary Confinement	• Vented DOT Type A Waste Container or Equivalent	SSC (Passive)	Design Feature/AC 5.9.12
	• WHB structure (includes structure and structural components) designed and maintained to prevent failure during a DBE resulting in waste container breach	• Waste Handling Building DBE design	SSC (Passive)	Design Feature/AC 5.1
		• Configuration Control	AC	AC 5.9.1/5.9.13
		• Quality Assurance	AC	AC 5.9.4
		• Preventative Maintenance	AC	AC 5.9.3
	• WHB 6-ton bridge crane and waste hoist designed and maintained to prevent failure during a DBE resulting in waste container breach	• Waste Handling Building 6-ton bridge crane and waste hoist DBE design	SSC (Passive)	AC 5.1
		• Configuration Control	AC	AC 5.9.1/5.9.13
		• Quality Assurance	AC	AC 5.9.4
		• Preventative Maintenance	AC	AC 5.9.3
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	AC	AC 5.9.12
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	AC	AC 5.9.8

Table 1.3-8, Summary of Defense-In-Depth Functions and Defense-in-Depth Features Important to Accident Scenarios **Page 5 of 7**

Accident	Defense-In-Depth Function	Defense-in-Depth Feature	Type of Feature (SSC or AC)	Type of TSR Control
CH 7 Spontaneous Ignition in U/G	• Primary Confinement	• Vented DOT Type A Waste Container	SSC (Passive)	Design Feature/AC 5.9.12
	• Secondary Confinement	• Underground Ventilation Exhaust System	SSC (Active)	Design Feature/AC 5.1
		• Underground Ventilation Exhaust HEPA Filters	SSC (Passive)	Design Feature/AC 5.1
		• Radiation Monitoring System (active waste disposal room exit alpha CAM for underground shift to filtration)	SSC (Active)	Design Feature/AC 5.1
		• Central Monitoring System (for actuation of underground shift to filtration only)	SSC (Active)	Design Feature/AC 5.1
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	AC	AC 5.9.12
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	AC	AC 5.9.8

Table 1.3-8, Summary of Defense-In-Depth Functions and Defense-in-Depth Features Important to Accident Scenarios Page 6 of 7

Accident	Defense-In-Depth Function	Defense-in-Depth Feature	Type of Feature (SSC or AC)	Type of TSR Control
CH9 Drop in U/G	• Primary Confinement	• Vented DOT Type A Waste Container or Equivalent	SSC (Passive)	Design Feature/AC 5.9.12
	• Secondary Confinement	• Underground Ventilation Exhaust System	SSC (Active)	Design Feature/AC 5.1
		• Underground Ventilation Exhaust HEPA Filters	SSC (Passive)	Design Feature/AC 5.1
		• Radiation Monitoring System (active waste disposal room exit alpha CAM for underground shift to filtration)	SSC (Active)	Design Feature/AC 5.1
		• Central Monitoring System (for actuation of underground shift to filtration only)	SSC (Active)	Design Feature/AC 5.1
	• Waste Handling Equipment (Forklift and Attachments, Facility Pallet) designed to prevent failure resulting in a dropped waste container	• Forklift and Attachments Design, Facility Pallet Design	SSC (Active)	Design Feature/AC 5.1
		• Configuration Control	AC	AC 5.9.1/5.9.13
		• Quality Assurance	AC	AC 5.9.4
	• Waste Handling Equipment maintained to prevent failure resulting in a dropped waste container	• Preventative Maintenance	AC	AC 5.9.3
	• Waste Handling Equipment operated to prevent failure resulting in a dropped waste container	• Pre-op Checks/Inspections (Conduct of Ops)	AC	AC 5.9.7
		• Operator Training and Qualifications	AC	AC 5.9.6/5.4
		• Waste Handling Procedures	AC	AC 5.9.5
		• Hoisting and Rigging Practices	AC	AC 5.9.6
		• Operations performed with spotter present	AC	AC 5.9.6
		• Document Control	AC	AC 5.9.2
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	AC	AC 5.9.12
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	AC	AC 5.9.8

Table 1.3-8, Summary of Defense-In-Depth Functions and Defense-in-Depth Features Important to Accident Scenarios Page 7 of 7

Accident	Defense-In-Depth Function	Defense-in-Depth Feature	Type of Feature (SSC or AC)	Type of TSR Control
CH10 DBT	• WHB structure (includes structure and structural components) designed and maintained to prevent failure during a DBT resulting in waste container breach	• Waste Handling Building DBT design • Configuration Control • Quality Assurance • Preventative Maintenance	SSC (Passive) AC AC AC	Design Feature/AC 5.1 AC 5.9.1/5.9.13 AC 5.9.4 AC 5.9.3
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	AC	AC 5.9.12
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	AC	AC 5.9.8
CH11 Roof Fall	• Primary Confinement	• Vented DOT Type A Waste Container or Equivalent	SSC (Passive)	Design Feature/AC 5.9.12
	• Secondary Confinement	• Underground Ventilation Exhaust System • Underground Ventilation Exhaust HEPA Filters • Radiation Monitoring System (active waste disposal room exit alpha CAM for underground shift to filtration) • Central Monitoring System (for actuation of underground shift to filtration only)	SSC (Active) SSC (Passive) SSC (Active) SSC (Active)	Design Feature/AC 5.1 Design Feature/AC 5.1 Design Feature/AC 5.1 Design Feature/AC 5.1
	• Underground disposal areas designed to prevent failure resulting in a breached waste container	• Underground Disposal Area Design • Configuration Control • Quality Assurance	SSC (Passive) SSC (Passive) AC	Design Feature/AC 5.1 AC 5.9.1/5.9.13 AC 5.9.4
	• Underground disposal areas maintained to prevent failure resulting in a breached waste container	• Ground Control/Inspections and Assessments • Geomechanical Monitoring	AC AC	AC 5.9.14 AC 5.9.14
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	AC	AC 5.9.12
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management	AC	AC 5.9.8

1.4 Organizations

The overall responsibility for the design, construction, operation, and decommissioning of the WIPP rests solely with the DOE. Within the DOE, the Assistant Secretary for Environmental Restoration and Waste Management (EM) is responsible for implementing the radioactive waste disposal policy. In 1993, the DOE Carlsbad Area Office (CAO) was created to be directly responsible for the WIPP Project. The CAO reports programmatically to the DOE-EM and administratively to the DOE-AL.

During the construction phase, DOE-AL contracted with the following organizations to participate in the WIPP Project:

- Sandia National Laboratories (SNL), Department of Waste Management Technology, Albuquerque, New Mexico, to serve as the Scientific Advisor

- Bechtel National Incorporated, Advanced Technology Division, San Francisco, California, to serve as the Architect/Engineer

- Westinghouse Electric Corporation, Waste Isolation Division, Carlsbad, New Mexico, to serve first as the Technical Support Contractor (1978-1985) and later as the Management and Operating Contractor (1985-present)

  NOTE: The U.S. Army Corps of Engineers was the construction manager under provisions of an Interagency Agreement prior to transfer of this responsibility to the Management and Operating Contractor (MOC).

SNL, as the Scientific Advisor, has been responsible for developing the conceptual design of the WIPP facility, and performing the site selection and characterization studies. SNL is also responsible for completing the performance assessment of the WIPP facility in compliance with 40 CFR 191 Subparts B and C.[1]

Bechtel, the Architect/Engineer, was responsible for developing the detailed design of the facility, including construction bid package development and design related geotechnical explorations. Bechtel engaged the services of Rockwell International as consultant for the design of special waste handling equipment.

As the Technical Support Contractor (TSC) (from 1978-1985), Westinghouse was responsible for providing general management and procurement support. In this role, Westinghouse performed technical reviews of the design, prepared the Safety Analysis Report, supported preparation of the Final Environmental Impact Statement, and provided support in operational planning and quality assurance. In 1985, the DOE-AL contracted with Westinghouse to provide management and operating services as the MOC. In this capacity, Westinghouse is responsible for general management and operating services, including operational safety, engineering management, quality assurance and control, project control, construction management, and environmental services. As part of its responsibility as MOC, Westinghouse ensures that all inputs to facility operations are properly reviewed for health, safety, and environmental implications.

The DOE has entered into a formal agreement with the State of New Mexico for the purpose of consultation and cooperation (WACC[2]). This agreement, including its associated working agreement and subsequent modifications, provides a basis for the Governor of New Mexico to exercise the state's right, to comment on and make recommendations regarding the public health and safety aspects of the WIPP Project. The WACC designates key events, sets time frames for review, provides for comments and resolution of comments, and establishes procedures for review of the WIPP Project activities and for resolving conflicts. The WACC agreement also provides a mechanism for conflict resolution.

References for Section 1.4

1. 40 CFR 191, U.S. Environmental Protection Agency, Environmental Radiation Protection for Management and Disposal of Spent Nuclear Fuel, High Level and Transuranic Wastes, Subpart B, Environmental Standards for Disposal, July 1994.

2. Working Agreement for Consultation and Cooperation, signed by the U.S. DOE and the State of New Mexico, July 1981 and subsequent revisions.

This page intentionally blank.

1.5 Statutes, Federal Rules, and DOE Directives Applicable to the Preclosure WIPP CH TRU Waste Operational Safety

Public Law 83-703	Atomic Energy Act of 1954
Public Law 90-148	Clean Air Act
Public Law 91-190	National Environmental Policy Act
Public Law 94-580	Resource Conservation and Recovery Act
Public Law 95-164	Federal Mine Safety and Health Act of 1977
Public Law 96-164	Department of Energy National Security and Military Applications of Nuclear Energy Authorization Act of 1980
Public Law 96-510	Comprehensive Environmental Response, Compensation, and Liability Act
Public Law 102-579	Waste Isolation Pilot Plant Land Withdrawal Act [as amended by Public Law [104-201]
10CFR Part 830	Nuclear Safety Management, April 5, 1994
10CFR Part 835	Occupational Radiation Protection, December 14, 1993
29 CFR Part 1910	Occupational Safety and Health Standards, June 27, 1974
30 CFR Part 57	Safety and Health Standards - Underground Metal and Nonmetal Mines, January 29, 1985
40 CFR Part 61, Subpart H	Subpart H - National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities; 40 CFR Part 61, National Emission Standards for Hazardous Air Pollutants, December 15, 1989
40 CFR Part 191, Subpart A	Subpart A - Environmental Standards for Management and Storage; 40 CFR 191, Environmental Radiation Protection for Management and Disposal of Spent Nuclear Fuel, High-level and Transuranic Radioactive Wastes, November 18, 1985
40 CFR Part 261	Identification and Listing of Hazardous Waste, May 19, 1980
40 CFR Part 262	Standards Applicable to Generators of Hazardous Waste, May 19, 1980
40 CFR Part 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, May 19, 1980
40 CFR Part 265	Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, May 19, 1980
40 CFR Part 268	Land Disposal Restrictions, May 19, 1980
40 CFR Part 270	EPA Administered Permit Programs: The Hazardous Waste Permit Program, April 1, 1983
40 CFR Part 280	Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks, September 23, 1988
DOE Order O 414.1	Quality Assurance, November 1998
DOE Order O 420.1	Facility Safety, October 1996
DOE Order O 430.1A	Life-Cycle Asset Management, October 1998
DOE Order 4330.4B	Maintenance Management Program, February 10, 1994
DOE Order 4700.1	Project Management Systems, June 2, 1992 (For reference only, superceded by DOE O 430.1A)
DOE Order 5000.3B	Occurrence Reporting and Processing of Operations Information, January 19, 1993
DOE Order 5400.1	General Environmental Protection Program, June 29, 1990
DOE Order 5400.4	Comprehensive Environmental Response, Compensation, and Liability Act Requirements, June 6, 1989
DOE Order 5400.5	Radiation Protection of the Public and the Environment, January 7, 1993

DOE Order 5440.1E	National Environmental Policy Act Compliance Program, November 10, 1992
DOE Order 5480.4	Environmental Protection, Safety, and Health Protection Standards, January 7, 1993
DOE Order 5480.18B	Nuclear Facility Training Accreditation Program, August 31, 1994
DOE Order 5480.19	Conduct of Operations Requirements for DOE Facilities, May 18, 1992
DOE Order 5480.20A	Personnel Selection, Qualification, Training Requirements for DOE Nuclear Facilities, November 15, 1994
DOE Order 5480.21	Unreviewed Safety Questions, May 12, 1994
DOE Order 5480.22	Technical Safety Requirements, September 15, 1992
DOE Order 5480.23	Nuclear Safety Analysis Reports, April 30, 1992
DOE Order 5500.1B	Emergency Management System, April 30, 1991
DOE Order 5500.2B	Emergency Categories, Classes, and Notification and Reporting Requirements, February 27, 1992
DOE Order 5500.3A	Planning and Preparedness for Operational Emergencies, February 27, 1992
DOE Order 5500.3B	Occurrence Reporting and Processing of Operations Information, January 19, 1993
DOE Order 5500.7B	Emergency Operation Records Protection Program, October 23, 1991
DOE Order 5500.10	Emergency Readiness Assurance Program, February 27, 1992
DOE Order 5820.2A	Radioactive Waste Management, September 1988
DOE Order 6430.1A	General Design Criteria, 1989 (For reference only, superceded by DOE O 420.1 and DOE O 430.1A)

Note: Conversion to, and implementation of, selected applicable DOE O series Orders are not required until inclusion into Managing and Operating Contractor contracts. As such, demonstration of compliance with applicable Orders, replacing any listed above, will be included in the appropriate Annual SAR Update when the Orders become effective and are implemented at WIPP.

SITE CHARACTERISTICS
TABLE OF CONTENTS

SECTION TITLE PAGE NO.

SITE CHARACTERISTICS
TABLE OF CONTENTS

SECTION TITLE PAGE NO.

SITE CHARACTERISTICS
LIST OF FIGURES

FIGURE **TITLE** **PAGE NO.**

SITE CHARACTERISTICS
LIST OF FIGURES

SITE CHARACTERISTICS
LIST OF TABLES

This page is intentionally left blank.

SITE CHARACTERISTICS

This Chapter provides information on the location of the WIPP facility and the site characteristics to support and clarify assumptions used in the hazards and accident analysis to identify and analyze potential external and natural phenomena accident initiators and accident consequences external to the facility. Included is information on: (1) site geography, (2) demographics, (3) nearby industrial, transportation, and military facilities, (4) meteorology, (5) demographics and land use, and (6) seismicity. Information relating to ecology, extractable resources, water and air quality, environmental radioactivity, surface and ground water hydrology, and geology, necessary to support the long-term performance assessment of the repository, may be found in the *Title 40 CFR 191 Compliance Certification Application for the Waste Isolation Pilot Plant*, DOE/CAO-1996-2184, October 1996.

2.1 Geography and Demography of the Area Around the WIPP Facility

2.1.1 WIPP Facility Location and Description

The Waste Isolation Pilot Plant (WIPP) Facility is located in Eddy County in southeastern New Mexico (Figure 2.1-1). The center of the WIPP facility is approximately 103°47'27" W longitude and 32°22'11" N latitude.

Prominent natural features within five miles (8.0 kilometers) of the center of the WIPP facility include Livingston Ridge and Nash Draw, which are located about five miles (8.0 kilometers) west. Livingston Ridge, the most prominent physiographic feature near the WIPP facility, is a northwest facing bluff (about 75 feet or 22.9 meters high) that marks the east edge of Nash Draw (a shallow drainage course about five miles [8.0 kilometers] wide).

Other prominent natural features are the Pecos River which is about 14 miles (22.5 kilometers) west at its nearest point, and the Guadalupe Mountains which includes the Carlsbad Caverns National Park at about 42 miles (67 kilometers) and the Guadalupe Mountains National Park which is about 65 miles (104.5 kilometers) west southwest. The nearest prominent man-made features are the city of Loving (with a 1990 population of 1243) which is 18 miles (29.0 kilometers) west southwest, and the city of Carlsbad (with a 1990 population of 24,896) which is 26 miles (41.8 kilometers) west.

2.1.1.1 WIPP Facility Area

The area of land that lies within the WIPP Site Boundary and committed to the WIPP facility is a square four miles (6.4 kilometers) on a side. It contains 10,240 acres or 4,146 hectares (16 mi^2 or 41.4 km^2) including Sections 15-22 and 27-34 in township T22S, R31E. The area containing the WIPP facility surface structures is surrounded with a chain link fence and covers about 35 acres or 14 hectares in Sections 20 and 21 of T22S, R31E. This fenced area is known as Property Protection Area. The location and orientation of the WIPP facility surface structures are shown in Figure 1.2-3. These structures include the Waste Handling Building (WHB) where radioactive waste is received and prepared for underground disposal, four shafts to the underground area, a Support Building containing laboratory and office facilities, showers, change rooms for underground workers, an Exhaust Filter Building (EFB), and a water supply system. Support structures outside of the chain link fence include sewage stabilization ponds, other auxiliary buildings, two mined-rock (salt) piles, and collection ponds for managing site runoff.

There are no industrial, commercial, institutional, recreational or residential structures within the WIPP Site Boundary and no through public highways, railways or waterways traverse the WIPP Site Boundary. Access to the WIPP facility is provided by two access roads that connect with U.S. Highway 62/180, 13 miles (21 km) to the north, and NM Highway 128 (Jal Highway), 4 miles (6.4 km) to the south. The north access road, which connects the site to U.S. Highway 62/180, is an access road built specifically for the DOE that will be used to transport TRU mixed waste from the highway to the site. The north access road is restricted for use by the personnel, agents and contractors of the DOE on official business related to the WIPP Project, or to personnel, permittees, licensees or lessees of the BLM. The south access road is county highway maintained by Eddy County and multiple-use access is allowed unless it is determined that access by industry or the general public represents a significant safety risk to WIPP personnel. There are four natural gas pipelines that traverse the vicinity of the WIPP facility. One pipeline that is within the WIPP Site Boundary is oriented northeast southwest and is about 1.2 miles (1.9 kilometers) north of the center of the WIPP surface structures at its closest point. This pipeline, along with other pipelines in the area of the WIPP facility, are discussed in Section 2.2.3.

The areas that have been designated as subdivisions within the WIPP Site Boundary are defined below and depicted in Figure 2.1-2.

The Property Protection Area is an area of approximately 35 acres or 14 hectares surrounded by a chain link fence. Most of the WIPP facility surface structures are located within this area. Except for the salt storage piles, and the wastewater stabilization ponds.

The Exclusive Use Area is an area of approximately 277 acres or 112 hectares surrounded by a barbed wire fence and posted no trespassing. Review of the WIPP Land Management Plan indicates that public access to the WIPP 16 section area up to the DOE "Exclusive Use Area" is allowed for grazing purposes and up to the DOE "Off-limits Area" for recreational purposes. Public access is controlled by the WIPP 24-hour security force, which regularly patrols the restricted access areas (Section 8.6).

The Off-limits Area (shown in Figure 2.1-2) is an area of approximately 1,421 acres or 575 hectares and is posted no trespassing. Access to this area will be restricted.

The WIPP Site Boundary encompasses an area of 10,240 acres or 4,146 hectares (16 sections). The DOE will not permit subsurface mining, drilling, or resource exploration unrelated to the WIPP Project within the WIPP Site Boundary during facility operation or after decommissioning. This prohibition precludes slant drilling under the WIPP facility from within or outside the WIPP facility, with the exception of existing rights under federal oil and gas leases No. NMNM 02953 and NMNM 02953C, which shall not be affected unless a determination is made to require the acquisition of such leases to comply with final disposal regulations or with the solid waste disposal act (42 U.S.C. 6901 et seq). [1]

Within the Property Protection Area, public access is restricted to employees and approved visitors. Within the Exclusive Use Area access is restricted to authorized personnel and vehicles. Mining and drilling for purposes other than those which support the WIPP project are prohibited within the 16-section (Land Withdrawal Act (LWA). In addition, small areas have been fenced to control access to material storage areas, borrow pits, the sewage stabilization ponds, and biological study plots.

A zone, provided between the mined area underground and the WIPP Site Boundary is a minimum of one mile (1.6 kilometers) wide. This thickness was specified based on recommendations made by Oak Ridge National Laboratory (ORNL). The ORNL recommendation of one to five miles (1.6 to 8.0 kilometers) for the size of the zone of intact salt was to preclude unacceptable penetration of the salt formation. The ORNL stated that the actual size of the zone must be based on site dependent factors including drilling operations, mining operations and salt dissolution rates. This was addressed in the Geological Characterization Report [2] where the authors state that the one mile (1.6 kilometers) thickness should provide more than 250,000 years of isolation using very conservative dissolution assumptions.

2.1.2 Exclusion Area Land Use and Control

2.1.2.1 Authority

The 10,240 acres (4,146 hectares) that lie within the WIPP Site Boundary are on federal land. During construction all the federal lands within the WIPP Site Boundary were managed in accordance with the terms of Public Land Order 6403 and a DOE/Bureau of Land Management (BLM) Memorandum of Understanding (MOU)[3] and the BLM Resource Management Plan.

During operations, the area within the WIPP Site Boundary will remain under federal control. This includes all facility areas described in Section 2.1.1.1

On October 30, 1992, the WIPP (LWA), Public Law 102-579 as amended by Public Law 104-201, was signed by President Bush transferring the land from the Department of the Interior (DOI) to the DOE. Consistent with the mission of the WIPP facility, lands within and around the WIPP Site Boundary are administered according to a multiple land use policy. Mining and Drilling for purposes other than those which support the WIPP project are prohibited within the 16-section LWA area subject such conditions and restrictions as may be necessary to permit the conduct of WIPP-related activities.[2]

2.1.2.1.1 Agricultural Uses

All the land within the WIPP Site Boundary up to the Exclusive Use Area has been leased for grazing, which is the only significant agricultural activity in the vicinity of the WIPP facility. The Smith Ranch, owned by Kenneth Smith, Inc. of Carlsbad, New Mexico, has lease rights to 2880 acres (1,166 hectares) within the northern portion of the WIPP Site Boundary. J. C. Mills of Abernathy, Texas, owner of the Mills Ranch, has lease rights to 7,360 acres (2,980 hectares) within the southern portion of the WIPP Site Boundary.

2.1.2.1.2 Water Use

There are no significant uses of surface or groundwater in the vicinity of the WIPP facility. Several windmills have been erected throughout the area to pump groundwater for livestock watering. Additionally, several ponds have been created to capture runoff for livestock.

2.1.2.1.3 Industrial and Commercial Facilities

There are no industrial surface facilities within a five-mile (8.0 kilometer) radius of the WIPP facility. Ranching is the only commercial operation within five miles of the facility, with the exception of oil and gas related activities. The five-mile (8.0 kilometer) radius encompasses grazing allotments of three separate ranches; however, only one ranch house is located in the area. It is about 3.5 miles (5.6 kilometers) from the center of the WIPP facility in the south southwest sector. There are four potash mines and two chemical processing plants (adjacent to the mines) between five and 10 miles (8.0 to 16.1 kilometers) of the WIPP facility.

References for Section 2.1

1 Public Law 102-579, 102nd Congress, Waste Isolation Pilot Plant Land Withdrawal Act, October 30, 1992 [as amended by Public Law 104-201].

2 SAND 78-1596, Geological Characterization Report for the WIPP Site, Southeastern New Mexico. Sandia National Laboratories, Albuquerque, NM, 1978.

3 Memorandum of Understanding, Bureau of Land Management and the Department of Energy, July 19, 1994.

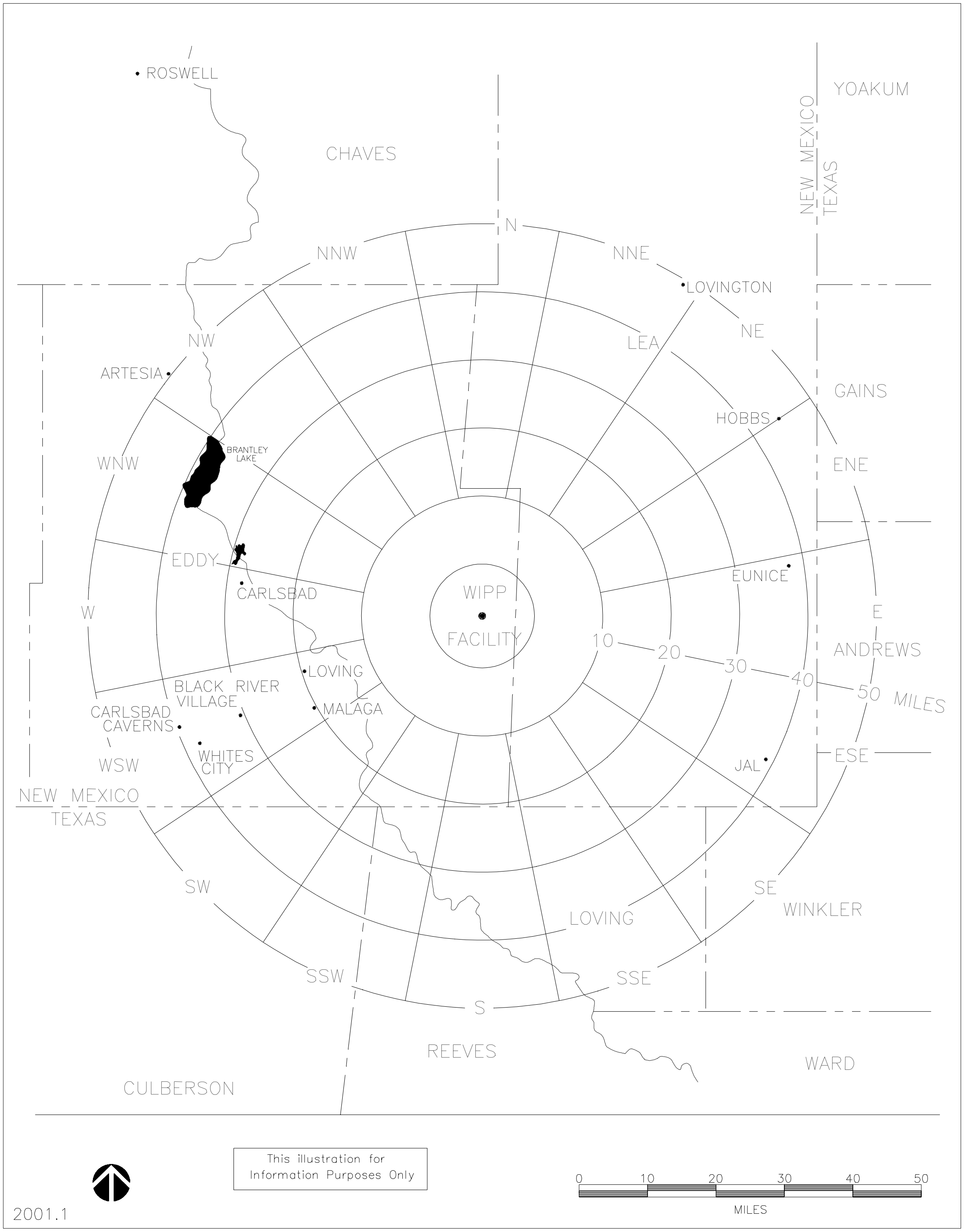


Figure 2.1-1, Region Surrounding the WIPP Facility

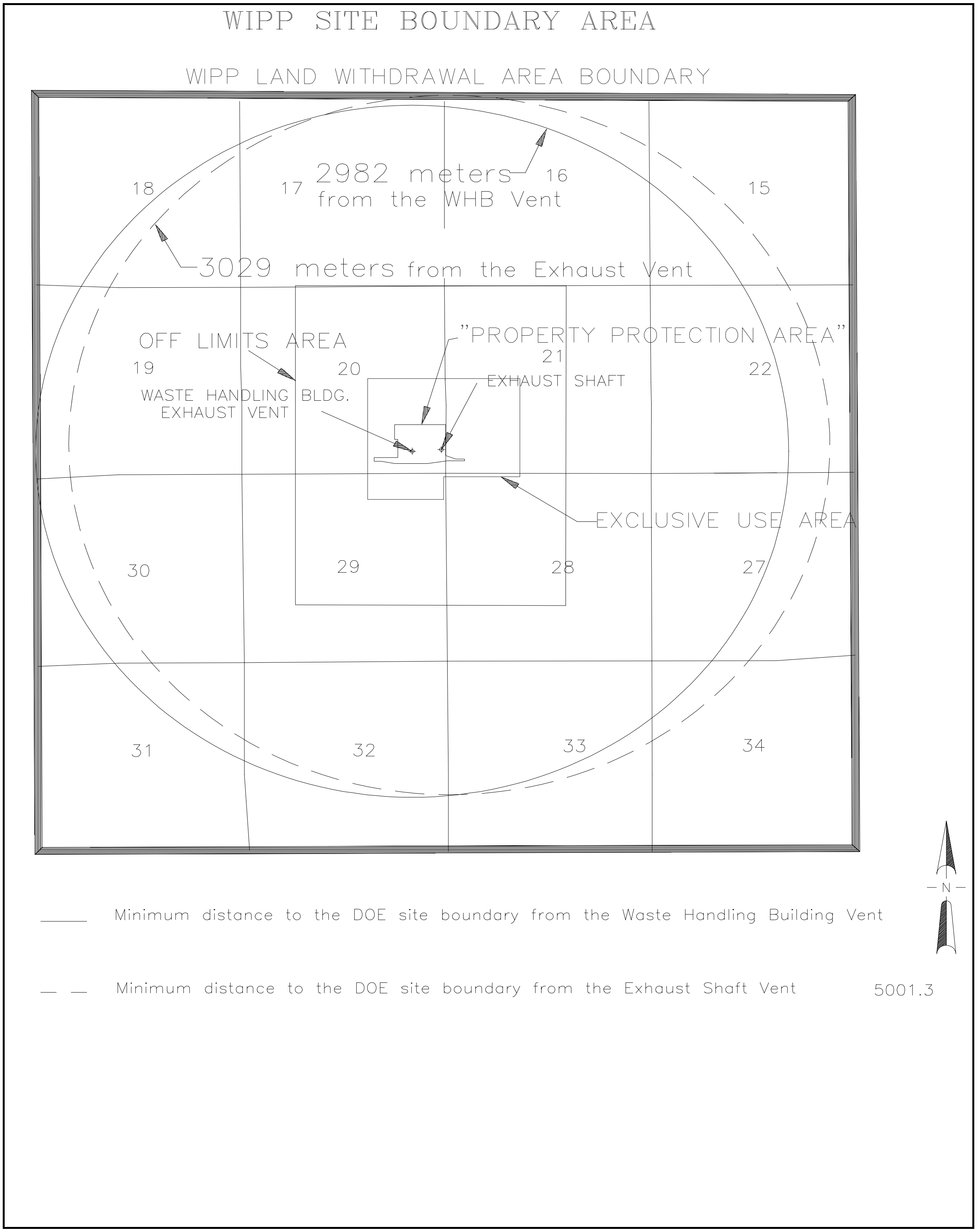


Figure 2.1-2, WIPP Facility Boundaries,

This page intentionally left blank.

2.2 Nearby Industrial, Transportation and Military Facilities

The extractive activities, transportation routes, and military operations that may have a potential affect on operations at the WIPP facility are discussed in this section.

2.2.1 Industrial and Commercial Facilities

There are some oil and gas related industrial facilities within a five-mile (8.0 kilometer) radius of the WIPP facility. The five-mile (8.0 kilometer) radius encompasses grazing allotments of three separate ranches; however, only one ranch house is located in the area. It is about 3.5 miles (5.6 kilometer) from the center of the WIPP facility in the south southwest sector. There are four potash mines and two chemical processing plants (adjacent to the mines) between five and 10 miles (8.0 and 16.1 kilometers) of the WIPP facility.

2.2.2 Extractive Activities

Within a five mile (8.0 kilometer) radius from the center of the WIPP Land Withdrawal Area (LWA), both oil and gas are extracted below the Salado formation. The majority of the newer wells produce oil and gas from the Brushy Canyon formation of the Delaware Mountain Group. Gas wells typically produce from the deeper Pennsylvanian-age formations (Atoka, Strawn, and Morrow formations). As of April 1995, there were 136 oil wells (some which produce both oil and gas), 21 gas wells, and 21 plugged wells within five miles (8.0 kilometers) of the Land Withdrawal Act (LWA) boundary (Figure 2.2-2a). The completion of these wells is stratigraphically below the repository horizon. There are likewise an additional 292 oil wells, 47 gas wells, and 83 plugged wells within ten miles of the LWA boundary (Figure 2.2-1). The plugged wells include both wells that are considered "dry holes" and wells that are no longer productive and have been permanently sealed.

Besides the oil and gas extractive activities, there are four active potash mines within ten miles (16.1 kilometers) of the WIPP LWA. Potash is extracted from the McNutt Potash member which is stratigraphically above the WIPP repository horizon.

2.2.3 Oil and Gas Pipelines

There are no crude oil pipelines within five miles (8.0 kilometers) of the WIPP facility. There are, however, 16 natural gas pipelines located within a five-mile (8.0 kilometer) radius of the WIPP facility. Many producing wells within the ten mile (16.1 kilometer) radius of the WIPP are connected to tank batteries by gathering systems of flexible, plastic tubing. These lines are typically buried at the time of installation; however, there are areas where these lines rest upon the surface of the ground. They carry a mixture of crude oil, natural gas, and produced waters. At the accumulation tanks, these fluids are separated, and the gas is then fed into pipelines. Thirteen of these pipelines have right-of-way lease permits issued by the U.S. Department of the Interior (DOI), Bureau of Land Management (BLM) for access to federal land, while four have permits issued by the State of New Mexico, State Land Office, for access to state lands. Two pipelines require both federal and state right-of-way lease permits. There is one pipeline located on federal land for which no right-of-way lease permit information is available.

The natural gas pipelines are owned and operated by three companies:

- El Paso Natural Gas Company, El Paso, Texas;

- Natural Gas Pipeline Company of America, Chicago, Illinois;
- Transwestern Pipeline Company, Roswell, New Mexico.

Figure 2.2-2a shows the location of each pipeline within five miles (8.0 kilometers) of the WIPP facility, along with pertinent information regarding each pipeline.

One major non-oil or gas pipeline lies within the WIPP Site Boundary. This is a 10 inch (25.4 centimeter) City of Carlsbad water pipeline that provides the WIPP facility with potable water.

2.2.4 Waterways

There are no navigable waterways within a five-mile (8.0 kilometer) radius of the WIPP facility. The nearest river is the Pecos River which is 12 miles (19.3 kilometers) west of the WIPP facility.

2.2.5 Military Facilities

There are no military facilities within a five-mile radius (8.0 kilometer) of the WIPP facility. Holloman Air Force Base is the nearest military facility to the WIPP Site and is located 138 miles (222.1 kilometers) to the northwest.

2.2.6 Airports and Aviation Routes

There are no airports within a ten-mile (16.1 kilometer) radius of the site. The nearest airstrip, 12 miles (19.3 kilometers) north of the WIPP facility, is privately operated by Transwestern Pipeline Company. The nearest commercial airport is Cavern City, 28 miles (45.1 kilometers) west of the WIPP facility near Carlsbad. Other airports in the area are Eunice (32 miles or 51.5 kilometers east), Carlsbad Caverns (42 miles or 67.6 kilometers southwest), Hobbs Airport (42 miles or 67.6 kilometers northeast), Jal (40 miles or 64.4 kilometers southeast), Lovington (50 miles or 80.5 kilometers northeast), and Artesia (51 miles or 82.1 kilometers northwest). The relationship of these airports to the WIPP facility is shown in Figure 2.2-3.

Portions of two federal airways are within five miles (8.0 kilometers) of the WIPP facility. Each airway is 10 miles (16.1 kilometers) wide. The centerline of low altitude airway V-102 is three miles (4.8 kilometers) northwest of the WIPP facility and high altitude airway J-15 is four miles (6.4 kilometers) northeast of the WIPP facility at their nearest points. These airways are shown in Figure 2.2-3. Traffic data for these airways are given in Table 2.2-1. The combined traffic on both routes is about 28 Instrument Flight Rule (IFR) flights per peak day. There are no approach or landing zones within five miles (8.0 kilometers) of the WIPP facility.

2.2.7 Land Transportation

2.2.7.1 Roads and Highways

Other than the highways that provide north or south access, only one other highway lies within a five-mile (8-kilometer) radius. This is New Mexico Highway 128, which is between four and five miles (6.4 to 8 kilometers) southwest of the WIPP facility (Figure 1.2-1). It connects the small community of Jal with NM 31, which leads into Loving and it provides access to Carlsbad. New Mexico Highway 128 is used by ranchers, school buses, potash miners, and by oil and gas company vehicles occasionally transporting drilling rigs (wide loads) to sites in the area. In 1985, it had an average daily traffic flow of about 400 vehicles. Several dirt roads in the area are maintained for ranching, pipeline maintenance, and access to drilling sites.

2.2.7.2 Railroads

Except for the rail spur that serves the WIPP facility, there are no railroad lines within the five-mile radius of the WIPP facility. Rail lines to International Minerals and Chemical Corp. Main Plant and Nash Draw operation, and the Mississippi Chemical Corp. Each plant, all potash mining operations, are located between six and 10 miles (9.7 to 16.1 kilometers) of the WIPP facility. All railroad lines within the general vicinity of the WIPP facility are used specifically to transport potash ore.

2.2.8 Projected Industrial Growth

While no industrial activity occurs within five miles (8 kilometers) of the WIPP facility, active potash mining is occurring. These ores are extracted from the Salado formation but are brought to the surface further than five miles (8 kilometers) from the WIPP. Other extractive activities are oil and gas production (as detailed in section 2.2.2). No extractive activity is allowed within the LWA with the exception of section 31 (the southwest corner section of the LWA). There is currently one gas well producing from that section below the 6000 foot (1828.8 meter) land withdrawal designation. This well was slant drilled from section 6 of Township 23 South. The other fifteen sections of the LWA are withdrawn to the center of the earth. Other permit applications for slant drilling into section 31 from outside sections have been denied by the BLM.

Four potash mining operations located around the WIPP facility were contacted concerning their anticipated growth. If these operations expand, there is a possibility that at least two new shafts will be sunk in the approximate two to five miles (3 to 8 km) radius. Plans for expansion are not firm because they are dictated in most cases by the market conditions for potash. Even if this expansion were to occur, it would not pose a safety risk for the WIPP facility since surface and underground operations would be restricted to areas outside the WIPP Site Boundary.

Except for the possible potash mining expansion discussed above, no significant increase in economic activity is forecast for the future within five miles (8 kilometers) of the WIPP facility.

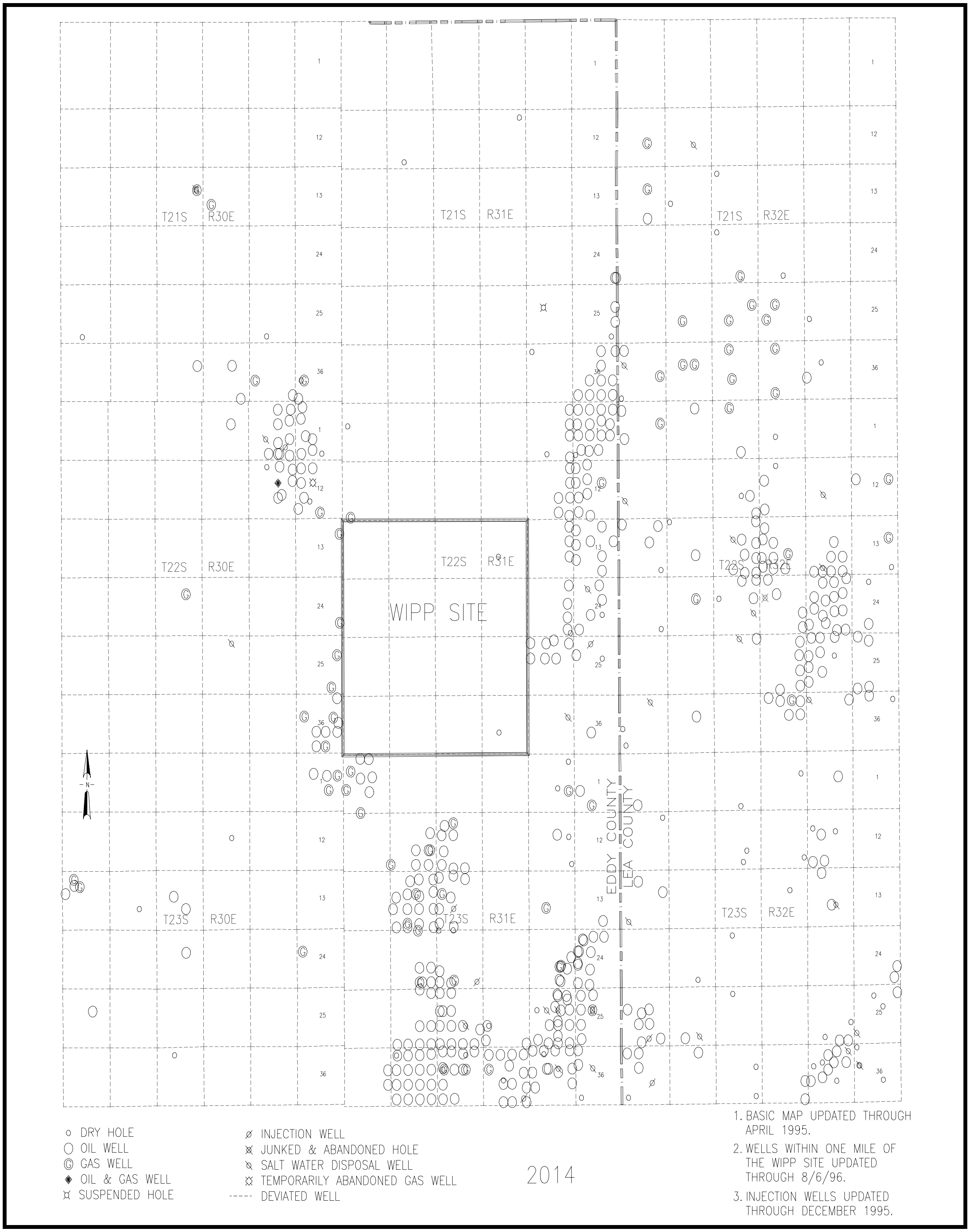


Figure 2.2-1, Natural Gas Wells,Oil Wells and Related Information Within a 10 Mile Radius

(1 kilometer = 0.62 miles)

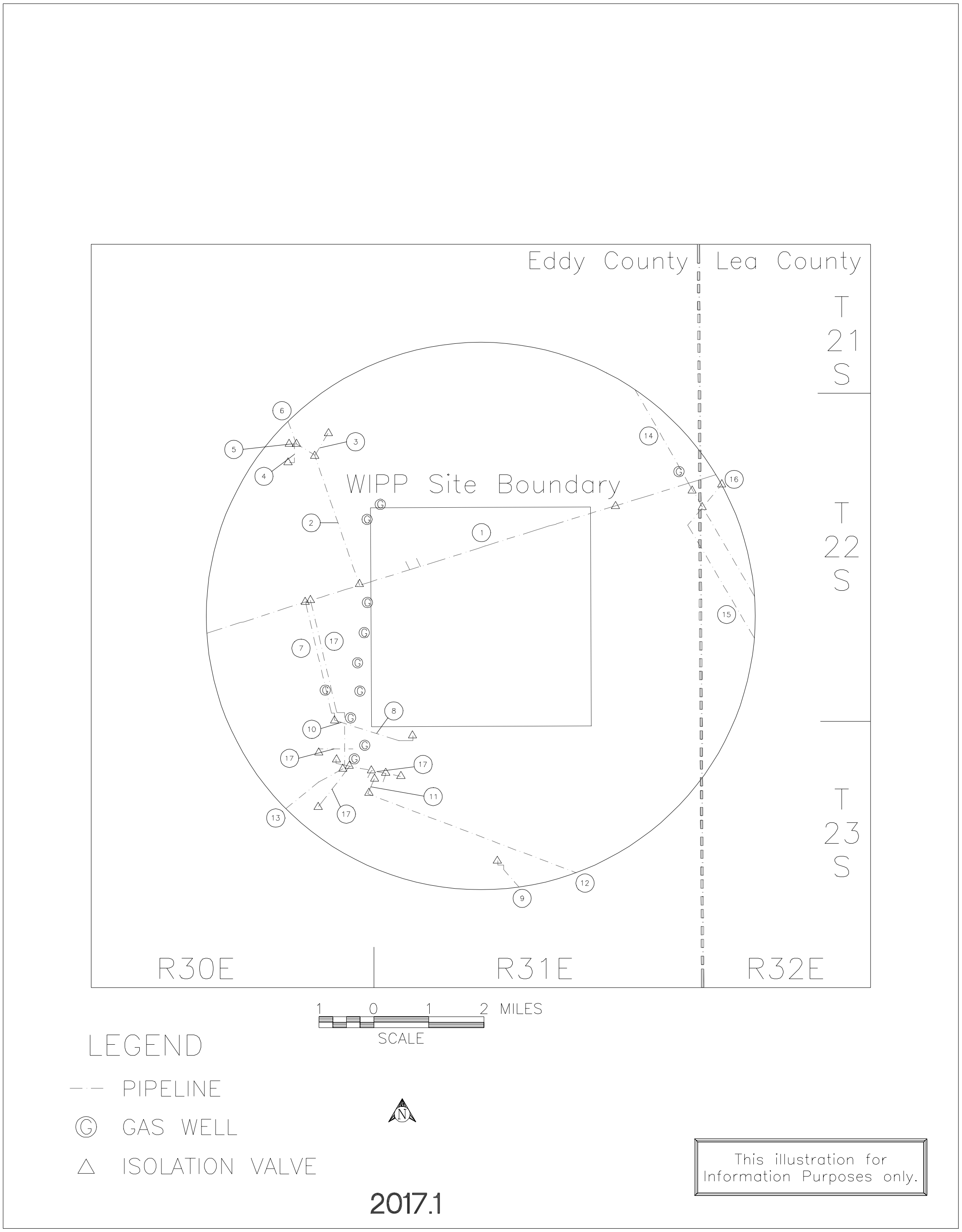


Figure 2.2-2a, 1995 Natural Gas Pipelines and Wells, 5 Mile Radius

(1 kilometer = 0.62 miles)

Figure 2.2-2b, Explanation to Figure 2.2-2a

1 El Paso Natural Gas Co., Eunice-Carlsbad Line (LC060762) 12.75" Dia Gas Line, Built 1945, Located 1.125 miles NNW of WIPP. Operating Pressure 721 PSIG, Burial Depth 24".

2 El Paso Natural Gas Co., James “A” No. 1 (NM17321) 4.5"/8.625" Dia Gas Line, Built 1974, Located 2.375 miles WNW of WIPP. Operating Pressure 721 PSIG, Burial Depth 24".

3 El Paso Natural Gas Co., Cabana No. 1 (NM18432) 4.5" Dia Gas Line, Built 1974, Located 4.25 miles NW of WIPP. Operating Pressure 721 PSIG, Burial Depth 24".

4 El Paso Natural Gas Co., James “E” No. 1 (NM19974) 4.5" Dia Gas Line, Built 1974, Located 4.25 miles NW of WIPP. Operating Pressure 721 PSIG, Burial Depth 24".

5 El Paso Natural Gas Co., El Paso “201" Spur Line (NM20125) 4.5" Dia Gas Line, Built 1974, Located 4.625 miles NW of WIPP. Operating Pressure 721 PSIG, Burial Depth 24".

6 El Paso Natural Gas Co., James “C” No. 1 (RW18344) 6.625" Dia Gas Line, Built 1974, Located 4.625 miles NW of WIPP. Operating Pressure 721 PSIG, Burial Depth 24".

7 El Paso Natural Gas Co., James Ranch Unit No. 1 (NM046228) (RW14190) 4.5" Dia Gas Line, Built 1958, Located 3.06125 miles WSW of WIPP. Operating Pressure 721 PSIG, Burial Depth 24".

8 El Paso Natural Gas Co., James Ranch Unit No. 7 (NM26987) 4.5" Dia Gas Line, Built 1976, Located 2.625 miles SW of WIPP. Operating Pressure 721 PSIG, Burial Depth 24".

9 El Paso Natural Gas Co., Arco State No. 1 (RW17822) 6.625" Dia Gas Line, Built 1971, Located 4.625 miles S of WIPP. Operation Pressure 837, Burial Depth 24".

10 El Paso Natural Gas Co., Lateral EE-4 (NM16959/(RW18065) 4.5" Dia Gas Line, Built 1973, Located 3.125 miles SW of WIPP. Operating Pressure 1200 PSIG, Burial Depth 36".

11 Natural Gas Pipeline Co. Of America, Lateral EE-6 Built 1974, 4.5" Dia Gas Line, Built 1974, Located 3.2 miles SSW of WIPP. Operating Pressure 1200 PSIG, Burial Depth 36".

12 Natural Gas Pipeline Co. Of America, Lateral EE-3 (NM16029) 8.625" Dia Gas Line, Built 1972, Located 3.4 miles SSW of WIPP. Operating Pressure 1200 PSIG, Burial Depth 36".

13 Natural Gas Pipeline Co. Of America, Lateral EE-7 (NM22471) 4.5" Dia Gas Line, Built 1974, Located 4.7 miles SW of WIPP. Operating Pressure 1200 PSIG, Burial Depth 36".

14 Transwestern Pipeline Co., West Texas Lateral (NM070224) 24" Dia Gas Line, Built 1960, Located 4.5 miles ENE of WIPP. Operating Pressure 1200 PSIG, Burial Depth 30".

15 Transwestern Pipeline Co., West Texas Lateral (NM8722) 30" Dia Gas Line, Built 1969, Located 4.25 miles ENE of WIPP. Operating Pressure 930 PSIG, Burial Depth 30".

16 Transwestern Pipeline Co., Monument Lateral (NM073482) 10" Dia Gas Line, Built 1960, Located 4.5 miles ENE of WIPP. Operating Pressure 930 PSIG, Burial Depth 30".

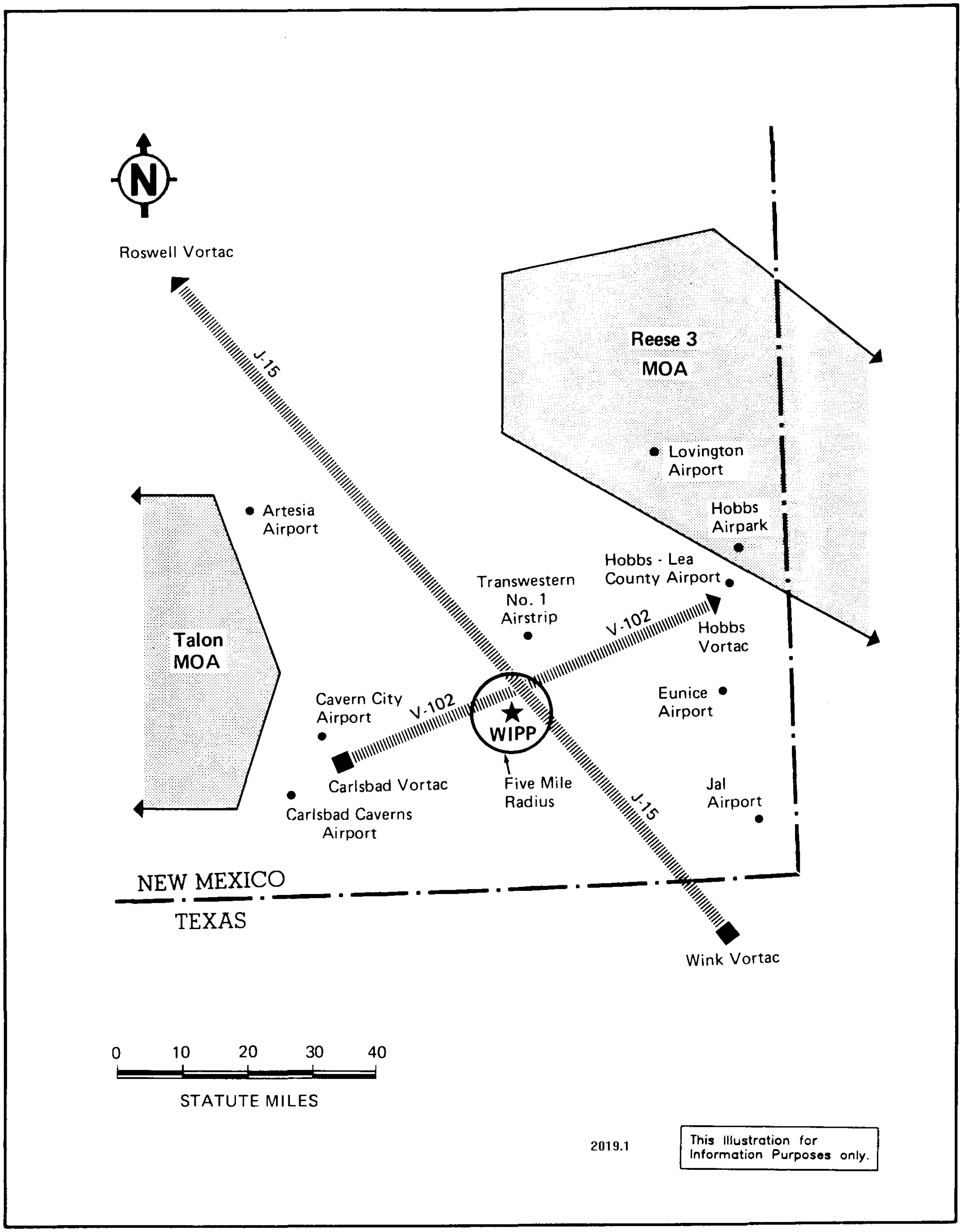


Figure 2.2-3, Airports and Aviation Routes Adjacent to the WIPP Facility

(1 kilometer = 0.62 miles)

Table 2.2-1, Aviation Routes Within 5 Miles (8 kilometers) of the WIPP Facility*

Name of Route	Altitude	Destination	Minimum Type	Origin and Flights/Day	Aircraft Flight Rule
FAA V-102	3,000 ft AGL	Carlsbad VORTAC Hobbs VORTAC	Commercial, military, and private	5**	IFR
FAA J-15	18,000 ft MSL	Wink VORTAC Roswell VORTAC	Commercial military, and private	23	IFR

*U.S. Department of Transportation, Federal Aviation Administration, Air Traffic Service, "En Route IFR Peak Day Charts, FY 1976."

**Flights per day on V-102 does not include aircraft operating under Visual Flight Rules.

NOTE: 1976 was the last year day charts were logged by FAA. Local airfield does not monitor this information.

2.3 Demographics and Land Use in the Carlsbad Resource Area

2.3.1 Demographics

The WIPP is located in the Southeastern part of Eddy County, near Lea County. The population density of Eddy County is 11.63 persons per square mile (4.49 persons /km^2); the Lea County population density is 12.69 persons per square mile (4.90 persons/km^2) (Census of Population).[1]

Demographics for the communities surrounding the WIPP site are listed below, by county.

EDDY COUNTY

Community	Population	Location Relative to the WIPP Site
Artesia	10,610	53 miles (85.3 kilometers) northwest
Carlsbad	24,896	26 miles (41.8 kilometers) west
Loving	1,243	18 miles (29.0 kilometers) west-southwest
Total Eddy County	48,605	

LEA COUNTY

Community	Population	Location, Relative to the WIPP Site
Eunice	2,731	40 miles (64.4 kilometers) east
Hobbs	29,115	40 miles (64.4 kilometers) east
Jal	2,153	45 miles (72.4 kilometers) southeast
Lovington	9,322	50 miles (80.5 kilometers) northeast
Total Lea County	55,765	

2.3.2 Land Use at the WIPP Site

At present, land within 10 miles (16 kilometers) of the site is used for potash-mining operations, active oil and gas wells, and grazing. This pattern is expected to change little in the future.

The *Waste Isolation Pilot Plant Land Withdrawal Act* (LWA) (Public Law 102-579 as amended by Public Law 104-201),[2] provides the DOE with lands for operation of the WIPP project. The law provides for the transfer of the WIPP site lands from the Department of the Interior (DOI) to the DOE and effectively withdraws the lands, subject to existing rights, from entry, sale, or disposition; appropriation under mining laws; and operation of the mineral and geothermal leasing laws. The LWA directed the Secretary of Energy to produce a management plan to provide for grazing, hunting and trapping, wild life habitat, the disposal of salt, and tailings and mining (PTB).[3]

There are no hydrocarbon production wells within the volumetric boundary defined by the LWA. One active well, referred to as James Ranch 13, was drilled in 1982 to tap gas resources beneath Section 31. This well was initiated in Section 6, outside the WIPP site boundary. The well enters Section 31 below a depth of 6,000 feet (1,829 meters) beneath ground level (PTB).[3]

Grazing leases have been issued for all land sections immediately surrounding the WIPP, with the exception of the 277 acre (112.1 hectare) Exclusive Use Area[5]. Grazing within the WIPP site lands operates within the authorization of the Taylor Grazing Act of 1934, the Federal Land Policy and Management Act (FLPMA), the Public Rangelands Improvement Act of 1978, and the Bankhead-Jones Farm Tenant Act of 1973. The responsibilities of the DOE include supervision of ancillary activities associated with grazing (e.g., wildlife access to livestock water development, assure water developments inside WIPP lands are configured according to the regulatory requirements, etc.) and ongoing coordination with respective allottees. Administration of grazing rights, including the collection of grazing fees, shall be in cooperation with the BLM in accordance with an existing Memorandum of Understanding (MOU) and the coinciding Statement of Work through guidance established in the East Roswell Grazing Environmental Impact Statement (DOE/WIPP 94-2033).[4] Portions of two grazing allotments administered by the BLM fall within the land withdrawal area: Livingston Ridge (No. 77027), and Antelope Ridge (No. 77032) (DOE/WIPP 93-004).[5]

2.3.2.1 Land Use in the Carlsbad Resource Area

Major land uses in the Carlsbad resource area include potash mining and oil and gas recovery (discussed previously), and ranching, farming, recreation, and tourism.

2.3.2.1.1 Ranching

There are 286 ranching units in the Carlsbad resource area (New Mexico Agricultural Statistics).[6] The approximate areas, in acres (1 hectare= 2.47 acre), are as follows:

County	Total	Federal	State	Deeded
Eddy	2,675,000	1,627,827	577,225	470,149
Lea	2,812,160	416,960	1,199,221	1,195,979

The number of livestock located on these ranching units will vary depending upon grazing conditions. However, the number of livestock (in head) for the Carlsbad resource area as reported in the 1993 *New Mexico Agricultural Statistics*[6] are:

County	Cattle	Dairy Herd	Sheep	Goats/ Horses/Pigs
Eddy	25,000	9,100	12,000	1,200
Lea	22,000	7,200	5,800	1,560

2.3.2.1.2 Farming

There are approximately 160,000 acres (64,750 hectare) of farmland in the Carlsbad resource area. The principal crops grown include cotton, alfalfa, and sorghum grains. There are also significant quantities of pecans grown in this area, and minor amounts of truck vegetables.

2.3.2.1.3 Recreation

Due to the topography, climatic conditions, and wildlife in the area of the WIPP site, an extensive (non-facility based) variety of recreational opportunities are available to include: hunting for both big and small game animals; camping; horseback riding; hiking; watching wildlife (e.g., bird watching); and sightseeing. The WIPP area contains significant biodiversity in addition to historic and prehistoric sites. These offer rewarding opportunities for scientific research and interpretive recreation.

2.3.2.1.4 Tourism

There are two national parks (Guadalupe Mountains and Carlsbad Caverns), a national forest (Lincoln), and two state parks (Living Desert Zoo and Gardens, and Brantley) located within or near the Carlsbad resource area. The Carlsbad Caverns National Park, which is 36 miles (58 kilometers) southeast of the WIPP site, has approximately 1 million visitors per year. There are three dams on the Pecos River that provide recreational activities during the summer months. The closest surface water to WIPP (the Pecos River) is located about 12 miles (19.3 kilometers) away.

References for Section 2.3

1 Census of Population, General Population Characteristics of New Mexico, Bureau of the Census. U.S. Department of Commerce, 1990

2 Public Law 102-579, Waste Isolation Pilot Plant Land Withdrawal Act, U.S. Congress, 1992 [as amended by Public Law 104-201].

3 WIPP-CAO-95-1014, Project Technical Baseline for Regulatory Compliance (PTB), United States Department of Energy, Carlsbad, N.M., Rev. 0, April 20, 1995.

4 DOE/WIPP 94-2033, Waste Isolation Pilot Plant Annual Site Environmental Report for Calendar Year 1993, September, 1994, Carlsbad, NM, 1994a.

5 DOE/WIPP 93-004, Waste Isolation Pilot Plant Land Management Plan, 1993b.

6 New Mexico Agricultural Statistics, U. S. Department of Agriculture, New Mexico Agricultural Statistics Service, Las Cruces, NM, 1993.

2.4 Meteorology

2.4.1 Recent Climatic Conditions

Current climatic conditions are provided to allow for the assessment of impacts of these factors on the disposal unit and the site. The WIPP facility does not rely on climatic conditions to control waste migration; however, meteorological information is used in the evaluation of the air pathway during operation of the facility.

2.4.1.1 General Climatic Conditions

The climate of the region is semiarid, with generally mild temperatures, low precipitation and humidity, and a high evaporation rate. Winds are mostly from the southeast and moderate. In late winter and spring, there are strong west winds and dust storms. During the winter, the weather is often dominated by a high-pressure system situated in the central portion of the western United States and a low-pressure system located in north-central Mexico. During the summer, the region is affected by a low-pressure system normally situated over Arizona.[1]

2.4.1.2 Regional Meteorological Conditions for Design and Operating Bases

2.4.1.2.1 Heavy Precipitation

The maximum 24-hour rainfall at Roswell was 5.65 inches (14.4 cm) in November 1901.[2] The maximum 24-hour snowfall in Roswell was 15.3 inches (38.9 cm) in December 1960. The greatest snowfall during a 1-month period was 23.3 inches (59.2 cm) in February 1905.[3]

2.4.1.2.2 Thunderstorms and Hail

The region has about 40 thunderstorm days annually. About 87.5% of these occur from May to September.[2] A thunderstorm day is recorded if thunder is heard; but, the thunderstorm record is not related to observations of rain or lightning and does not indicate the severity of storms in the region.

Hail usually occurs in April through June and is not likely to develop more than three times a year. During a 39-year period at Roswell, hail was observed 97 times (about 2.5 times a year), occurring nearly two thirds of the time between April and June.[4] For the 1° square (32° to 33° N by 103° to 104°W) surrounding the WIPP facility, hailstones 0.75 inches (1.9 cm) and larger were reported eight times from 1955 to 1967 (slightly less than once a year).

2.4.1.2.3 Tornadoes

For the period 1916-1958, 75 tornadoes were reported in New Mexico on 58 tornado days.[5] Data for 1953 through 1976 indicate a state wide total of 205 tornadoes on 152 tornado days,[6] or an average of 9 tornadoes a year on 6 tornado days. The greatest number of tornadoes in 1 year was 18 in 1972; the least was 0 in 1953. The average tornado density in New Mexico during this period was 0.7 per 1,000 mi^2 (2,590 km^2). Most tornadoes occur in May and June.[7] From 1955 through 1967, 15 tornadoes were reported within the 1° square containing the WIPP surface facility.[8]

H.C.S. Thom has developed a procedure for estimating the probability of a tornado striking a given point.[9] The method uses a mean tornado path length and width and a site specific frequency. Applying Thom's method to the WIPP facility yields a point probability of 0.00081 on an annual basis, or a recurrence interval of 1,235 years. An analysis by Fujita yields a point tornado recurrence interval of 2,832 years in the Pecos River Valley.[10]

According to Fujita, the WIPP design basis tornado with a million year return period has a maximum wind speed of 183 mi/h (294.6 km/hr), translational velocity of 41 mi/h (66 km/hr), a maximum rotational velocity radius of 325 ft (99.1 km), a pressure drop of 0.5 lb/in^2 (3.4 kPa), and a pressure drop rate of 0.09 lb/in^2/s (0.62 kPa/s).

2.4.1.2.4 Freezing Precipitation

The region of the WIPP facility has about 1 day of freezing rain or drizzle a year.[4] An ice accumulation of more than 0.25 inch (0.63 cm) has not been observed. Any ice accumulation that does occur is thin because of the scarcity of precipitation during the winter months and because daytime temperatures rise well above freezing.

2.4.1.2.5 Strong Winds

The maximum 1-min wind speeds recorded at Roswell are shown in Table 2.4-1. The fastest 1-min wind ever recorded at Roswell was 75 mi/h (120.7 km/h) from the west in April 1953.[11] Windstorms with speeds of 50 knots (93 km/hr) or more occurred ten times (during the period between 1955 and 1967) about one a year.[7] The mean recurrence interval for annual high winds at 30 ft (9.1 m) above the ground in south eastern New Mexico is shown in Table 2.4-2.[9,12] The 100-year recurrence 30-foot (9.1 m) level wind speed in southeastern New Mexico is 82 mi/h (132 km/hr). Based on a gust factor of 1.3,[13] the highest instantaneous gust expected once in 100 years at 30 ft (9.1 m) above grade is 107 mi/h (172.2 km/h). The vertical wind profile for two 100-year recurrence intervals has been estimated from the 30-foot (9.1 m) values using the 1/7 power law[16] and is presented in Table 2.4-2.

2.4.1.2.6 Restrictive Dispersion Conditions

Hosler[14] and Holzworth[15] analyze records from several National Weather Service stations with the objectives of characterizing atmospheric dispersion potential. Seasonal and annual frequencies of inversions based at or below 500 ft (152.4 m) for the WIPP facility region are shown in Table 2.5-3. Most of these inversions are diurnal (radiation-induced) and occur because the radiation cooling at the earth's surface is increased by conditions that frequently exist at the WIPP facility. The conditions are lack of moisture, clear skies and low air density. When these conditions exist in the early morning, radiation lost from the surface is not adequately absorbed and reradiated by upper level air to heat the air at the surface sufficiently. Consequently, the air at the surface quickly becomes cooler than the upper level air and the colder surface air becomes trapped.

Holzworth gives estimates of the average depth of vertical mixing, which indicates the thickness of the atmospheric layer available for the mixing and dispersion of effluents.[15] The seasonal afternoon mixing heights for the region (Table 2.4-4) range from 1,320 meters (4,329.6 ft) in winter to 3,050 meters (10,004 ft) in summer. Seasonal morning mixing heights in the region range from 300 meters (984 ft) in winter to 680 meters (2,230.4 ft) in summer.

2.4.1.2.7 Sandstorms

Blowing dust or sand may occur occasionally in the region due to the combination of strong winds, sparse vegetation and the semiarid climate. High winds associated with thunderstorms are frequently a source of localized blowing dust. Dust storms covering an extensive area are rare, and those that reduce visibility to less than 1 mi (1.6 km) occur only with the strongest pressure gradients such as those associated with intense extratropical cyclones which occasionally form in the region during winter and early spring. Winds of 50 to 60 mi/h (80.5 to 96.6 km/h) and higher may persist for several days if these pressure systems become stationary.[3] Ten windstorms of 58 mi/h (93.4 km/h) and greater were reported during 1955-1967 within the 1° square in which the WIPP facility is located.[7] Blowing dust or sand may reduce visibility to less than 5 mi (8.0 km) over an area of thousands of square miles. However, restrictions of less than 1 mi (1.6 km) are quite localized and depend on soil type, conditions, cultivation practices and vegetation in the immediate area.[3]

2.4.1.2.8 Snow

The 100-year recurrence maximum snowpack for the WIPP facility region is 10 lb/ft^2 (0.5 kPa).[12] The probable maximum winter precipitation (PMWP) in the WIPP facility region is taken to be the probable maximum 48-hour precipitation during the winter months of December through February. The PMWP for the WIPP facility is estimated to be 12.8 inches (32.5 cm) of rain (i.e., 66 lb/ft^2 or 3.2 kPa).[16,17] The snowload for the WIPP facility is calculated (ground level equivalent) to be 27 lb/ft^2 (1.3 kPa). Specific roof loads are estimated based on ANSI's methodology.[12]

2.4.2 Local Meteorology

2.4.2.1 Data Sources

On site meteorological data (hourly) are used to characterize the local meteorology of the WIPP facility.

2.4.2.2 Temperature Summary

Temperatures are moderate throughout the year, although seasonal changes are distinct. The mean annual temperature in southeastern New Mexico is 63°F (17.2°C). In the winter (December through February), night-time lows average near 23°F (-5°C), and average maxima are in the 50s. The lowest recorded temperature at the nearest Class-A weather station in Roswell was -29°F (-33.8°C) in February 1905. In the summer (June through August), the day-time temperature exceeds 90°F (32.2°C) approximately 75 percent of the time.[1] The National Weather Service documented a measurement of 122°F (50°C) at the WIPP site as the record high temperature for New Mexico. This measurement occurred on June 27, 1994. Table 2.4-5 shows the annual average, maximum, and minimum temperatures from 1990 through 1994.

2.4.2.3 Precipitation Summary

Precipitation is light and unevenly distributed throughout the year, averaging 13 inches (33 centimeters) for the past five years. Winter is the season of least precipitation, averaging less than 0.6 inches (1.5 centimeters) of rainfall per month. Snow averages about 5 inches (13 centimeters) per year at the site and seldom remains on the ground for more than a day at a time because of the typically above-freezing temperatures in the afternoon. Approximately half the annual precipitation comes from frequent thunderstorms in June through September. Rains are usually brief but occasionally intense when moisture from the Gulf of Mexico spreads over the region.[1] Monthly average, maximum, and minimum precipitations recorded at the WIPP site from 1990 through 1994 are summarized in Figure 2.4-1.

2.4.2.4 Wind Speed and Wind Direction Summary

The frequencies of wind speeds and directions are depicted by windroses in Figures 2.4-2 through 2.4-6 for the WIPP site, and Figures 2.4-7 through 2.4-11 for Carlsbad, New Mexico. In general, the predominant wind direction at the WIPP site is from the southeast, and the predominant wind directions in Carlsbad are from the south, southeast, and west.

2.4.2.5 Topography

The land surface in the vicinity of the WIPP facility is a semiarid, wind blown plain sloping gently to the west and southwest. Its surface is made somewhat hummocky by an abundance of sand ridges and dunes. The average slope within a 3-mile (4.8 km) radius is about 50 ft/mi (9.5 m/km) from the east to west.

A plot of terrain profiles from the center of the WIPP facility out to 5 miles (8.1 km) is presented in Figure 2.4-12 for each of the 16 direction sectors.

References for Section 2.4

1 DOE/EIS-0026, Final Environmental Impact Statement, Waste Isolation Pilot Plant, U.S. Department of Energy, Washington, DC, 1980.

2 Weather Bureau Technical Paper No. 2, Maximum Recorded U.S. Point Rainfall, (Rev.) U.S. Department of Commerce, 1963.

3 Climates of the States, Vol. 2 - Western States, Roswell, New Mexico, U.S. National Oceanic and Atmospheric Administration (NOAA), Water Information Center, Inc., Port Washington, NY, 1974.

4 Technical Report EP-83, Hail Size and Distribution, U.S. Army, Quartermaster Research and Engineering Center, 1958.

5 Technical Paper No. 20, Tornado Occurrences in the United States, U.S. Department of Commerce, 1960.

6 Climatological Data National Summary, National Oceanic and Atmospheric Administration (NOAA), 1976.

7 Technical Memorandum WBTM FCST 12, Severe Local Storm Occurrence, 1955-1957, Environmental Sciences and Services Administration (ESSA), U.S. Department of Commerce, Silver Spring, 1969.

8 WASH 1300, Technical Basis for Interim Regional Tornado Criteria, U.S. Atomic Energy Commission, Washington, DC.

9 Monthly Weather Review, Tornado Probabilities, November-December, 1963.

10 SMRP Research Paper No. 155, A Site-Specific Study of Wind and Tornado Probabilities at the WIPP Site in Southeast-New Mexico, Research Project, Department of Geophysical Sciences, University of Chicago, 1978.

11 Environmental Data Service, June 1968, Weather Atlas of the United States, (originally titled Climatic Atlas of the United States), reprinted in 1975 by Gale Research Co.

12 ANSI A58.1-1972, Building Code Requirements for Minimum Design Loads in Buildings and Other Structures, Revision of A58.1-1955, American National Standards Institute, Inc., July 1972.

13 DGAF 140, Relations Between Gusts and Average Wind Speeds for Housing Load Determination, Daniel Guggenheim, Airship Institute, Cleveland, Ohio, 1946.

14 Monthly Weather Review, 89 (9), Low-Level Inversion Frequency in the Contiguous United States, 1961.

15 U.S. Environmental Protection Agency (EPA), Mixing Heights, Wind Speeds and Potential for Urban Air Pollution Throughout the Contiguous United States, Research Triangle Park, North Carolina, 1972.

16 Hydrometeorological Report No. 33, Seasonal Variations of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours, Weather Bureau, 1956.

17 Housing and House Finance Agency, Snow Load Studies, Office of the Administrative Division of Housing Research, 1956.

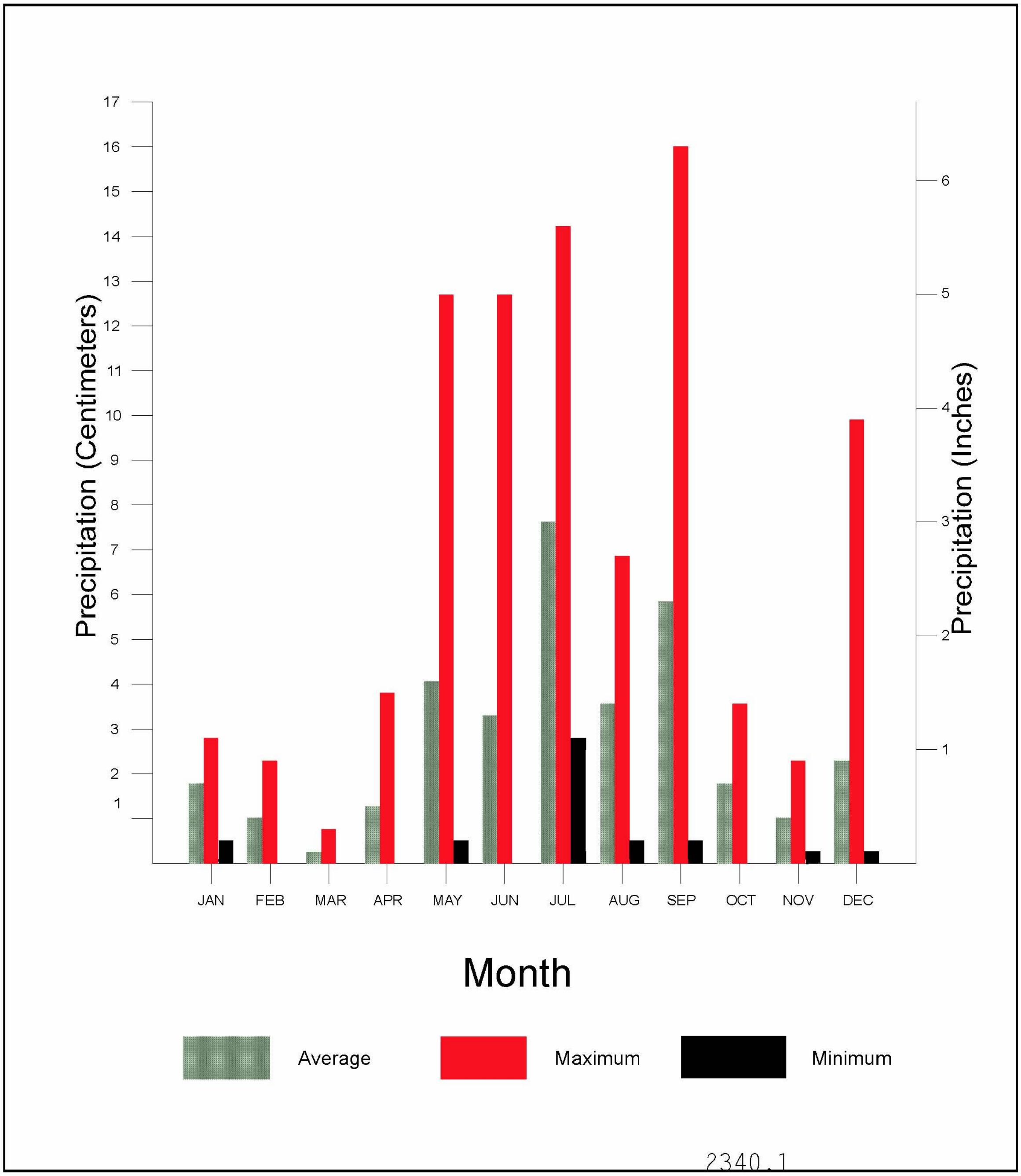


Figure 2.4-1, Monthly Precipitation for the WIPP Site from 1990 through 1994

Figure 2.4-2, 1990 Annual Windrose - WIPP Site (figure unavailable)

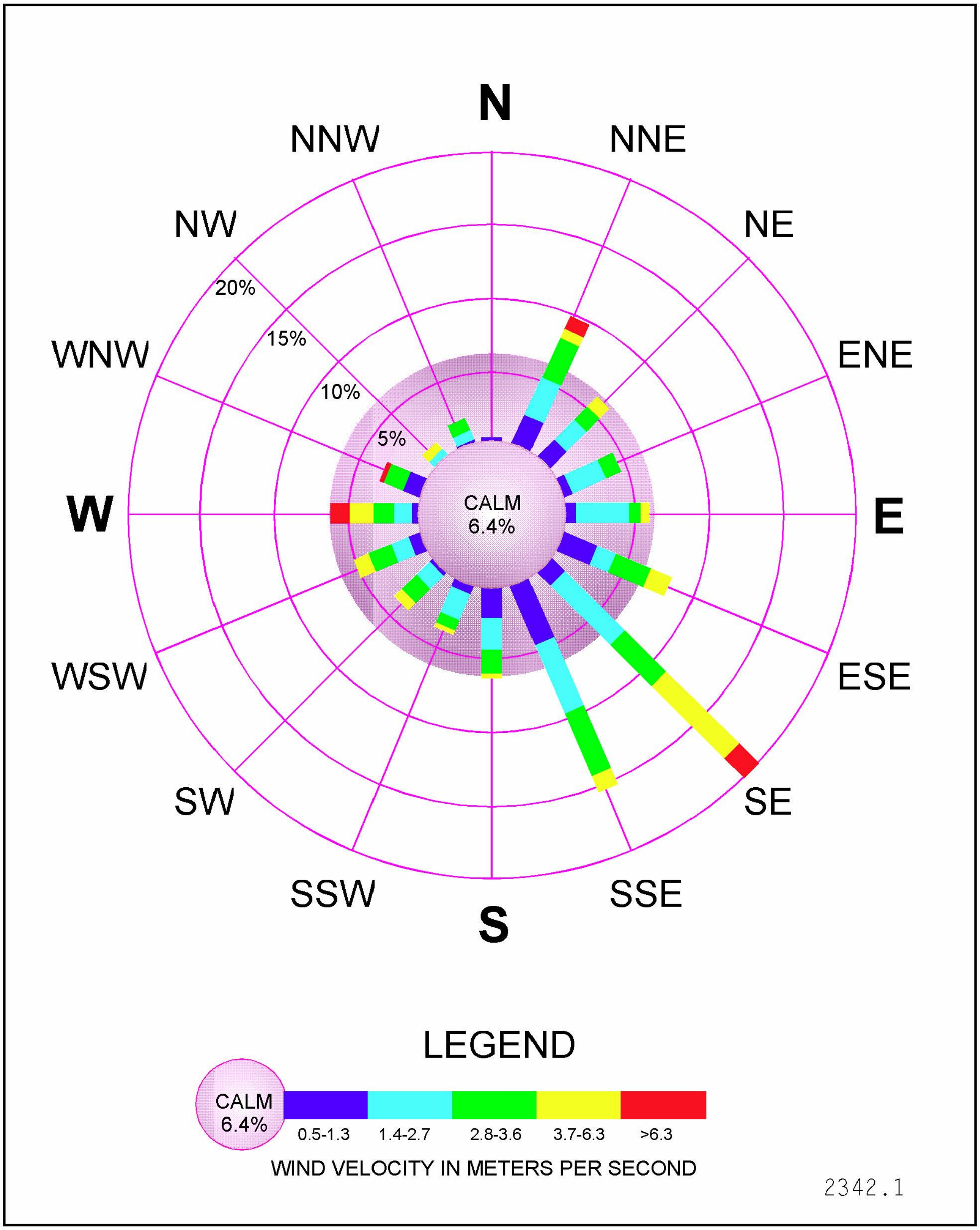


Figure 2.4-3, 1991 Annual Windrose - WIPP Site

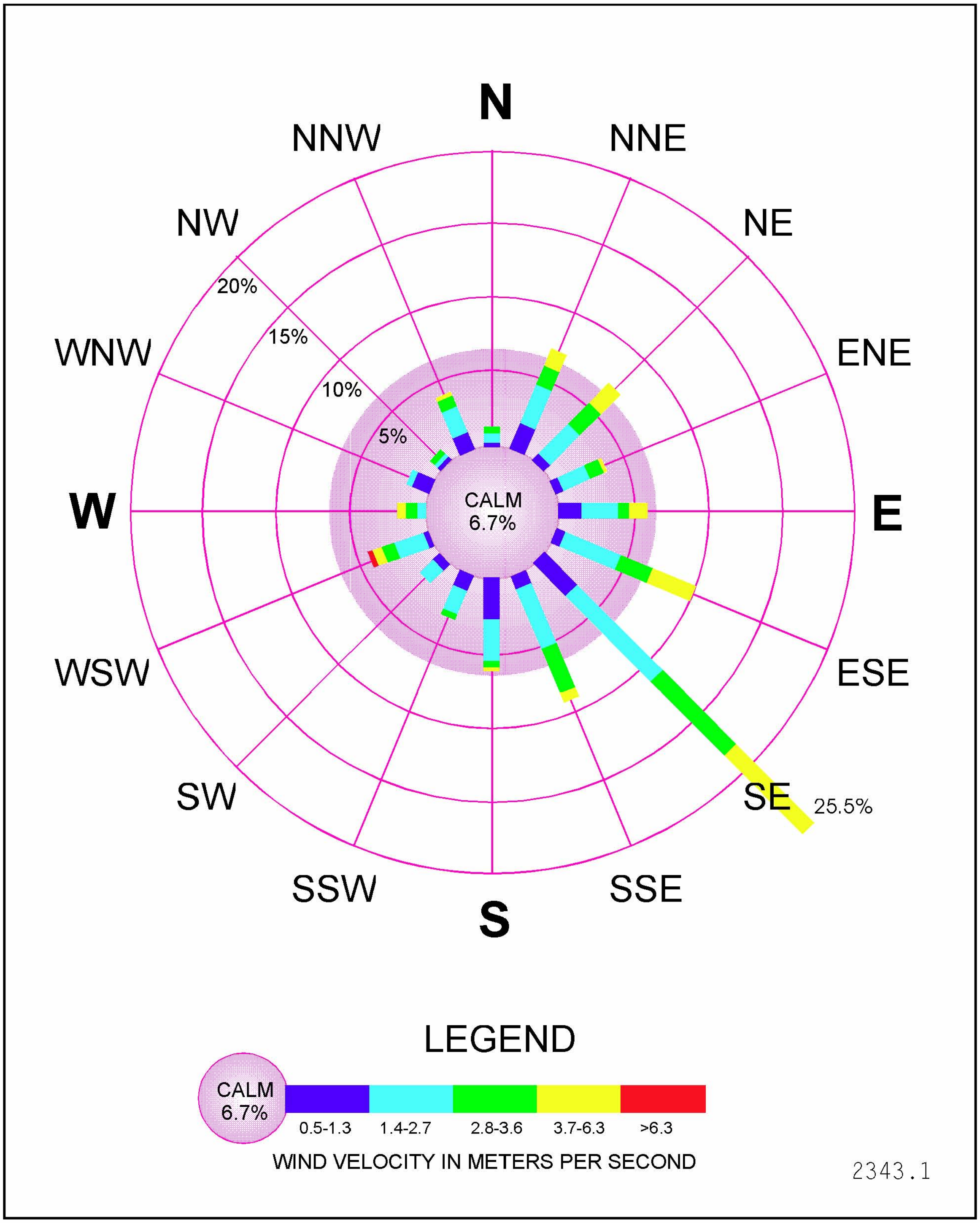


Figure 2.4-4, 1992 Annual Windrose - WIPP Site

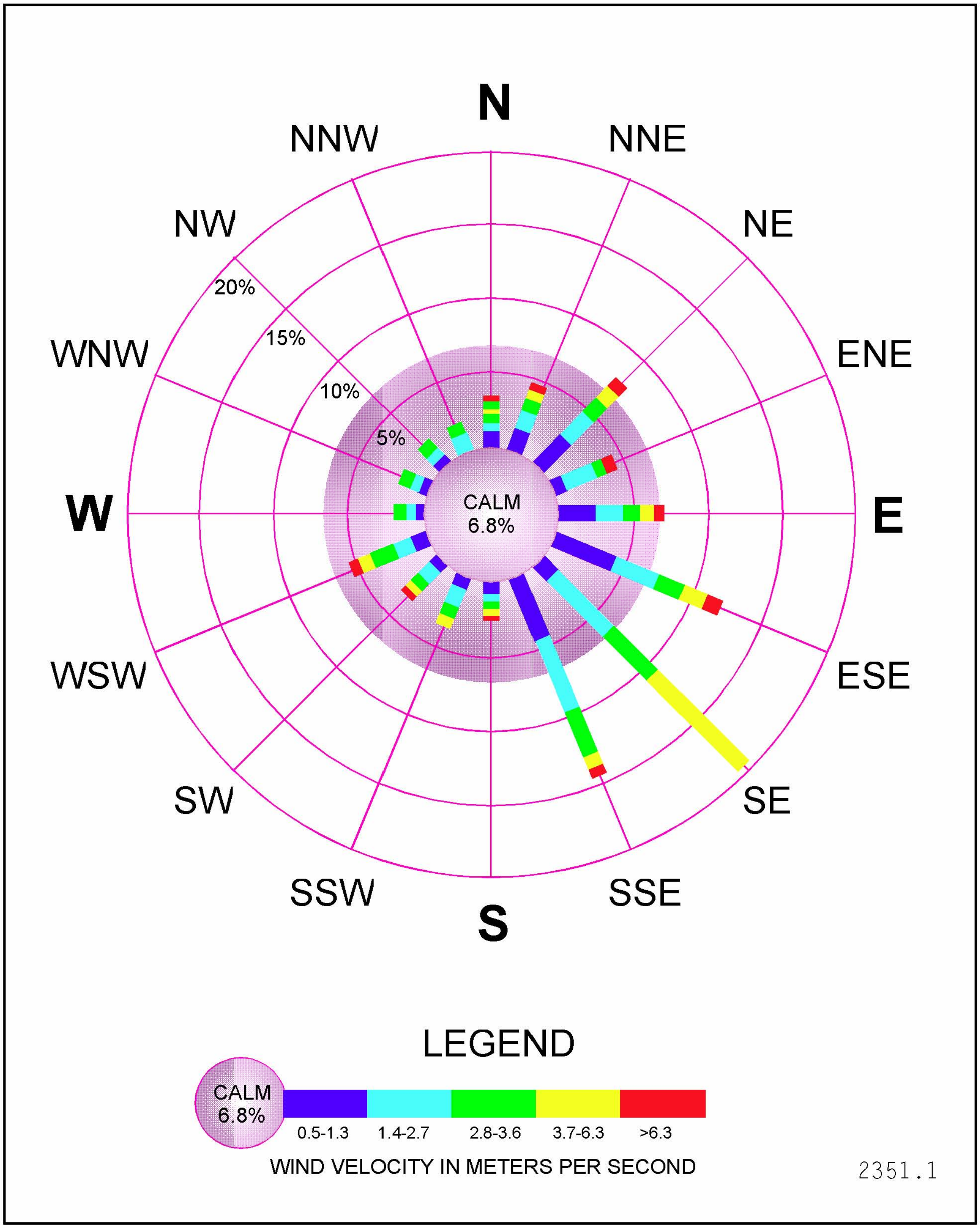


Figure 2.4-5, 1993 Annual Windrose - WIPP Site

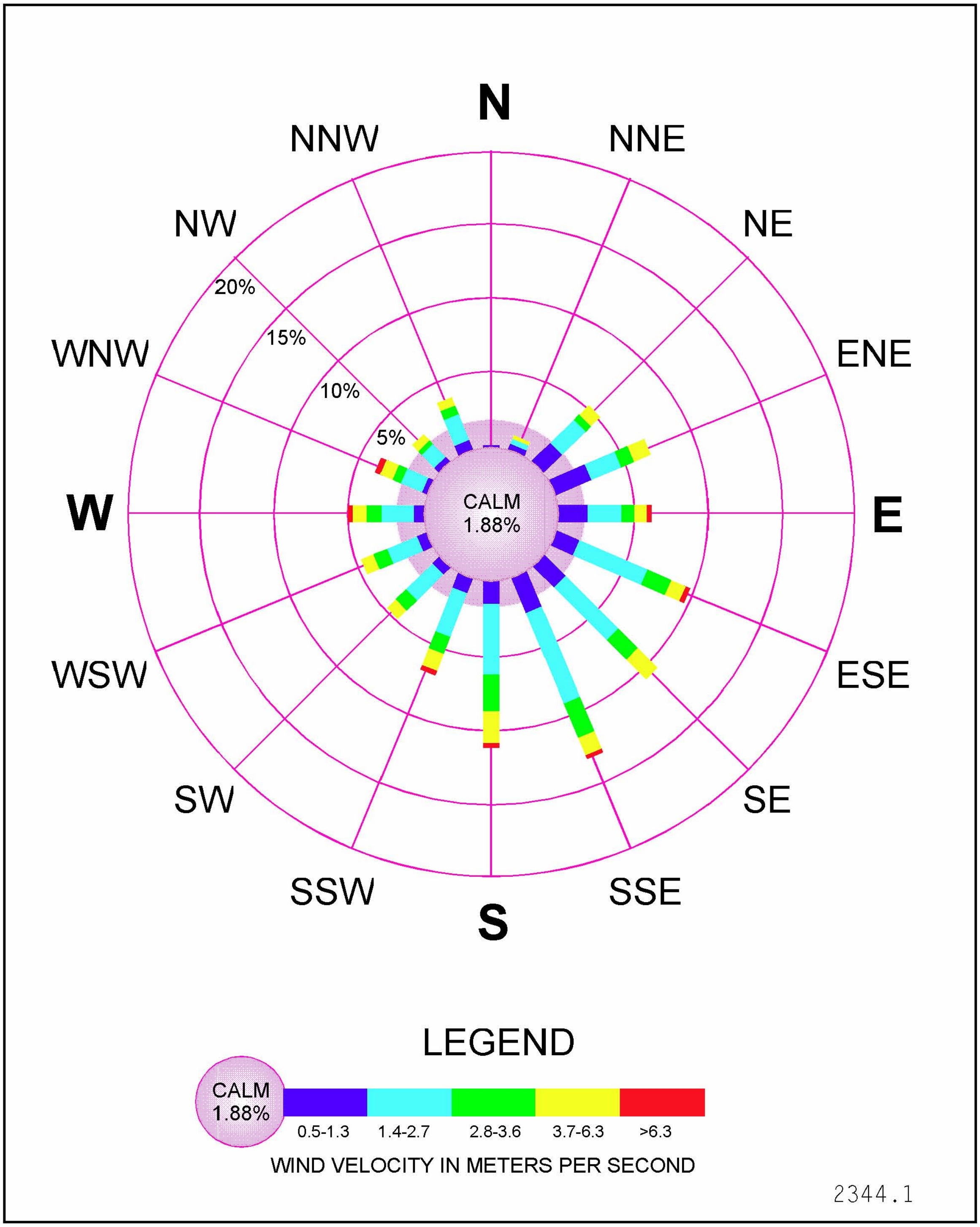


Figure 2.4-6, 1994 Annual Windrose - WIPP Site

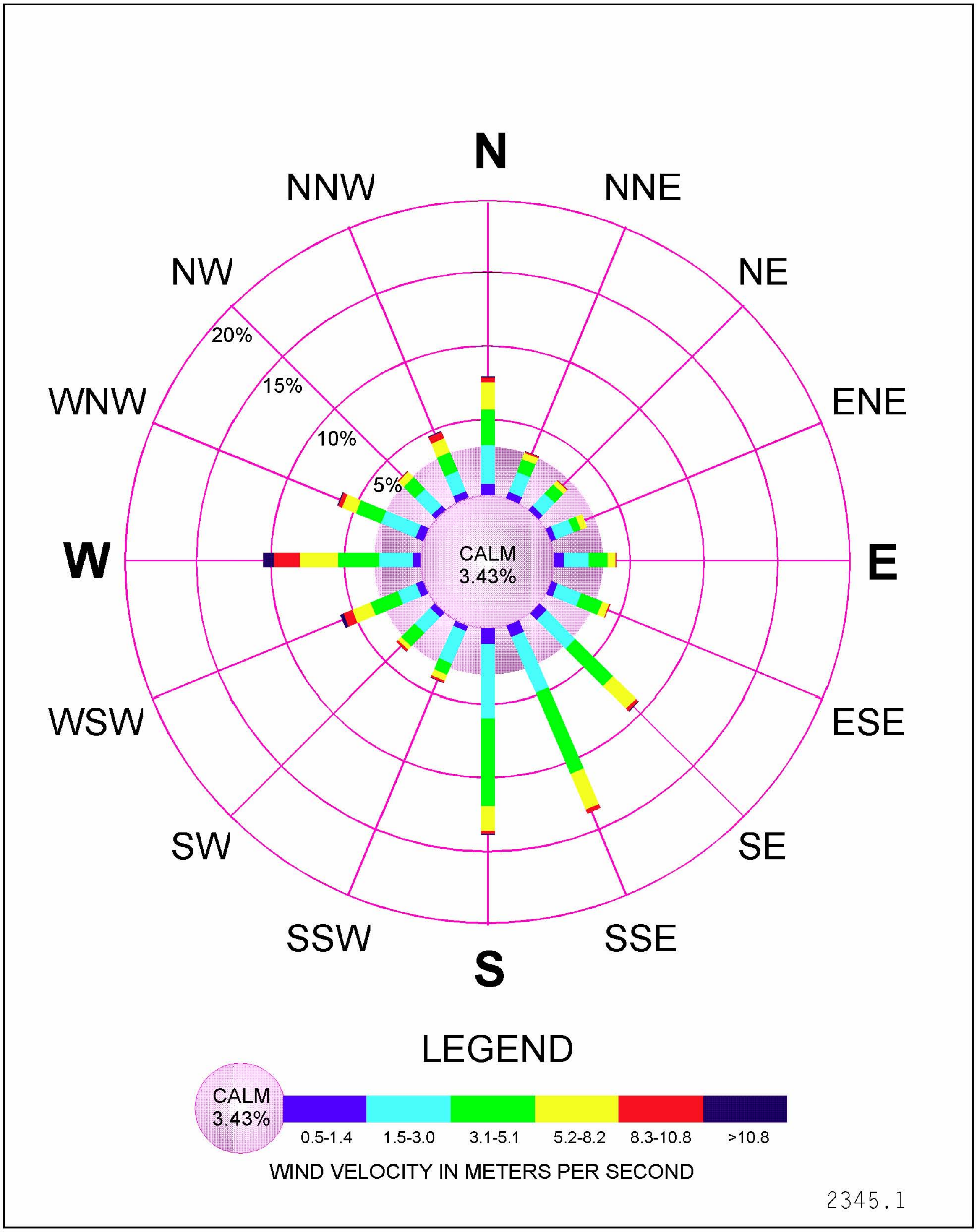


Figure 2.4-7, 1990 Annual Windrose - Carlsbad

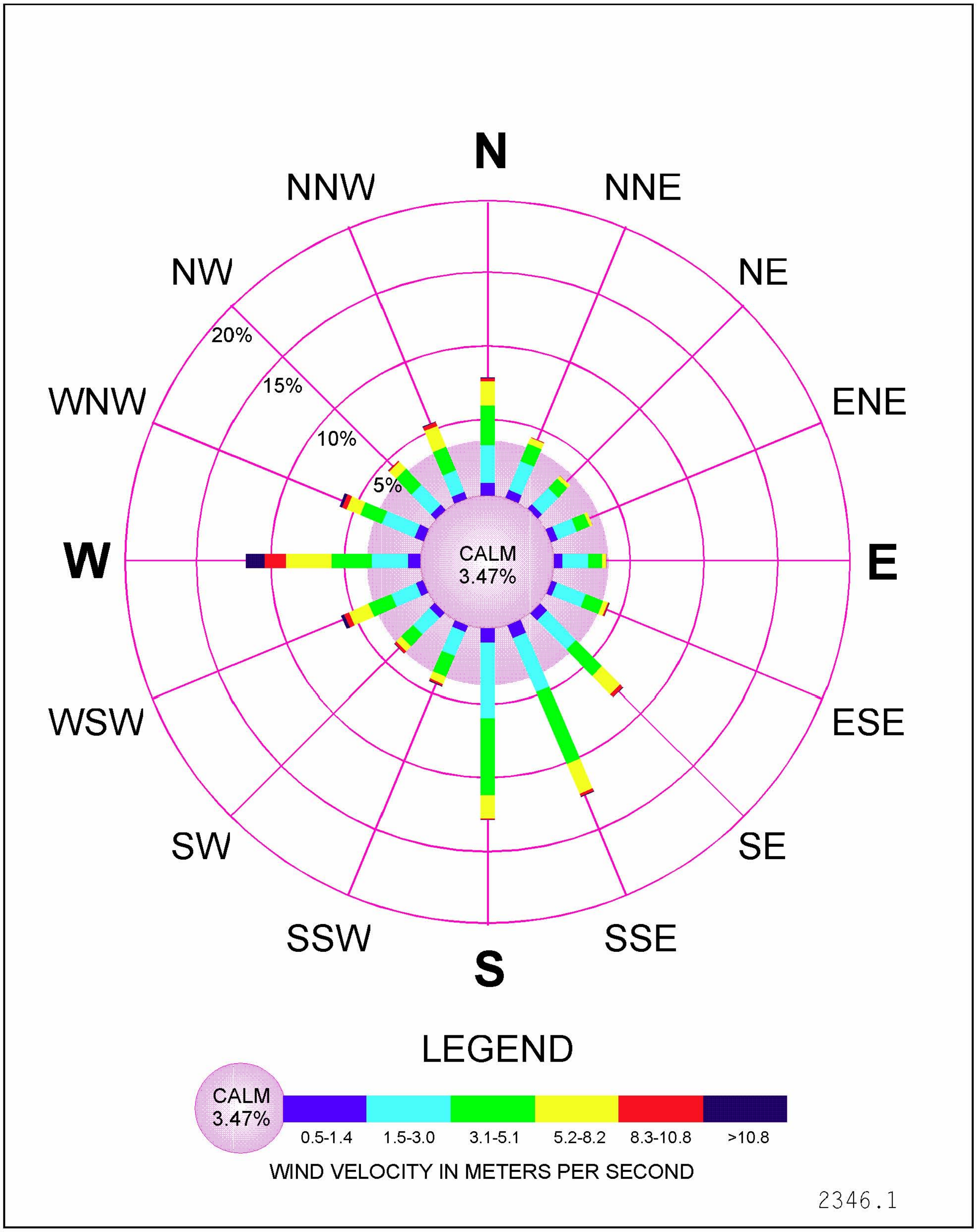


Figure 2.4-8, 1991 Annual Windrose - Carlsbad

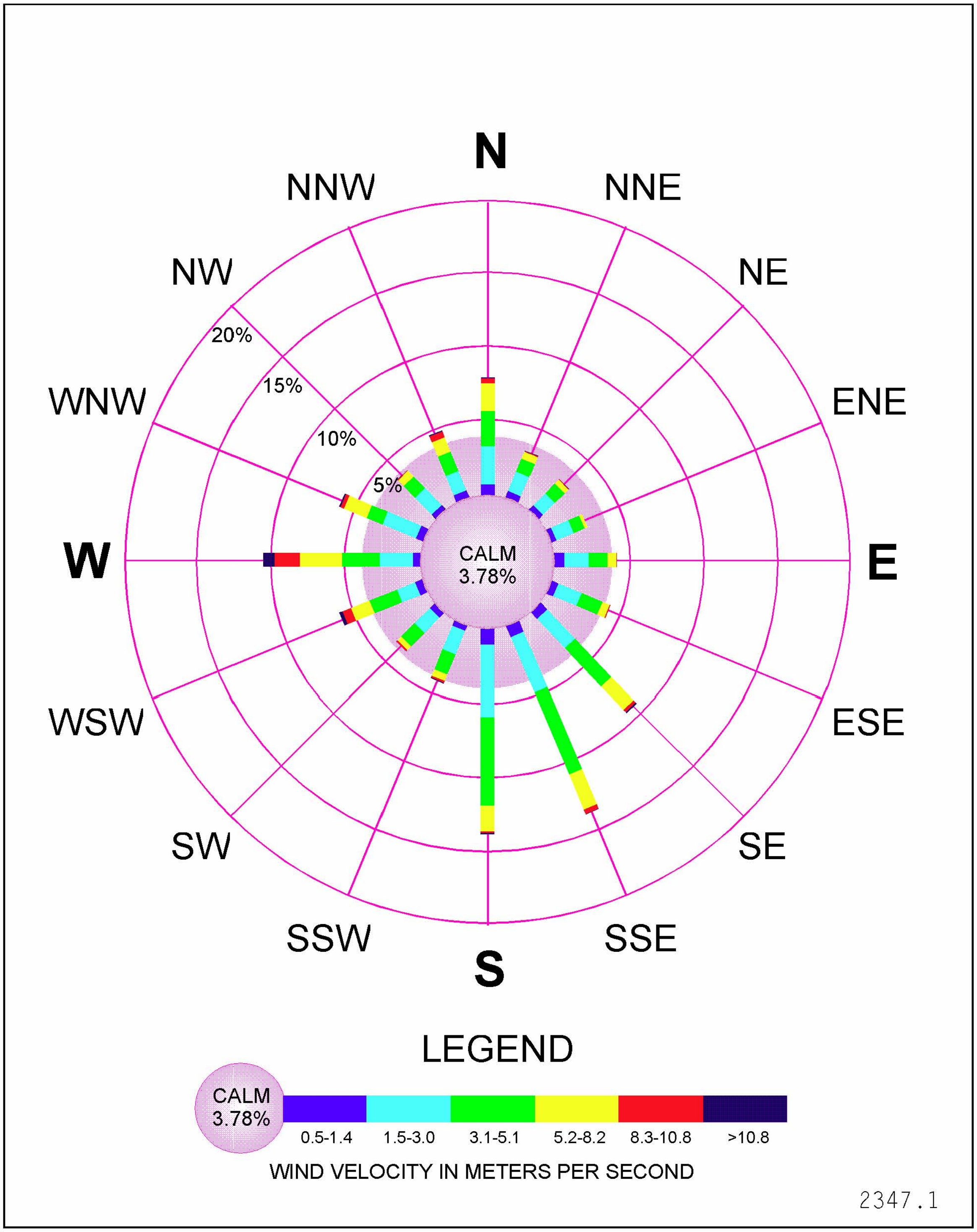


Figure 2.4-9, 1992 Annual Windrose - Carlsbad

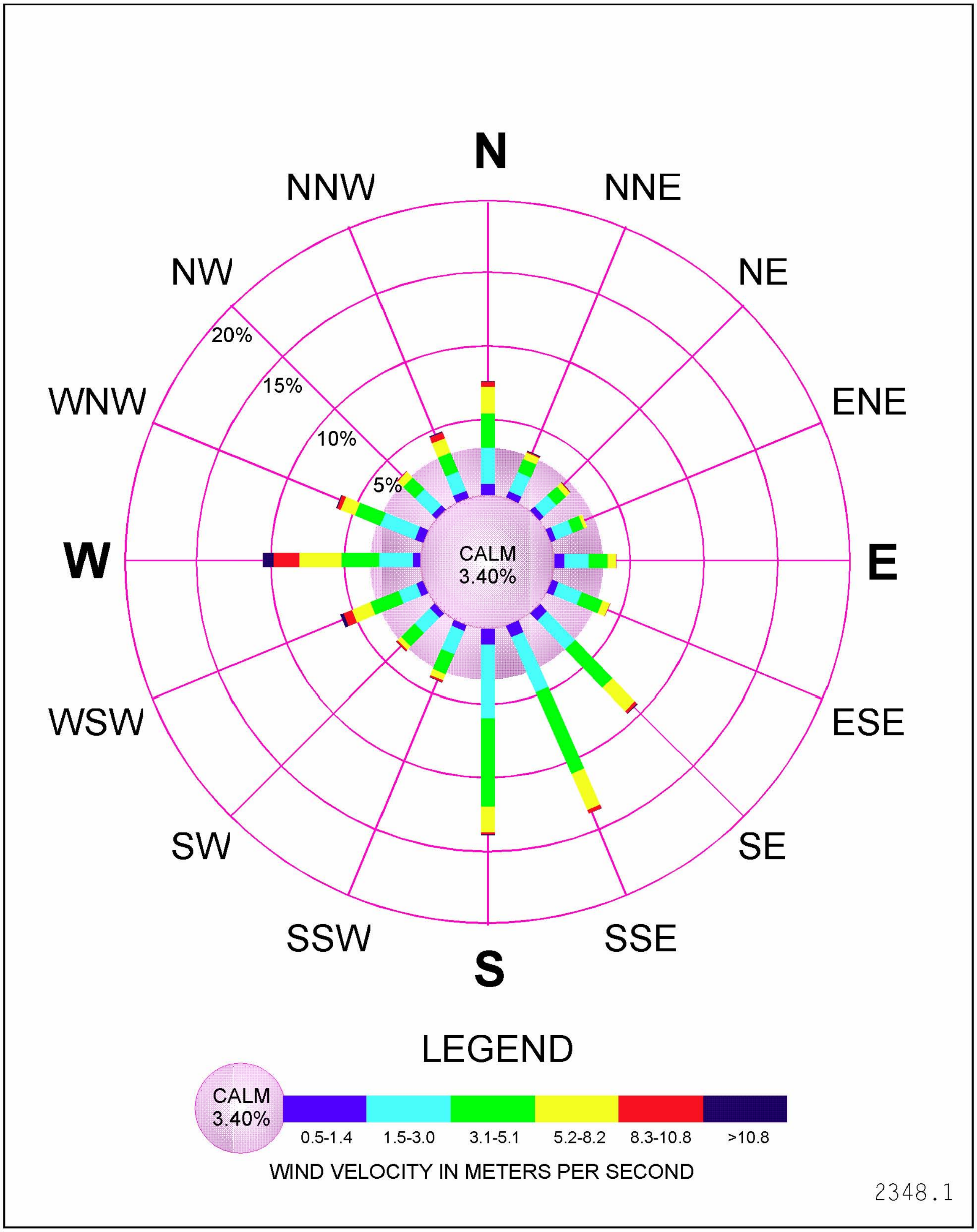


Figure 2.4-10, 1993 Annual Windrose - Carlsbad

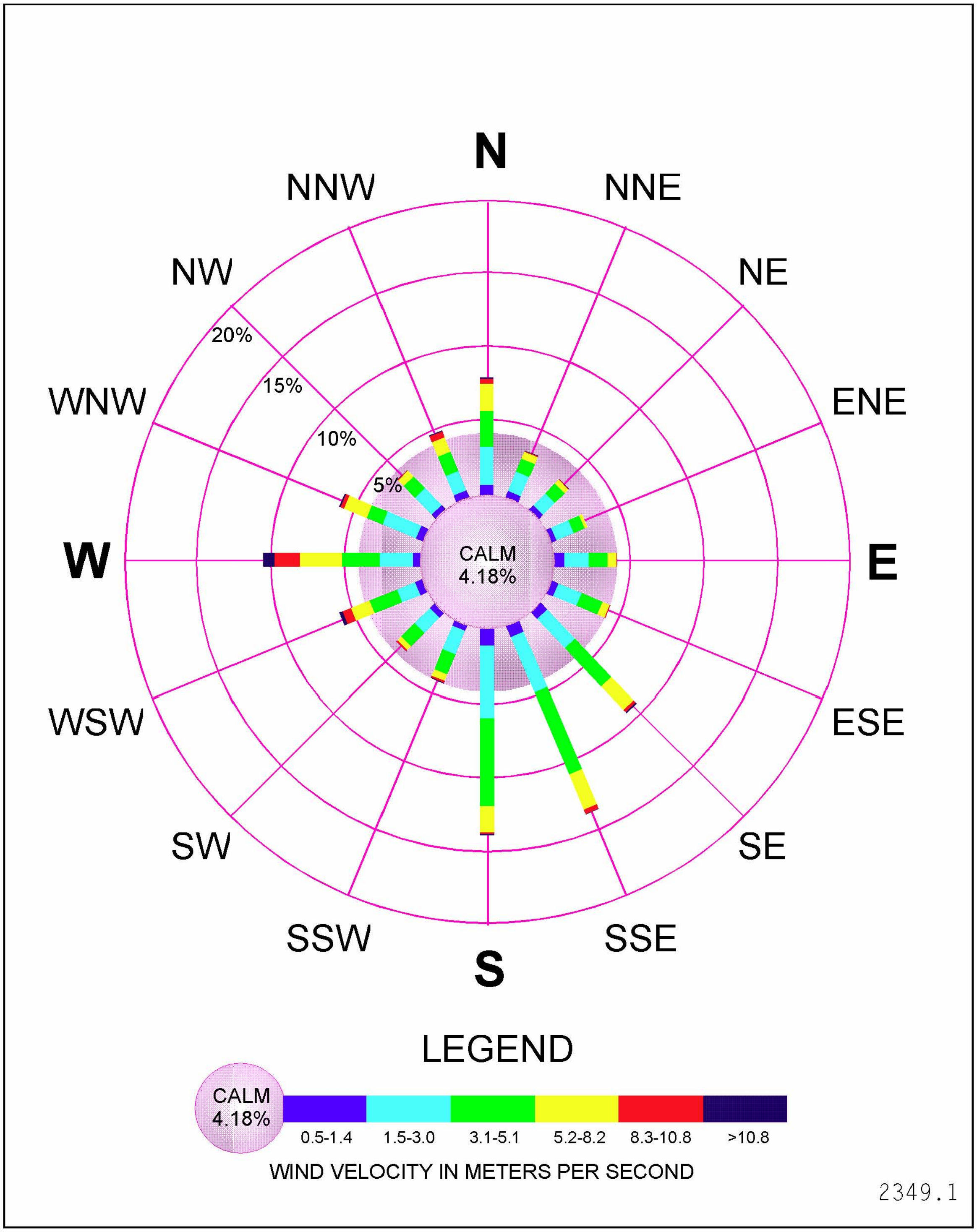


Figure 2.4-11, 1994 Annual Windrose - Carlsbad

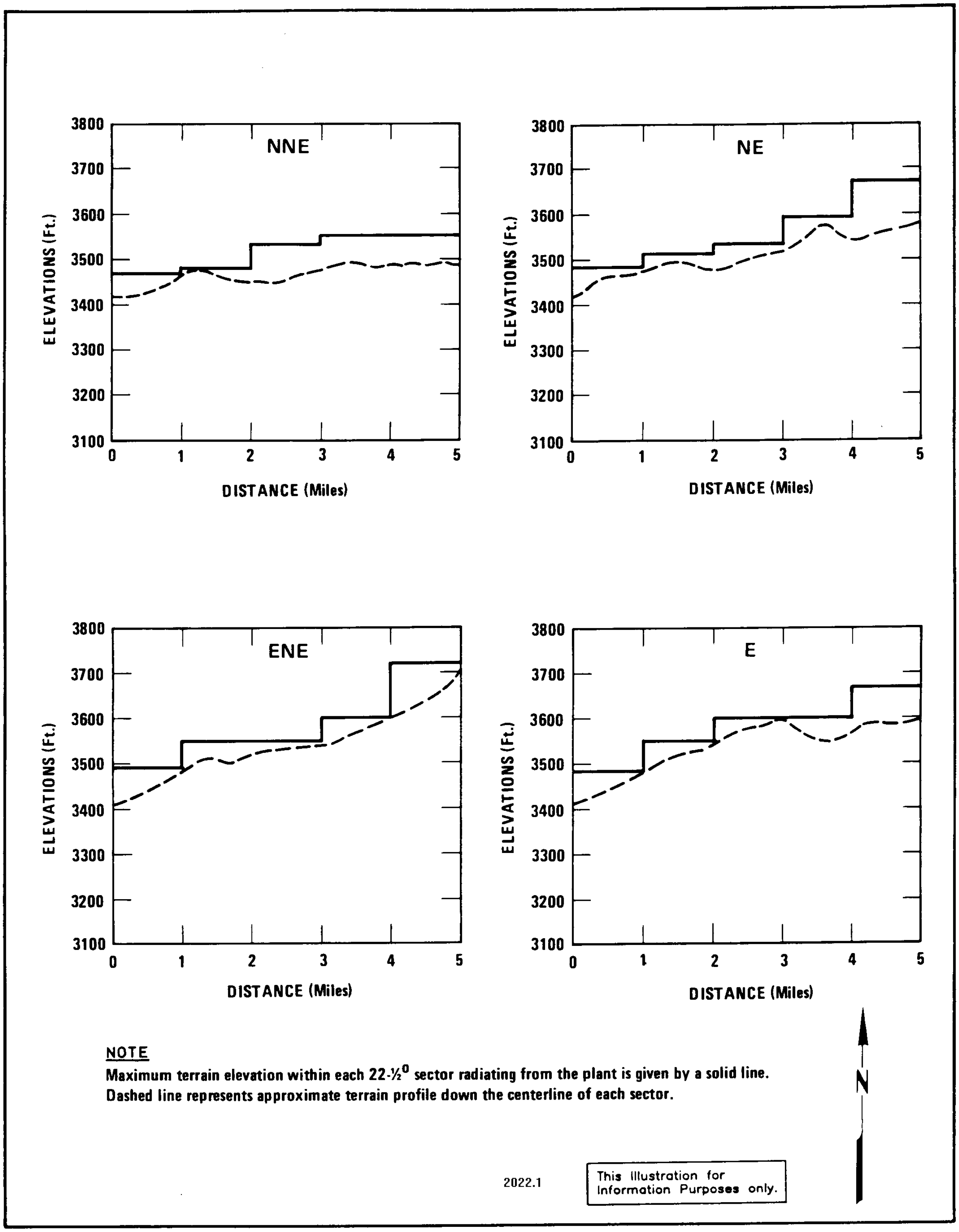


Figure 2.4-12A, Terrain Elevations Out to 5 Miles from Center of the WIPP Facility Sheet 1 of 4

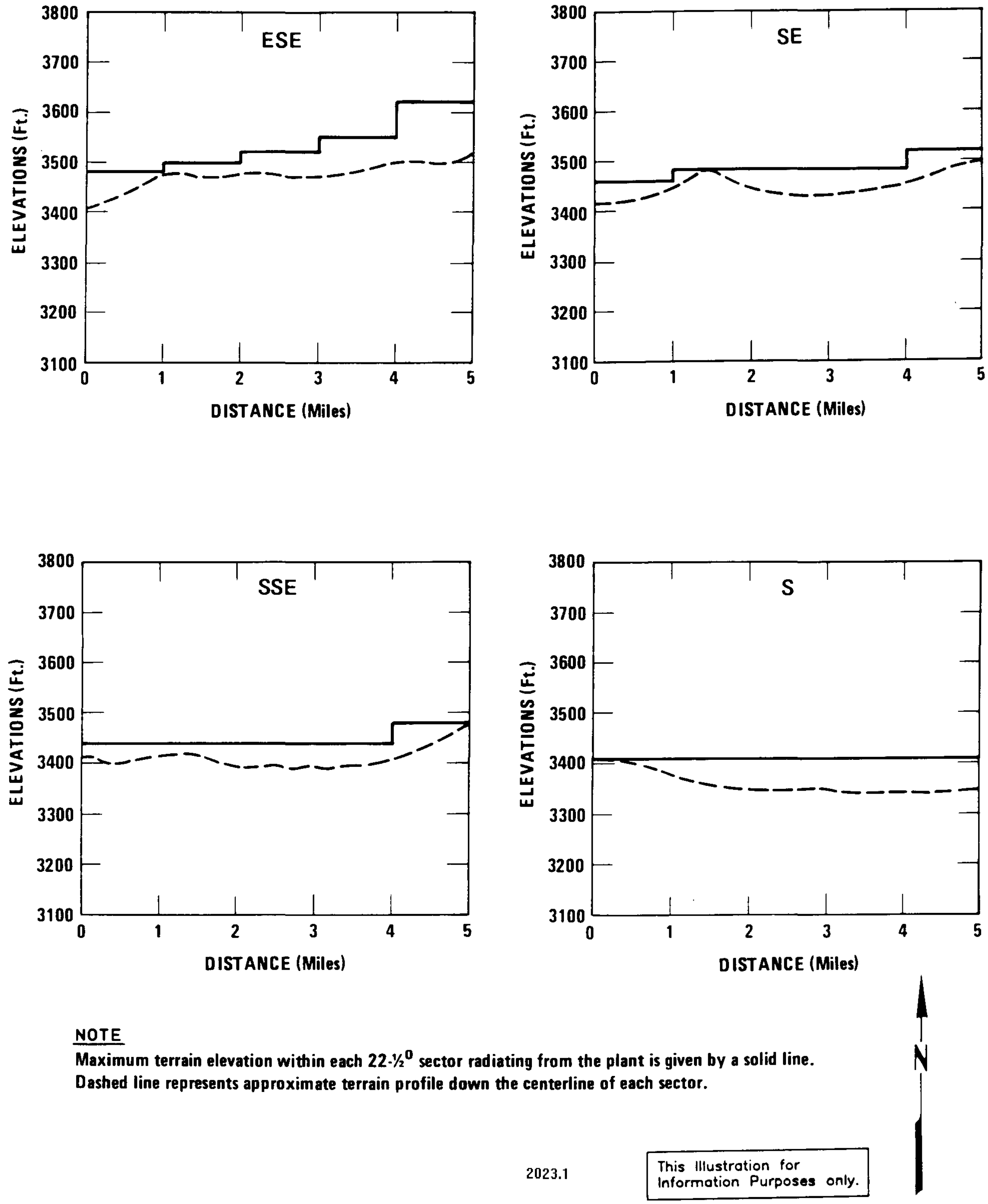


Figure 2.4-12B, Terrain Elevations Out to 5 Miles from Center of the WIPP Facility Sheet 2 of 4

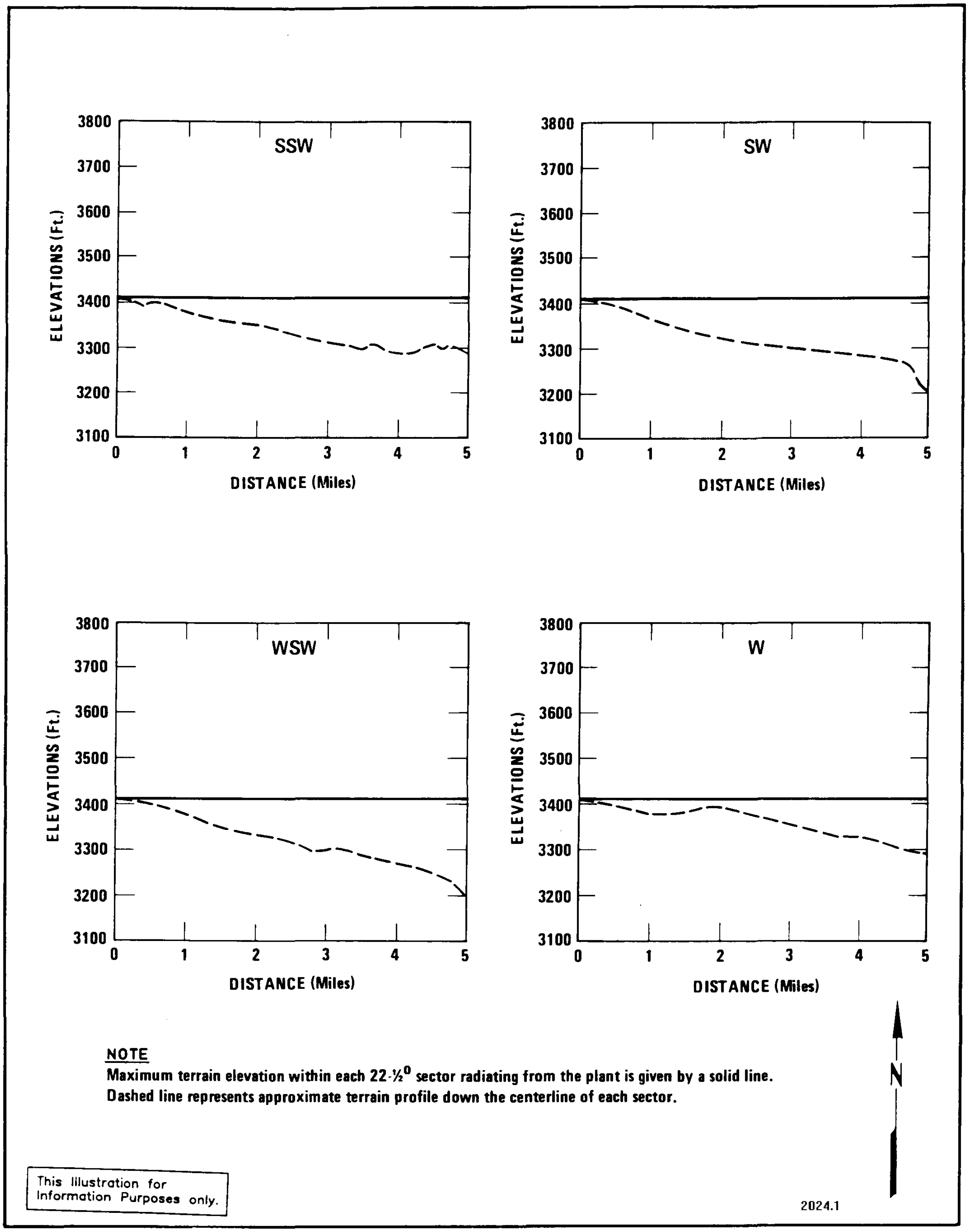


Figure 2.4-12C, Terrain Elevations Out to 5 Miles from Center of the WIPP Facility Sheet 3 of 4

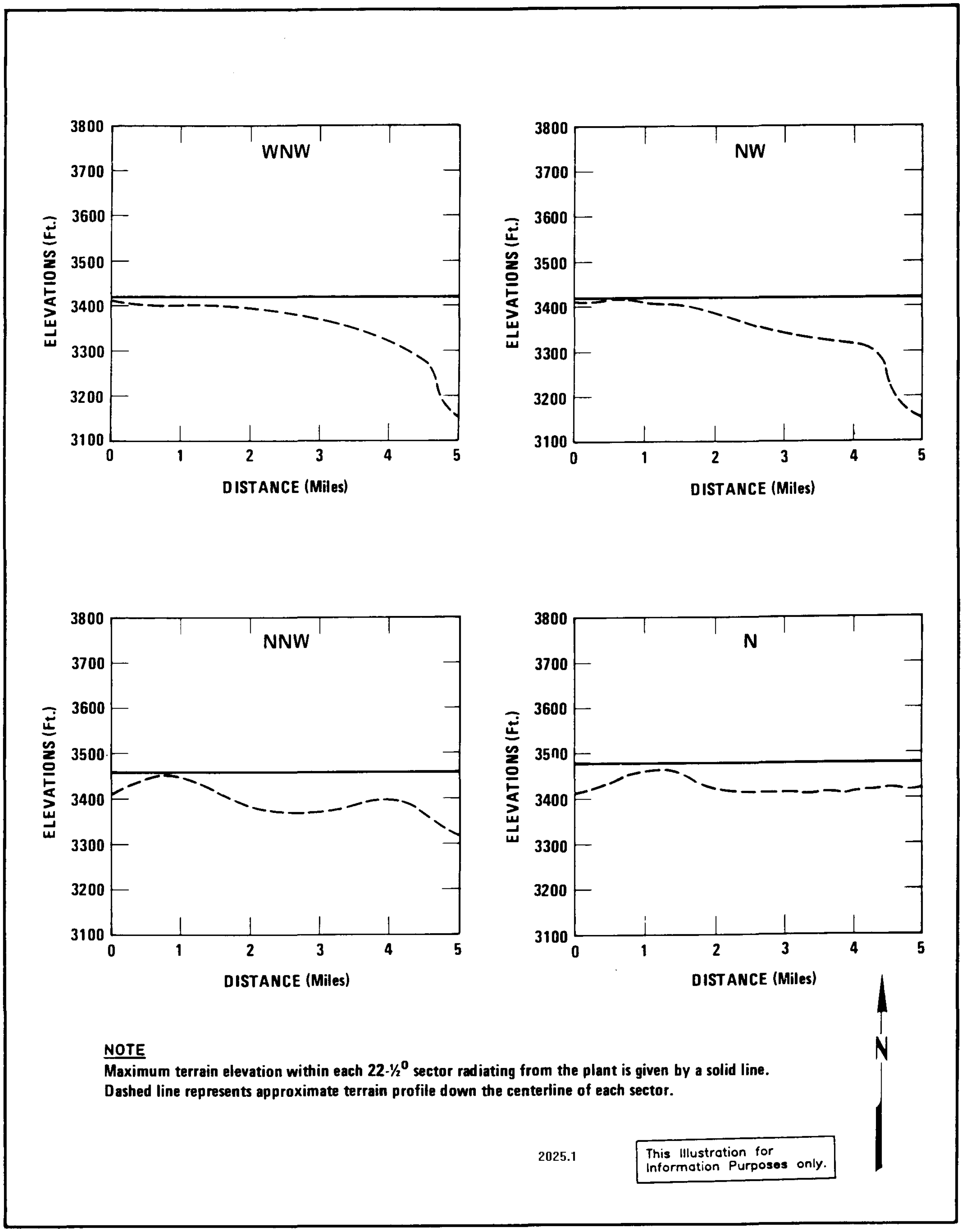


Figure 2.4-12D, Terrain Elevations Out to 5 Miles from Center of the WIPP Facility
Sheet 4 of 4

Table 2.4-1, Maximum Wind Speeds for Roswell, New Mexico*

Month	Max wind speed, mph	Month	Max wind speed, mph
January	67	July	66
February	70	August	72
March	66	September	54
April	75	October	66
May	72	November	65**
June	73	December	72

*Climates of the States, Vol. 2 - Western States, Roswell, NM, U.S. National Oceanic and Atmospheric Administration (NOAA), Water Information Center, Inc., Asheville, NC, 1974, p. 804. Local Climatological Data, Annual Summary 1985, Roswell, NM, NOAA-ED.

**Occurred more than once.

Table 2.4-2, Recurrence Intervals for High Winds in Southeastern New Mexico*

	Speed, mph			
Recurrence, years	30'	50'	100'	150'
2	58	62	65	73
10	68	73	81	86
25	72	77	86	91
50	80	86	95	101
100	82	88	97	103

*O. G. Sutton, Micrometeorology (McGraw-Hill Book Co., Inc., New York, 1953), p. 238.

Table 2.4-3, Seasonal Frequencies of Inversions*

Season	Inversion frequency (% of total hours)	Maximum %**
Spring	32	65
Summer	25	68
Fall	35	72
Winter	46	78
Annual	35	70

*C. R. Hosler, "Low-Level Inversion Frequency in the Contiguous United States," Monthly Weather Review, 89 (9) (1961).

**Frequency of 24-hour periods with at least 1 hour of inversion based at or below 500 feet.

Table 2.4-4, Seasonal Values of Mean Mixing Heights*

Season	Mean afternoon mixing height, m	Mean morning mixing height, in.
Spring	2800	480
Summer	3050	680
Fall	2000	440
Winter	1320	300
Annual	2400	470

*G. C. Holzworth, Mixing Heights, Wind Speeds and Potential for Urban Air Pollution Throughout the Contiguous United States, U.S. Environmental Protection Agency (EPA), Research Triangle Park, NC (1972).

Table 2.4-5, Annual Average, Maximum, and Minimum Temperatures

Year	Annual Average Temperature (○C)	Annual Average Temperature (○F)	Maximum Temperature (○C)	Maximum Temperature (○F)	Minimum Temperature (○C)	Minimum Temperature (○F)
1990	17.8	64.0	46.1	115.0	-13.9	7.0
1991	17.2	63.0	42.8	109.0	-7.8	18.0
1992	17.2	63.0	42.8	109.0	-10.0	14.0
1993	17.8	64.0	42.8	109.0	-18.9	-2.0
1994	17.8	64.0	50.0	122.0	-14.4	6.0
Average	17.6	63.6	44.9	112.8	-13.0	8.6

Source: WIPP Annual Site Environmental Report for Calendar Years 1990 through 1994 (Draft)

2.5 Vibratory Ground Motion

This section is directed towards establishing the seismic design basis for vibratory ground motion directly applicable to Design Class I and II confinement structures and components at the WIPP facility. The application of the results contained in this section to seismic design of plant facilities is discussed in Section 3.2.7. This presentation is aimed at conservatively estimating the Design Basis Earthquake (DBE) for the WIPP site facility.

The approach used in this analysis is to develop a probabilistic peak acceleration to be used in design. This peak acceleration is derived from a correlation between historical earthquake activity and various active geologic structures and tectonic provinces. These results are used to establish the site's DBE in Section 2.5.5.

2.5.1 Seismicity

In this section, data are presented for earthquakes within 180 miles (290 km) of the WIPP facility. This area is defined as the WIPP facility region for this discussion. The information for the WIPP facility region earthquakes before 1962 is based on chronicles of the effects of those tremors on people, structures and land forms (called macroseismic evidence). Virtually all information on earthquakes occurring after the beginning of 1962 in the WIPP facility region is derived from instrumental data recorded at various seismograph stations.

2.5.1.1 Pre-1962 Earthquake Data

Most earthquakes reported in New Mexico before 1962 occurred in the Rio Grande Valley area between Albuquerque and Socorro, a distance of more than 186 miles (300 km) from the WIPP site. About half of the earthquakes of Modified Mercalli Intensity (MMI) V or greater in New Mexico between 1868 and 1973 were in this region. In conformity with previous studies,[1,2,3] those events are not of immediate concern to this study. There has been one earthquake associated with moderate to considerable damage (intensity VIII) prior to 1962 within the WIPP facility region. The Valentine, Texas earthquake of 1931, occurred about 120 miles (193 km) south-southwest of the location of the WIPP facility. The area within 120 miles (193 km) of the WIPP facility has experienced only low-intensity earthquakes (intensity V or less).

Figure 2.5-1 shows locations of earthquakes occurring before 1962 within 186 miles (300 km of the WIPP site. These epicenters were assigned on the basis of macroseismic evidence and are also listed in Table 2.5-1. Supplemental descriptive material for most of those events is provided primarily by Sanford and Toppozada [1] and other sources.[4,7] All intensities listed in Table 2.5-1 are Modified Mercalli Intensities.[7] An abridged version of this scale is presented in Table 2.5-2.

The Valentine, Texas earthquake of August 16, 1931 was large enough to generate significant interest so that much more data are available for that event. A number of isoseismal maps were compiled soon after its occurrence. [5,7] Recently, Sanford and Toppozada assigned MMI on the basis of descriptions of the effects of this event and plotted the resulting isoseismal map reproduced in Figure 2.5-2. Several features of this plot are noteworthy. First, according to Figure 2.5-2, the intensity location of the WIPP facility from this earthquake was V. Second, isoseismal lines close to the zone of the highest intensity are elongated northwest-southeast conforming to the structural integrity of the region.

Two instrumental locations have been published for the Valentine, Texas earthquake. The United States Coast and Geodetic Survey (USCGS) places the epicenter at 29.9N and 104.2W with an origin time of 11:40:15 Greenwich Mean Time (GMT).[5] Byerly[9] made a detailed instrumental investigation of that earthquake and found the epicenter to be 30.9N and 104.2W with an origin time of 11:40:21 GMT. Byerly's[9] epicenter, 66 miles (106 km) north of the USCGS epicenter, is somewhat closer to the region of highest reported intensity and may for this reason be considered the more accurate of the two.[1] These two instrumental epicenters are plotted in Figure 2.5-2. Although neither of these instrumental locations is particularly close to Valentine, Texas, the USCGS and Byerly epicenters bracket the area of maximum reported intensity fairly well. For the purposes of Figure 2.5-1, Valentine, Texas has been adopted for the location of both the main earthquake and its aftershocks in agreement with Sanford and Toppozada.[1]

The area over which an earthquake is perceptible can be used to estimate its magnitude.[10,11] If a felt area of 4.5 x 10^5 mi^2 (1.2 x 10^6 km^2) is accepted as reported by the USCGS,[6] and a magnitude felt area formula for the central United States and Rocky Mountain region is used,[11] a magnitude of about 6.4 is calculated for the Valentine, Texas earthquake. This result is compatible with the maximum intensity reported for the shock[1] and is the same as the magnitude for this event calculated at Pasadena, California.[12]

2.5.1.2 Comprehensive Listing of Earthquakes From All Studies - January 1, 1962 through September 30, 1986

Presented in Table 2.5-3 is a listing of earthquake origin times, locations, and magnitudes, based on instrumental data gathered and analyzed by a number of different organizations. The listing is for earthquakes within the WIPP facility region for the 24 3/4 year interval from January 1, 1962 through September 30, 1986. The organization providing the earthquake parameters listed in the table is identified by an X in the appropriate column. Organizations providing data for the table were as follows:

- New Mexico Institute of Mining and Technology (NMT)
- U.S. Geological Survey (USGS)
- Los Alamos National Laboratory (LANL)
- Albuquerque Seismological Laboratory (ASL)
- University of Texas at Austin (UTA)
- University of Texas at El Paso (UTEP).

2.5.1.2.1 Magnitudes

Recent seismic events occurred at WIPP on January 2, 1992 and April 13, 1995. These events had magnitudes of 5.0 and 5.4 respectively. The January 2, 1992 Rattlesnake Canyon Earthquake had an epicenter located 37 miles (60 km) east southeast of the WIPP site. The Rattlesnake Canyon Earthquake and the April 13, 1995 earthquake had no effect on any of the structures at WIPP, as documented by post event inspections by the WIPP staff and the New Mexico Environment Department. These events were within the parameters used to develop the seismic risk assessment of the WIPP structures (Section 2.5.5). The Rattlesnake Canyon event likely was tectonic in origin based on a 7 +/- mile (12+/- km) depth. (Ref Part B Permit Application, Rev. 5, Appendix D6, Section D6-4 Seismicity)

Up to August 1981, NMT calculated magnitudes differently than other organizations. As a result, systematic differences in calculated magnitudes were observed. In Table 2.5-3, all magnitudes calculated by organizations other than NMT were modified by applying corrections. In all cases, these modifications reduced the reported magnitude by amounts ranging from 0.3 to 0.5.

After August 1981, NMT started using a magnitude scale based on the duration (t_D) of the recorded signal from onset of the P phase to when the trace amplitude approaches background noise. The equation used,

$$M_D = 2.79 \log t_D - 3.63$$

was derived by LANL researchers[21] and determined to be equivalent to the Richter local magnitude scale for earthquakes in northern New Mexico. Ake and Sanford[18] established that the LANL formula can be applied to earthquakes in central New Mexico which fall in the local magnitude range of 1.1 to 4.2. A careful study of the applicability of the formula to earthquakes in southeastern New Mexico and west Texas has not been made.

However, random comparisons between magnitudes calculated from the amplitude of S_g (Shear Wave) and duration of ground motion in the time period 1962 to 1974 indicate general consensus good agreement (within 0.3 magnitude units) between the two methods.

Most recurrence formulas in Section 2.5.4.2 are based on the earthquake data set included in Table 2.5-3, but at lower magnitudes. Therefore, the latest listing of events within the WIPP facility region does not require an upward revision in earthquake risk or the DBE.

2.5.1.2.2 Completeness of the Earthquake Data Set

From January 1, 1962 to April 5, 1974, events in the WIPP facility region were located by readings from stations generally several hundred miles from the epicenter. On April 5, 1974, a single station (CLN) was established near the center location of the WIPP facility which continued operation to September 1980. These stations are plotted in Figure 2.5-3. From November 1975 to late 1979, a seismograph array was in operation near Kermit, Texas. These are shown in Figure 2.5-4.

A small network of stations centered in the Davis Mountains of West Texas was operated by the UTA from July 1977 to July 1978. No stations were running near the location of the WIPP facility from shutdown of station CLN in September 1980 to startup of a three station network in August 1982. The WIPP seismograph network was not fully operational until March 1983.

The histograms in Figure 2.5-5 illustrate how the shifts in instrumentation affected the completeness of the earthquake data set presented in Table 2.5-3. The period from January 1, 1962 through September 30, 1986 was divided into eight time intervals of 1130 days, and the number of events greater than 3.0, 2.5, 2.0, and 1.5 were determined for each interval. The first four intervals (from January 1, 1962 through May 17, 1974) cover the period prior to installation of any stations at, or near the location of the WIPP facility. The fifth and sixth intervals (from May 18, 1974 through July 24, 1980) cover the period when station CLN, the Kermit array, and the UTA networks were in operation. Most of the seventh interval (from July 25, 1980 to August 28, 1983) covers the period between shutdown of station CLN and startup of the WIPP seismographic network. During the last interval (from August 29, 1983 through September 30, 1986) the WIPP array was fully operational.

The histogram in Figure 2.5-5 for events with M3.0 (upper left) suggests a complete data set of this magnitude level. The greatest number of events (6) occurred during the second interval (from February 4, 1965 through March 9, 1968), a period when no seismograph was operating within 135 miles (217 km) of the location of the WIPP facility except station FOTX during the first 67 days of the interval. (Station FOTX was located 72 miles (116 km) southeast of the WIPP facility). The least number of earthquakes occurred in the first, third, and eighth intervals. The WIPP seismographic network was fully operational during the eighth interval, but no seismic instrumentation within 135 miles (217 km) of the location of the WIPP facility existed during the first and third intervals except station FOTX (in operation the last 228 days of the first interval). Because the number of observed quakes with M3.0 does not correlate with the presence or absence of instrumentation at or near the WIPP facility, the data set is believed to be complete at that strength level. If the data set is complete, then the variations in activity observed in the histogram represent true temporal changes in the activity rate for earthquakes with M3.0.

In the lower two histograms of Figure 2.5-5, the period of maximum instrumentation is even more clearly defined by the increase in numbers of earthquakes during the fifth and sixth time intervals. In summary, the general shape of the histograms relative to temporal changes in instrumentation indicates the data set is probably complete above magnitude 2.7, and that it becomes progressively less complete at lower magnitudes.

2.5.1.2.3 Recurrence Interval Formulas

Many studies have demonstrated a linear relation between the logarithm of the cumulative number of earthquakes (N) and the magnitude (M), i.e.,

$$\log N = a - bM.$$

The values of the constants "a" and "b" are derived from existing earthquake data by plotting log N versus M and performing linear regression on those points that fall above the minimum magnitude where the data set is complete. The formulas obtained in this manner can be extrapolated to determine the recurrence interval for the maximum probable earthquake in the region. Section 2.5.4.2 describes in some detail how these relations can be used in establishing risk and ultimately the DBE.

Shown in Figures 2.5-6 and 2.5-7 is a log N versus M plot for the combined time periods from January 1, 1962 through September 30, 1986. Seismographs were not in operation near the WIPP facility from July 24, 1980 to August 29, 1983. Linear regression for data points greater than magnitude 1.9 yields the recurrence equation,

$$\log N = 4.05 - 1.01\ M.$$

The value of "b," 1.01, is three percent less than that obtained by Sanford et al. (1.04) using data for the 3 1/4 year period, April 1974 through June 1977. The "a" values cannot be compared because (1) the magnitudes in Table 2.5-3 are on the average approximately 0.4 less than those listed in Sanford et al.,[45] (2) the time period is approximately three times greater here than in Sanford et al,[3] and (3) the degree of activity at the M2.0 strength level was not as great in later periods as it was from April 1974 through June 1977 (see histograms in Figure 2.5-5).

2.5.1.2.4 Geographic Distribution of Earthquakes

Table 2.5-3 differs in another important way from earlier listings of earthquakes within 180 miles (290 km) of the WIPP facility. All but a few shocks in the table have epicenters determined by the algorithm HYPO 71 Revised,[19] rather than by the circle-arc method. The locations from the latter method were retained only when a satisfactory solution could not be obtained from HYPO 71.[19] Inclusion of crustal shear wave (Sg) arrival time readings in the HYPO 71[19] program probably makes it superior to the circle-arc method.

The accuracy of locations in Table 2.5-3 depends on many variables: the number, distance, and distribution of stations providing readings for the solution, and the quality of crustal compressional wave (Pg) and Sg phases picked. For the events that occurred within or near arrays of stations, primarily during the period April 1974 through September 1980, the accuracy of locations is reliable. However, for most of the earthquakes during the 24 3/4 year period, the locations depended on readings from stations several hundred kilometers away, falling in a narrow azimuthal range relative to the epicenter. The error in location under these circumstances can be considerable. However, even in the worst case (generally earthquakes in the far southern and southeastern regions of the study area) the locations are believed to be within ±16 miles (±25 km).

Figure 2.5-8 is a map showing all epicenters listed in Table 2.5-3. The distribution of earthquake activity in this figure is compatible with the boundaries of source regions discussed in Section 2.5.4.1. On the basis of the seismic activity, the eastern boundary of the Rio Grande rift source zone can be placed at the boundary proposed by Algermissen and Perkins[21] or at the alternate boundary proposed in Section 2.5.4.1. The later boundary is clearly less well-defined by seismic activity than the Algermissen and Perkins boundary.

All boundaries proposed for the Central Basin Platform (CBP) in Section 2.5.4.1 are generally compatible with the distribution of earthquake activity in Figure 2.5-8, but none are totally satisfactory. The earthquake epicenters in the vicinity of the CBP appear to require enlargement of the source zone to the southwest and contraction to the east and northeast. The nearest approach of CAP seismicity to the WIPP site appears to be east of boundaries proposed by Algermissen and Perkins[22] and those suggested by geologic and tectonic consideration.

Figure 2.5-9 is a map showing epicenters from Table 2.5-3 that fall in the time period April 5, 1974 through October 6, 1978. To some extent, the maps presented in Figures 2.5-8 and 2.5-9 distort the distribution of seismic activity. Detection of smaller quakes in the data set was variable in space and time as a result of changes in the numbers and distribution of seismograph stations. To avoid this problem, Figure 2.5-10 shows only epicenters for earthquakes with $M \geq 2.5$, a cut-off level only slightly below the magnitude at which the data set is believed complete.

The temporal variability of earthquake activity on the CAP and elsewhere within 180 miles (290 km) of the WIPP facility is illustrated in Figures 2.5-11 through 2.5-18. Plotted in these figures are epicenters for events with M2.5 which occurred in eight sequential time periods, each of 1130 days duration from January 1, 1962 to September 30, 1986.

2.5.2 Geologic Structures and Tectonic Activity

A study of the WIPP facility region suggests a fundamental geologic and tectonic separation into two significantly different subregions: (1) the Permian Basin and (2) the Basin and Range subregions. The geologic structures and tectonism of the Permian Basin are dominantly associated with large-scale basin, interbasin and basin margin subsidence or emergence that occurred during the Paleozoic era. Basin and Range structures and tectonism to the west are those associated with Basin and Range topography. The activity characteristic of this subregion began in middle to late Tertiary time and is probably still occurring to some extent.

The Permian Basin subregion is defined as that part of the Permian Basin within the site region. The WIPP facility is slightly more than 60 miles (97 km) from the western margin of the Permian Basin (Figure 2.5-19). The Permian Basin is a broad structural feature made up of a series of Paleozoic sedimentary basins whose last episodes of large-scale subsidence during late Permian time were associated with a thick accumulation of evaporites. This basin now exists as a subsurface structural feature extending roughly from the Amarillo uplift on the north to the Marathon thrust belt on the south and some 300 miles (483 km) eastward from the Diablo platform and Sacramento and Guadalupe Mountain areas into west-central Texas.[23]

The development of the Permian Basin began with the formation of a broad sag (named the Tobosa basin[24]) following deposition of lower Ordovician strata. Prior to the late Mississippian, several periods of minor folding, faulting and uplift with erosion occurred. Nevertheless, general structural stability prevailed.[50,51,52] Subsequently, tectonic activity accelerated in the area climaxing in late Pennsylvanian and was split into two rapidly subsiding basins (the Midland to the east and the Delaware to the west) by the medial Central Basin Platform.[25] Structural development of the Permian Basin within this framework continued until late Permian when broad-scale basement stabilization occurred concurrently with evaporite deposition.

Thus, the major tectonic elements of the Permian Basin were completely formed before the deposition of Permian salt-bearing rocks, and relative crustal stability of the region has been maintained since Permian time. Since then, the Permian Basin has been characterized throughout the Mesozoic and Cenozoic eras by erosional processes interrupted by only minor episodes of terrestrial and shallow water deposition. Regionally, the Permian Basin has been tilted and warped, but deep-seated faults since Permian time are rare except along the western margin of the basin outside the area of salt preservation. In areas where salt is near the surface, such as southeastern New Mexico, there are no indication of younger deep-seated faulting and only a few isolated igneous intrusives of post-Permian age.[25]

The Basin and Range subregion is defined as that part of the Basin and Range physiographic province within the site region. As shown in Figure 2.5-19, this subregion borders the western margin of the Permian Basin subregion to the west and southwest of the site. The Basin and Range subregion is characterized by fault block mountain ranges, many of which are bounded on the west by major high-angle normal fault systems. Uplift along these fault systems has resulted in gentle eastward tilting of the mountain blocks and the formation of intermontane or graben-like valleys. Major development of these characteristic structural features occurred from late Tertiary into early Pleistocene time.[50,51,52] Continued tectonism in the Basin and Range subregion is suggested by widely scattered Quaternary fault offsets on the order one to several meters. A number of fault offsets of this age along the western flanks of the Guadalupe, Delaware, Sacramento and San Andres mountains are described in the literature.[26,27,50,51,52] More recently, additional but similar fault systems have been found and described within the Basin and Range physiographic province in Trans-Pecos, Texas.[28]

The different physiographies of the two site subregions, as defined and briefly described above, are closely related to their distinctive geologic histories and structural configurations. This is suggested by Figure 2.5-20 which shows the boundary between the great Plains and Basin and Range physiographic provinces.[50,51,52] For this reason, Figure 2.5-19 is a good approximation to the boundary between the Permian Basin and Basin and Range subregions as suggested by the geologic evidence just outlined.

The results of a 1978 leveling survey between El Paso, Texas and Carlsbad, New Mexico,[29] are consistent with this geologically suggested regional separation. Comparison of this survey with previous leveling surveys along the same route carried out in 1934, 1943 and 1958, indicates that the Diablo Plateau region of Trans-Pecos, Texas (in the Basin and Range subregion as defined above) has been uplifted approximately 4 to 5 centimeters during this interval in archlike fashion in relation to the end points of the survey. Extending east from El Paso, the leveling route traverses Basin and Range subregion-type structures including the Hueco Basin, the Hueco Mountains, the Diablo Plateau, the Salt Basin and the Guadalupe Mountains before terminating on the High Plains in the Permian Basin subregion near Carlsbad. The observed relative uplift correlates well with the broad aspects of the tectonic evolution of the Diablo Plateau. The observed elevation changes are most easily attributed to deep-seated tectonic activity.[29]

The observed movements along the El Paso - Carlsbad line are not the largest in the area. Movements along the Roswell-Pecos line, which is entirely within and near the western margin of the Permian Basin subregion, are larger (Figure 5 of Reference 42). However, the movements on this route, which runs along a railroad near the Pecos River, are probably dominated by artificial water withdrawal.[46,47] Carlsbad appears to be relatively "inactive" with respect to Roswell, which is located well outside regions of known neotectonic activity.[29]

In summary, the WIPP facility region leveling data are consistent with the geologic evidence in that they suggest current tectonic activity in the Basin and Range subregion and current stability in the Permian Basin subregion. Because current tectonic activity implies crustal movement that in turn implies elastic strain accumulation and release, earthquakes are often considered a barometer of tectonic activity. The occurrence of more frequent and larger earthquakes is thus consistent with a higher level of tectonism.

Earthquakes occurring between 1923 and 1979 and between April 1974 and February 1979 are superimposed on the suggested site subregions in Figures 2.5-19 and 2.5-21, respectively. From Figure 2.5-19 it may be seen that most pre-instrumental and a substantial proportion of 1962 to 1977 instrumental earthquakes are located in the Basin and Range subregion. In the Permian Basin subregion, an important cluster of instrumental epicenters occurs on the Central Basin Platform, and a thin scattering of both instrumental and pre-instrumental events appears throughout the rest of this subregion. In the case of pre-instrumental events in the WIPP facility region, this distribution of shocks may be at least partly controlled by a population density that has always been greatest along the Rio Grande rift (within the Basin and Range subregion). A somewhat similar pattern appears in Figure 2.5-21, although in this figure (for which the smaller magnitude events on the Central Basin Platform have been made recordable by the inclusion of data from station CLN at the location of the WIPP facility) the recent predominance of the Central Basin Platform in terms of the total number of recorded events is apparent. The largest recorded earthquake in the Basin and Range subregion is the 1931 Valentine, Texas event whose magnitude is estimated to be about 6.4. The largest event on the Central Basin Platform is of magnitude 3 to 4 depending upon precisely how magnitudes of events in these areas are calculated. The largest event in the Permian Basin subregion but, not on or near the Central Basin Platform, was the 16 June 1978 event near Snyder, Texas, at the extreme eastern margin of the site region. This event was about 4.7 in magnitude.

Based on 11 years of instrumental data (1962 - 1972 inclusive), analysis of earthquakes throughout New Mexico of magnitude greater than or equal to 2.5 (which are believed to have been uniformly located during this interval) indicates a roughly comparable level of earthquake activity in the inactive and in the active physiographic provinces.[2,18] This result must further qualify the confidence with which the modest differences in historical seismicity levels (in terms of number of events) in the (inactive) Permian Basin and (active) Basin and Range subregions can be argued to be significant.

Thus, in light of geologic evidence and consistent recent leveling survey data, the Basin and Range subregion, as shown in Figures 2.5-19 or 2.5-21, exhibits a higher level of recent tectonism than the Permian Basin subregion. This is supported by the maximum magnitude earthquakes occurring in these subregions during historical time. The distribution of all known site region earthquakes shows that, with the exception of the Central Basin Platform area, the Permian Basin subregion has experienced marginally fewer events than the Basin and Range subregion. A significant cluster of small events is located along the Central Basin Platform.

2.5.3 Correlation of Earthquake Activity with Geologic Structures or Tectonic Provinces

The best available evidence does not suggest that recorded earthquakes have been well correlated with faults anywhere in the WIPP facility region. This is true for both the surface faults of the Basin and Range subregion (a number of which show evidence of Quaternary movement) and for the geologically older subsurface faults in the Permian Basin subregion.

Although no earthquakes in the WIPP facility region are known to be correlated to specific faults, a substantial cluster of seismic activity has occurred on and near the Central Basin Platform since about the mid-1960s. This suggests division of the Permian Basin subregion into a Central Basin Platform portion and a background portion. The seismicity pattern leading to this suggestion is made fairly explicit in Figures 2.5-19 and 2.5-21. There is no known evidence of any differences since late Permian time in the geologic histories of the Central Basin Platform and surrounding portions of the Permian Basin (Sections 2.5.2). In addition, there does not appear to be enough data at present to convincingly determine the direction of tectonic forces and the type of faulting on the Central Basin Platform;[4] therefore, this information could not be used to distinguish the Central Basin Platform.

First Shurbet,[13] and later Sanford and Toppozada[1] and Rogers and Malkiel[15] suggested that Central Basin platform earthquakes are not tectonic but are instead related to water injection and withdrawal for secondary recovery operations in oil fields in the Central Basin Platform area. Such a mechanism for the Central Basin Platform seismic activity could provide a reason why the Central Basin Platform is separable from the rest of the Permian Basin on the basis of seismicity data but not by using other common indicators of tectonic character. Both the spatial and temporal association of Central Basin Platform seismicity with secondary recovery projects at oil fields in the area are suggestive of some cause and effect relationship of this type.[15]

In summary, the best available evidence does not suggest that known earthquakes are well correlated with faults in the WIPP facility region. A substantial number of earthquakes have occurred on and near the Central Basin Platform since about the mid-1960s. The cause of the spatial coincidence of recent seismicity with this buried large-scale Paleozoic structure is not known. With this exception, WIPP facility region earthquakes may be correlated with two tectonic provinces for the purposes of this study. The first is a relatively inactive province made up of the eastern and northeastern two-thirds (approximately) of the WIPP facility region (and encompassing the WIPP facility). The other WIPP facility region tectonic province is a relatively inactive province made up of the rest of the WIPP facility region. A simple and reasonable model of these two general WIPP facility region tectonic provinces is furnished by the Permian Basin/Basin and Range subregion characterization of Section 2.5.2.

2.5.4 Probabilistic Earthquake Potential

In recent years, several procedures have been developed that allow formal determination to be made of earthquake probabilistic design parameters[30,31] and a number of studies have been performed incorporating these procedures[22,32,33] In typical seismic risk analyses of this kind, the region of study is divided into seismic source areas within which future events are considered equally likely to occur at any location. For each seismic source area, the rate of occurrence of event above a chosen threshold level is estimated using the observed frequency of historical events. The sizes of successive events in each source are assumed to be independent and exponentially distributed; the slope of the log number versus frequency relationship is estimated from the relative frequency of different sizes of events observed in the historical data. This slope, often termed the b value,[16] is determined either for each seismic source individually or for all sources in the region jointly. Finally, the maximum possible size of events for each source is determined, using judgment and the historical record.[37] Thus, all assumptions underlying a measure of earthquake risk potential derived from this type of analysis are explicit, and a wide range of assumptions may be employed in the analysis procedure.

In this section, the particular earthquake risk parameter calculated is peak acceleration expressed as a function of annual probability of being exceeded at the WIPP site. The particular analysis procedure applied to the calculation of this probabilistic peak acceleration is taken from a computer program written by McGuire.[33] In that program the seismic source zones are modeled geometrically as quadrilaterals of arbitrary shape. Contributions to site earthquake risk from individual source zones are integrated into the probability distribution of acceleration, and the average annual probability of exceedence then follows directly. The theory and mechanics of McGuire's computer program may be found in a number of papers,[30,34] so they are not outlined here.

In the analysis, input parameters at each stage of the development are taken from the best conservative estimates. Where more than one good estimate exists, alternative values are examined. The principal input parameters are: site region acceleration attenuation, source zone geometry, recurrence statistics, and maximum magnitudes. Based on theses parameters, several curves showing probabilistic peak acceleration are developed, and the conclusions that may be drawn from these curves are considered. The data treated in this way are used to arrive at a general statement of risk from vibratory ground motion at the site during its active phase of development and use.

2.5.4.1 Acceleration Attenuation

The first input parameters considered are those having to do with acceleration attenuation in the site region as a function of earthquake magnitude and hypocentral distance. The risk analysis used in this study employs an attenuation law of the form,

$$a = b_1 \exp(b_2 M_L) \text{ R-b}^3$$

where a is acceleration in cm/s^2, M_L is Richter local magnitude, and R is the distance in Kilometers. A number of relationships of the above from exist in the literature.[36,38] In all these studies, however, the constants $b_{1,}b_2$, and b_3 are found for data collected exclusively, or almost exclusively, west of the Rocky Mountains and are therefore perhaps not directly applicable at the WIPP facility region. Theoretical and empirical evidence indicates fundamental difference in acceleration attenuation between the western and central parts of the United States.[20,39,40]

The particular formula used in this study is based on a central United States model developed by Nuttli.[41,42] The formula coefficients $b_1 = 17$, $b_2 = 0.92$, and $b_3 = 1.0$ were selected as the best ones.

Curves using these coefficients are shown in Figure 2.5-23. This adopted attenuation law represents a conservative compromise between the estimated curves of various authors and the required form.[37,41,44]

Seismic Source Zones

Geologic, tectonic and seismic evidence indicates that three seismic source zones may be used to adequately characterize the region. These are well approximated by the Basin and Range subregion, the Permian Basin subregion exclusive of the Central Basin Platform, and the Central Basin Platform itself. The seismic source zones are outlined in Figures 2.5-19 and 2.5-21. However, specific boundaries are only intended to be simply defined approximations. For the purpose of earthquake risk analysis at the WIPP facility, some measure of the effect of the likely uncertainty in these source zone boundaries is desirable. Rather than allow the source zone boundaries to vary randomly by some amount, alternative boundaries are used based on an independent analysis of the WIPP facility region. These are taken from the study by Algermissen and Perkins of earthquake risks throughout the United States,[21] and were used in a previous analysis of WIPP site seismic risk by SNL.[15] A detailed discussion of how this characterization was developed and how it best fits recent estimates of site region seismic properties may be found in that reference.

Site region seismic source zones after Algermissen and Perkins are shown in Figure 2.5-23. Superposed on this figure are the earth-quake epicenters of Figure 2.5-1. It is clear from this superposition that the zonation presented generally conforms with historical seismicity. The source zonation of Figure 2.5-23 has no explicit analog to the Permian Basin subregion exclusive of the Central Basin Platform. This is considered part of the broad background region.

Another estimate of the appropriateness of the source zones as drawn in Figure 2.5-23 can be obtained from a consideration of Quaternary faulting. As shown in Figure 2.5-24, evidence of Quaternary fault offset is almost, but not quite completely, contained within the two western seismic source zones of Algermissen and Perkins. These two zones may be combined under the name "Rio Grande rift" since they include the parts of those provinces significant to the evaluation of probabilistic acceleration at the WIPP facility.

The general Algermissen and Perkins model, then, consists of three sources:

- The Rio Grande rift zone drawn by combining the western source zones as discussed above.
- The Central Basin Platform zone as shown in Figure 2.5-26.
- A WIPP site source zone centered at the site to model background seismicity in the High Plains. The manner in which the irregular Algermissen and Perkins source zones are adapted to the quadrilateral source zone configuration, which is required for the application of the seismic risk analysis method as discussed above, is straightforward (Figure 2.5-25).

For the purposes of this study, some minor modifications of the Algermissen and Perkins source zones were made. Geologic and tectonic evidence suggests that the physiographic boundary between the Basin and Range and Great Plains provinces provides a good and conservative approximation of the source zones as discussed in Sections 2.5.2 and 2.5.3. In addition, refined information from the Kermit array[15] indicates that the geometry used to model the limits of the Central Basin Platform source zone may be modified somewhat from the original preferred model for the WIPP site region seismic source zones in this study. This model is preferred because it is based more completely on consideration of geologic and tectonic information, as well as seismic data, and because it results in more conservative development of risks at the WIPP facility.

There is one purely geometrical issue to be resolved. It involves specifying a focal depth for events in each of the model source zones. There is little doubt that the focal depths of earthquakes in the WIPP facility region should be considered shallow. Early instrumental locations were achieved using an arc intersection method employing travel-time-distance curves calculated from a given crustal model, and the assumption of focal depths of five kilometers, 10 kilometers, or for later calculations, eight kilometers. Good epicentral locations could generally be obtained under these assumptions.

Within the range discussed, (that is, focal depths to 10 kilometers) the issue of selecting a proper depth for the probabilistic acceleration analysis at the WIPP site may be shown to be important only in the site source zone itself. For example, the difference in hypocentral distance (the distance to be used in the acceleration attenuation formula) for a closest approach event in the Central Basin Platform is only 1.05 kilometers in this depth range, assuming that the closest approach of this source zone is 35 kilometers as indicated by Figures 2.5-25 and 2.5-26. This is clearly the greatest difference of this kind outside the WIPP facility source zone. Within the WIPP facility source zone the selection of focal depth can be very important simply because the form of the attenuation law used asymptotically approaches infinite acceleration at very small distances. This is certainly not mechanically realistic and is not the intent of the empirical fitting process to an attenuation law of this form. A focal depth of five kilometers is used in all source zones of this study including that of the site. For smaller hypocentral distances, the form of the attenuation law adopted here severely exaggerates the importance of very small, very close shocks, in the estimation of probabilistic acceleration at the WIPP site (Figure 2.5-22).

2.5.4.2 Source Zone Recurrence Formulas and Maximum Magnitudes

The risk calculation procedure used in this study requires that earthquake recurrence rates for each seismic source zone be specified. This is done formally by computing the constants "a" and "b" in the equation,

$$\log N = a - b M$$

where N is the number of earthquakes of magnitude greater than or equal to M within a specified area occurring during a specified period.

For the WIPP facility region, three formulas of this type are needed—one for the active province west and southwest of the site (the Basin and Range subregion or Rio Grande rift source zone), another for the inactive province of the WIPP facility exclusive of the Central Basin Platform (the Permian Basin subregion or background source zone), and a final one for the Central Basin Platform. In practice, the difficulties in finding meaningful recurrence formulas for such small areas in a region of low historical earthquake activity are formidable.

Several estimates of recurrence rates in the WIPP facility region have been published.[1,14,21] For earthquakes within 180 miles (290 km) of the WIPP facility, exclusive of shocks from the Central Basin Platform and aftershocks of the 1931 Valentine, Texas earthquake, Sanford and Toppozada[1] find recurrence formulas of the form:

$$\log N_O = 1.65 - 0.6 M_L$$

using instrumental data only, and

$$\log N_O = 1.27 - 0.6 M_L$$

using both historical and instrumental data. In these and following recurrence formulas in this section, M_L is the Richter local magnitude and N_O is the number of earthquakes in the area of interest normalized to a time period of one year and an area of $3.6x10^4$ $miles^2$ (9.3×10^4 km^2).

Because the numbers of shocks used to establish the linear portions of these curves are very small (16 and 25, respectively), and the total time intervals over which data were collected are very short (11 and 50 years, respectively), an error in the slope (or b value) is quite possible. In fact, a certain dissatisfaction with these results on the part of Sanford and Toppozada[1] is indicated by their development of alternative curves defined to have a slope of 1.0 instead of 0.6. To the problems imposed by the spatially and temporally restricted data set available must be added the fundamental uncertainty associated with the definition of magnitude in the WIPP facility region. However, Sanford et al.[3] indicate that data collected since the Sanford and Toppozada[1] study of 1974 do not change any of the original conclusions regarding the magnitude, location, and recurrence intervals of major earthquakes within 180 miles of the WIPP facility.

Recent work[14] allows a preliminary treatment of the data. This work is based on 11 years of instrumental seismicity data which have been reinterpreted with respect to magnitude. In addition, recurrence formulas are computed for broad physiographic regions of New Mexico vastly increasing the data base. For example, Sanford et al.[14] find

$$\log N_O = 2.4 - 1.0\ M_L$$

for the High Plains physiographic province of the Permian Basin subregion or background source zone, and

$$\log N_O = 2.5 - 1.0\ M_L$$

for the Basin and Range - Rio Grande rift region. The b value in these equations is further substantiated by very recent work[44] in which all instrumental data on New Mexico earthquakes from 1962 through 1977 has been considered. The general criterion used in this earthquake risk analysis for the Rio Grande rift/Basin and Range subregion and Permian Basin/background source zones is the Sanford et al.[14] recurrence formula for the physiographic province. For this recurrence formula, an individual source zone occurs with the "a" value scaled to reflect area difference. The area of the High Plains province of interest for this analysis is approximately a 60 mile (97 km) radius [1.2×10^4 $miles^2$ (3.1×10^4 km^2)] surrounding the WIPP facility, but exclusive of part of the Central Basin Platform. Thus, the proper recurrence formula for site area background seismicity becomes,

$$\log N_O = 1.93 - M_L \text{Site source zone.}$$
(background)

Similarly, the part of the Southern Basin and Range - Rio Grande rift region of interest has been referred to in the above discussion as the Algermissen and Perkins[22] Rio Grande rift source zone and has an area of about 4.1×10^4 $miles^2$ (1.1×10^5 km^2). The proper recurrence formula for the Algermissen and Perkins Rio Grande rift source zone becomes,

$$\log N = 2.56 - 1.0\ M_L.$$

The Basin and Range subregion as shown in Figure 2.5-19 has an area of about 6.4×10^4 mi^2 (6.4×10^5 km^2). Thus, the proper recurrence formula for the Basin and Range Subregion becomes,

$$\log N = 2.75 - 1.0\ M_L.$$

This leaves only the Central Basin Platform, which is treated somewhat differently. Although the initial formulas[14] above were developed for areas near 7.2 x 10^4 miles^2 (1.9 x 10^5 km^2) (with some increased confidence in their validity because of the relatively large areas of data collection), this cannot be done for the Central Basin Platform source zone because it is unique and of very limited area. Therefore, it cannot be treated as a scaled-down version of some broader region. Although recent work using data from the Kermit array[15] is available for this source zone, the recurrence formulation of Sanford et al.[2] is used in this risk analysis primarily for consistency in approach. Based on the seismicity detected in the Central Basin Platform since the installation of station CLN in April 1974, the cumulative number of shocks versus magnitude may be expressed as,

$$\log N_O = 3.84 - 0.9\ M_L.$$

If the active portion of the Central Basin Platform is assumed to have an area of 2.9 x 10^3 miles^2 (7.5 x 10^3 km^2) during this period,[2] the proper recurrence relation for the Central Basin Platform source zone becomes,

$$\log N = 2.74 - 0.9\ M_L.$$

Because the Central Basin Platform seismicity is so really limited, this same recurrence formula is used for all alternative geometric characterizations. This has the effect of maintaining a constant activity rate for the Central Basin Platform as an entity.

These are the primary recurrence relationships used in the current risk analysis for the WIPP site. However, whereas magnitudes as used in the site region attenuation law above, or in consideration of maximum magnitude for a given source zone below, are by definition Richter local magnitudes, M_L, the earthquakes used to determine the recurrence formulas have measured magnitudes crucial to formula development. Some apparent disagreement exists in how site region magnitudes should be computed, with some suggestion [15] that the local magnitudes determined by Sanford et al.[2] may be, in some sense, too low. In order to test the effect of this possibility, an alternate set of recurrence formulas is derived by incrementing the M_L values in the above relationships by 0.5, in general agreement with the suggested relation between a "corrected" magnitude[15] and the local magnitude of Sanford et al.[2] The effect of this process is clearly to increase the activity rate of all source zones.

The four formulas now become:

$\log N = 2.43 - M_{CORR}$	Site source zone (background)
$\log N = 3.06 - M_{CORR}$	Algermissen & Perkins Rio Grande rift source zone
$\log N = 3.25 - M_{CORR}$	Basin & Range subregion
$\log N = 3.19 - 0.9\ M_{CORR}$	Central Basin Platform

The final parameter to be determined before WIPP facility risk may be computed is source zone maximum magnitude. A simple consideration of maximum historical magnitude within each of the three general source zones is not conservative. This is particularly true of the northern part of the Rio Grande rift source zone (Zone 43 of Algermissen and Perkins[22]) where a maximum historical intensity of only V is known. As discussed above, the fault scarps in these areas, particularly along the margins of the San Andres and Sacramento mountains, imply that major earthquakes have occurred in this region within the past 5 x 10^5 years. The length of the faulting in these two areas [about 36 to 60 miles

(58 to 97 km)] suggests the possibility of earthquakes comparable in strength to the Sonoran earthquake of 1887.[1]

That Sonoran earthquake (M - 7.8) produced 50 miles (80 km) of fault scarp with a maximum displacement of about 28 feet (8.5 m) extending southward from the U.S. - Mexico border at about 109W longitude. Sanford and Toppozada[1] assume that a similar future event is possible west of a line whose location is in good general agreement with the eastern boundary of either the Rio Grande rift zone as shown in Figure 2.5-25, or the Basin and Range subregion as shown in Figure 2.5-26. This eclipses the more southerly Valentine, Texas earthquake, whose magnitude was about 6.4. For this analysis, a maximum magnitude event of 7.8 is assumed possible anywhere within the Rio Grande rift/Basin and Range subregion source zone.

The selection of maximum magnitude events for the WIPP facility source zone and the Central Basin Platform source zone is more difficult. Algermissen and Perkin[21] assign a maximum historical intensity of VI to the Central Basin Platform. This is presumably the earthquake of August 14, 1966 which has been assigned this intensity in United States Earthquakes 1966.[45] On the basis of this intensity and the empirical relationship of Gutenberg and Richter,[43] a maximum magnitude event of 4.9 has been selected for the Central Basin Platform by Algermissen and Perkins as appropriate for their probabilistic acceleration analysis. The magnitude scale was designed to give some indication of the elastic energy released at the earthquake source, and in this context a 4.9 value is almost certainly an exaggeration of the energy really released during that particular earthquake. This conclusion is based on both macroseismic and instrumental evidence. In addition, several magnitudes have been published for this earthquake (USCGS-3.4; Sanford et al.[2] - 2.5) which are substantially lower than the 4.9 value used by Algermissen and Perkins. As discussed above, the maximum historical magnitude in the Central Basin Platform source zone is probably between 3.0 and 4.0, even after uncertainty in magnitude calculation methods is considered.

The features of this source zone that might bear on its possible maximum magnitude are the lack of recent geologic evidence of tectonism and the high activity rate that may or may not be directly associated with secondary oil recovery efforts. Sanford and Toppozada[1] conjecture that the maximum magnitude might be 6.0 for this source zone, and in this study of risks, their example is followed for one set of calculations. Because this value may be exceptionally conservative, an alternative maximum magnitude of 5.0 is also considered.

With regard to the WIPP facility zone, there is even less indication that significant magnitude events are reasonably likely. There is no Quaternary fault offset,[46] and seismic activity is low. However, recent studies[17] show that some level of background seismicity must currently be considered for the site area if conservatism is to be served. Apparently, an earthquake that current best evidence indicates was tectonic in origin, and with a magnitude of 3.6 has, occurred within the site source zone itself, within about 40 kilometers of the WIPP facility. In addition, the June 16, 1978 event with an approximate magnitude of 4.4 occurred within the Permian Basin subregion although near its extreme eastern margin. That event may have been induced by secondary oil recovery operations. Two maximum magnitudes are considered for the WIPP facility source zone in the risk analysis of this section: 4.5, that is, maximum historical event near the site of tectonic origin plus about one magnitude unit; and 5.5, the maximum event recorded anywhere within the Permian Basin subregion, plus about one magnitude unit.

2.5.4.3 Calculation of Risk Curves

Risk Curves for the WIPP facility calculated using the McGuire[35] formulation are presented in this section; first for individual model WIPP facility region source zones, and then for a few illustrative combinations of risks from all source zones in the WIPP facility region to form total WIPP facility risk curves. In particular, a set of curves is calculated for the WIPP facility source zone, another set for the Central Basin Platform and a third set for the Basin and Range or Rio Grande rift source zone to the west of the site. With a presentation of this type, the effect of earthquake source parameter variation may be explored source by source, and the inherent complexity of the broad spectrum parameter approach is thereby somewhat compartmentalized. The strength of the broad spectrum approach is that it allows an objective (although not precisely formulated) estimate of the uncertainty in risk values associated with given peak accelerations under the suite of possible geologic and seismic assumptions discussed above.

For the Basin and Range subregion or the Rio Grande rift source zone, two geometries (Figures 2.5-23 and 2.5-26) and two recurrence formulas (Section 2.5.4.2), but only one maximum magnitude are considered. Thus, a total of four risk curves, for this general source area to the west of the site, are presented in Figure 2.5-27. The specific parameters associated with each of the four curves are listed in Table 2.5-4.

In the case of the Central Basin Platform source zone, three geometries (Figures 2.5-23 and 2.5-26), two maximum magnitudes, and two recurrence formulas are considered, so that a total of 12 risk curves are implied. However, preliminary calculations for the Central Basin Platform source zone as suggested by recent seismicity (Central Basin Platform source zone is outlined by heavy dashed lines in Figure 2.5-26) show that risks from this particular model of the Central Basin Platform source zone geometry are generally less at low accelerations and much less at higher accelerations than those derived from the two alternative geometries for given maximum magnitude and recurrence formula conditions. For example, considering the case of a maximum Central Basin Platform source zone with a magnitude of 6.0 , and a recurrence formula of the form log $N = 3.19-0.9\ M_{CORR}$ annual risks of $3.07x10^{-3}$, 6.80×10^{-3}, and $1.50x10^{-3}$ at the 1.3 ft/s^2 (40 cm/s^2) acceleration level and $5.89x10^{-4}$, $1.46x10^{-3}$ and $3.67x10^{-5}$ at about the 2 ft/s^2 (60 cm/s^2) acceleration level are computed at the site using the Algermissen and Perkins,[21] Central Basin Platform geology and recent Central Basin Platform seismicity suggested source geometries, respectively. Thus, the four risk curves for the seismically implied Central Basin Platform source geometry as shown in Figure 2.5-26, in association with the two maximum magnitudes and recurrence formulas for this source zone discussed above, cannot produce the most conservative estimation of risk at the WIPP facility. Because of the way risks from various source zones are combined to derive total risk curves, the do not lead to significantly lower estimates of total WIPP facility risks than those obtained using the Algermissen and Perkins geometry, given the particular form of the individual source zone risk curves in this study. Therefore, risk curves corresponding to the two alternative geometries are shown in Figure 2.5-28.

Finally, two maximum magnitudes and two recurrence formulas are considered for the background seismicity of the site source zone. The four risk curves thereby implied are shown in Figure 2.5-29. To aid in the task of keeping the assumptions underlying all these curves accessible, the parameters associated with each curve in Figures 2.5-27 through 2.5-29 are listed in Table 2.5-4.

The effects of varying the maximum magnitude within a given source zone are straightforward, although the details of these effects at the WIPP facility depend on the specific source-site geometric configuration. The general effect of increasing the maximum magnitude in any source zone is to increase the maximum acceleration at the WIPP facility attributable to that source zone, and to increase the WIPP facility risks from that source zone at all lower acceleration levels. In the case of the Central Basin Platform source zone, increasing the maximum source magnitude from 5.0 to 6.0 has the effect of increasing the WIPP facility risk from this source by a factor of 12.7 for the case of the Algermissen and Perkins[21] geometry, and about 18.5 for the geologically suggested source geometry at the 40 cm/s^2 acceleration level. This may be seen by comparing curves (1,2), (3,4), (5,6), and (7,8) of Figure 2.5-28. At low risk levels, the asymptotic approach of the lower maximum magnitude curves (the odd numbered curves of Figure 2.5-28) to an acceleration of just under 1.6 ft/s^2 (50 cm/s^2), and of the higher maximum magnitude (or even numbered) curves to an acceleration of about 3.94 ft/s^2 (120 cm/s^2), is clear. Very similar behavior is exhibited in Figure 2.5-29 for the background seismicity of the WIPP facility source zone. In this case, the ratio of site risks at the 1.3 ft/s^2 (40 cm/s^2) acceleration level due to curves generated using maximum magnitudes of 4.5 and 5.5 is 1.21, and somewhat over twice this at the 4.59 ft/s^2 (140 cm/s^2) level.

The effect of different recurrence formulas may be seen in any of Figures 2.5-27 through 2.5-29. As discussed above, the reason for considering different recurrence formulas is primarily to address the issue of uncertainty in the WIPP facility region magnitude determination, since the way in which magnitudes of recently recorded earthquakes are determined has a direct bearing on the form of the recurrence formulas derived for source zones in the WIPP facility region. In contrast, the maximum magnitudes specified for each of these source zones do not depend critically on calculated magnitudes, and therefore, are not dependent on the method of magnitude determination. For a given source zone geometry, maximum magnitude, and acceleration attenuation law, all risk curves approach the same maximum acceleration asymptote. The effect of any uncertainty in magnitude determination (acting through differences in recurrence formulas) is most noticeable at relatively higher risk levels. This may be seen by comparing curve pairs (1,2) or (3,4) in Figure 2.5-27, pairs (1,3), (2,4), (5,7) or (6,8) in Figure 2.5-28, or pairs (1,3) or (2,4) in Figure 2.5-29. For each of these risk curve pairs, the curves differ only in recurrence formula. The risk level at which convergence occurs for each of these pairs is clearly dependent on the risk level at which asymptotic behavior becomes evident under a given set of conditions. Convergence is not evident under the parameters used for the site source zone at the probabilities considered. For the two Central Basin Platform source zone geometries, convergence takes place at probabilities near 10^{-5} for a maximum source zone magnitude of 5.0, and at lower probabilities for the higher 6.0 maximum magnitude. This relatively simple behavior of curves from two different geometries occurs because the closest approach to the site is virtually identical for each of the two alternate Central Basin Platform source zones whose risk curves are platted in Figure 2.5-28. For earthquakes in the Basin and Range subregion or Rio Grande rift source zone, convergence is not evident at the lowest annual risk level calculated. For each of the cases discussed, different recurrence formulas lead to significantly different accelerations at risks lower than the convergence values. The final effect of parameter variation on the individual source zone risk curves has to do with the variation of the geometries of these zones. This effect is most easily seen in Figure 2.5-27 where effects of maximum magnitude variation do not occur. Curve pairs (1,3) and (2,4) in this figure differ only in source zone geometry characterization. The ratio of these curve pairs is not greatly dependent on risk level, being near 2.1, 3.4, and 2.6 for accelerations of 40, 80 and 3.94 ft/s^2 (120 cm/s^2), respectively. In both cases, risks from the Basin and Range subregion characterization are somewhat higher at a given acceleration level than those from the Rio Grande rift source zone of Algermissen and Perkins, because a slightly greater proportion of the Basin and Range subregion is closer to the WIPP facility, as may be seen by comparing Figures 2.5-25 and 2.5-26. For the Central Basin Platform source zone curve pairs (1,5), (2,6), (3,7), and (4,8) differ only by source geometry. The asymptotic convergence of these risk curve pairs closely approximates the behavior of convergence under recurrence formula variation discussed above, and at about the same risk levels for given maximum magnitude conditions. Again, variation is greatest at high risk levels. Ratios of risk levels for the curve pairs above are almost independent of the recurrence formula being 1.5 for curve pairs (1,5) and (3,7) and 2.2 for pairs (2,6) and (4,8) at the 1.3 ft/s^2 (40 cm/s^2) acceleration level.

In very general terms, increasing the maximum magnitude of any source zone using the recurrence formulas suggested by the magnitude calculation of Rogers and Malkiel,[15] or selecting the geology implied Central Basin Platform and Basin and Range subregion source zone geometries, has the effect of increasing site risk levels. Using these observations, several extreme WIPP facility risk curves are generated below.

Although much can be learned by considering each WIPP facility region source zone separately, several important issues cannot be addressed until total risk curves are generated combining the contributions from the individual source zones. The process is illustrated graphically in Figure 2.5-30. In this figure are shown the individual source zone curves for the Algermissen and Perkins[21] Central Basin Platform and Rio Grande rift zones (Figure 2.5-25) for maximum magnitudes of 6.0 and 7.8 respectively, and for the site source zone using a maximum magnitude of 5.5. In each case, the Sanford et al.[2] recurrence formulas are used. These are curve 2 of Figure 2.5-28, 1 of figure 2.5-27, and 2 of Figure 2.5-29. The total WIPP facility risk curve calculated by combining these three individual curves is shown as a solid light line in Figure 2.5-30. This particular total risk curve closely approximates the most conservative curve calculated in the WIPP Geological Characterization Report (Figure 5.3-6 of Reference 30, curve 4), except that a maximum WIPP facility source zone magnitude of 5.5 instead of 5.0 is used. One point is clear from Figure 2.5-31, under the assumptions used to calculate the source zone risks shown in this figure, the significance of the Rio Grande rift source zone to the total risk at the WIPP facility is relatively small at all acceleration levels. In fact, this is a general result for all combinations of source zone parameters considered. For the earthquake recurrence relationships considered for the various source zones, this will be true at lower acceleration levels no matter what assumptions are made about the maximum magnitudes in the WIPP facility and Central Basin Platform source zones. At higher acceleration levels, this will be true unless the lowest maximum magnitude proper for the WIPP facility source zone is lower than the 4.5 value considered here.

Note further that for the case considered in Figure 2.5-30, where 6.0 is the maximum magnitude event for the Central Basin Platform source zone, probabilities are largely controlled by earthquakes in this zone up to accelerations of around 0.04 g. For higher accelerations, the WIPP facility source zone is more important. The cross-over acceleration is clearly a function of the relative maximum magnitudes in the Central Basin Platform and WIPP facility source zones. For a lower maximum magnitude in the WIPP facility source zone relative to the Central Basin Platform source zone, the latter zone would be expected to dominate the WIPP facility total risk curve to higher acceleration levels. If the Central Basin Platform source zone maximum magnitude is lower relative to the WIPP facility source zone, its significance is totally eclipsed by the WIPP facility source zone at all acceleration levels. Perhaps the most obvious feature of the total risk curve of Figure 2.5-31 is its dominance by the WIPP facility source zone at higher accelerations. Consideration of different combinations of source zone parameters indicates that this feature of risk curves at the WIPP facility is universal for all cases derivable from the parameters considered. Therefore, if the probabilities at which these higher acceleration levels occur are thought to be of interest, it is the assumptions made about the immediate WIPP facility area that are most critical.

The question of total WIPP facility risk at a number of acceleration levels and under a number of assumptions about source zone parameters is addressed graphically in Figure 2.5-31, where several extreme cases are considered. Four curves in all are shown. Curves 1 and 2 both assume maximum source zone magnitudes of 7.8, 6.0, and 5.5 for the Basin and Range subregion (or Rio Grande rift), Central Basin Platform, and WIPP facility source zones, respectively, and recurrence formulas suggested by the Roger and Malkiel[15] magnitudes. That is, curve 1 of Figure 2.5-31 is the result of combining individual source zone risks at the WIPP facility represented by curve 4 of Figure 2.5-27, curve 8 of Figure 2.5-28, and curve 4 of Figure 2.5-29. Similarly, curve 2 of Figure 2.5-31 is the result of combining individual source zone risks at the site represented by curves 2 and 4 of Figures 2.5-27 through 2.5-29, respectively. The difference between curves 1 and 2 of Figure 2.5-31 is that curve 2 uses source zone geometries taken from Algermissen and Perkins,[21] while curve 1 uses the slightly more conservative alternate source zone geometries discussed in Section 2.5.4.2. Curves 3 and 4 of Figure 2.5-31 both assume smaller maximum source zone magnitudes of 7.8, 5.0, and 4.5 for source zones taken in the same order as above and recurrence formulas suggested by Sanford et al.[14] The individual risk curves used to generate these two total risk curves may be deduced from the above description and Table 2.5-4. The differences between curves 3 and 4 are precisely the geometric differences between curves 1 and 2.

It is clear from the four total site risk curves of Figure 2.5-31 that the geometric differences considered for the source zones do not introduce important differences in total WIPP facility risk at any acceleration level, although what small differences do exist are most evident at low accelerations. More importantly, for all parametric variations allowed in this study, extremum curves as shown in this figure imply accelerations associated with 10^{-3}/y risks ranging between about 1.31 and 2.46 ft/s^2 (40 and 75 cm/s^2), accelerations associated with 10^{-4}/y risks between 75 and 130 cm/s^2, and 10^{-5}/y risk accelerations between 4.27 and 8.04 ft/s^2 (130 and 245 cm/s^2).

2.5.5 Design Basis Earthquake

The stringent seismic criteria for nuclear power plants do not apply to the WIPP facility due to the unique character of the design and function of the facility. In particular, the terms "Operating Basis Earthquake" (OBE) and "Safe Shutdown Earthquake" (SSE) are not applied to the WIPP facility. Rather, the term "Design Basis Earthquake" (DBE) is used for the design of Class II and IIIA confinement structures and components (Section 3.2.7). As used here, the DBE is equivalent to the design earthquake used in Regulatory Guide 3.24 (U.S. Nuclear Regulatory Commission).[47] That is, in view of the limited consequences of seismic events in excess of those used as the basis for seismic design, the DBE is such that it produces ground motion at the WIPP facility with a recurrence interval of 1,000 years (Section 3.1.3). In practice the DBE is defined in terms of the 1,000-year acceleration and design response spectra.

The generation of curves expressing probability of occurrence or risk as a function of peak WIPP facility ground acceleration is discussed in detail in Section 2.5.4 for a number of possible characterizations of WIPP facility region source zones and source zone earthquake parameters. The most conservative (and the least conservative) risk curves are shown in Figure 2.5-31.

From this figure, the most conservative calculated estimate of the 1000 year acceleration at the WIPP facility is seen to be approximately 0.075g. The geologic and seismic assumptions leading to this 1000-year peak acceleration include the consideration of a Richter magnitude 5.5 earthquake at the site, a 6.0 magnitude earthquake on the Central Basin Platform, and a 7.8 magnitude earthquake in the Basin and Range subregion. These magnitudes correspond roughly to equivalent epicentral intensity events of VII, VIII and XI on the Modified Mercalli intensity scale.[8] These values, especially the first two, are considered quite conservative, and the other parameters used in the 0.075g derivation are also very conservatively chosen. For additional conservatism, a peak design acceleration of 0.1g is selected for the WIPP facility DBE. The design response spectra for vertical and horizontal motions are taken from Regulatory Guide 1.60 (U.S. Nuclear Regulatory Commission)[48] with the high frequency asymptote scaled to this 0.1g peak acceleration value. These response spectra are shown in Figures 3.2-2 and 3.2-3.

This DBE and the risk analysis that serves an important role in its definition are directly applicable to Design Class II and IIIA confinement structures and components at the WIPP Facility. Underground structures and components are Design Class IIIB and as such are not subject to DBE. Mine experience and studies on earthquake damage to underground facilities[49] show that tunnels, mines, wells, etc., are not damaged for sites having peak accelerations at the surface below 0.2g.

Design Class IIIB underground facilities do not require the consideration of seismic effects based on the above, and seismic load combinations with increased allowable stresses will not control the design.

References for Section 2.5

1 New Mexico Bureau of Mines and Mineral Resources, Seismicity of Proposed Radioactive Waste Isolation Disposal Site in Southeastern New Mexico, 1974.

2 New Mexico Institute of Mining and Technology, Report to Sandia Laboratories, A Report on Seismic Studies of the Los Medanos Area in Southeaster New Mexico, 1978.

3 SAND80-7096, New Mexico Institute of Mining and Technology, Report to Sandia National Laboratories Seismicity in the Area of the Waste Isolation Pilot Project. Released as a Sandia National Laboratories Report, 1980.

4 U.S. Dept. Commerce, United States Earthquakes 1930, Coast and Geodetic Survey, Washington, D.C., 1932.

5 U.S. Dept. Commerce, United States Earthquakes, 1931, Coast and Geodetic Survey, Washington, D.C., 1932.

6 U.S. Dept. Commerce, United States Earthquakes 1936, Coast and Geodetic Survey, Washington, D.C., 1938.

7 Seismol. Soc. Am. Bull., Modified Mercalli Intensity Scale of 1931, 1931.

8 Univ. Tex. Bull. No. 3201, The Valentine, Texas Earthquake, 1933.

9 Seismol. Soc. Am. Bull., Catalog of Nevada Earthquakes, 1852-1960, 1965.

10 Prentice-Hall Inc., Englewood Cliffs,N.J., Earthquake Engineering, 1970.

11 Princeton Univ. Press, Seismicity of the Earth and Associated Phenomena, 1954.

12 New Mexico Bureau Mines and Mineral Resources, Seismicity of the Rio Grand Rift in New Mexico, 1972.

13 Geol. Soc. Am. Abstracts with Programs, The Seismicity of New Mexico 1962 through 1972, 1976.

14 U.S. Dept of the Interior, U.S. Geological Survey, Monthly Listing, Preliminary Determination of Epicenters, Washington, D.C., 1973, 1974, 1977.

15 Sandia Laboratories, Geological Characterization Report, 1978.

16 New Mexico Institute of Mining and Technology, Oak Ridge Operations Contract No. AT-(40-1)-4582, A Report on Seismic Recording at the Los Medranos Area of Southeastern New Mexico, 1974-1975, 1976.

17 New Mexico Institute of Mining and Technology, Geophysics Open-File Report 45, A Magnitude Scale for Central New Mexico Based on Signal Duration, 1983.

18 U.S. Geol. Surv. Open-file Report, A Computer Program for Determining Hypocenter, Magnitude, and First Motion Pattern of Local Earthquakes, 1972.

19 J. Geophys. Res., 78, Seismic Wave Attenuation and Magnitude Relations for Eastern North America, 1973.

20 Los Alamos Scientific Laboratory, Informal Report LA-6406-MS, LASL Seismic Programs in the Vicinity of Los Alamos, New Mexico, 1976.

21 U.S. Geol. Srv. Open-file Report 76-416, A Probabilistic Estimate of Maximum Ground Acceleration in the Contiguous United States, 1976.

22 A.A.P.G. Bull. 47, Late Paleozoic Tectonics and Mountain Ranges, Western Texas to Southern Colorado, 1963.

23 Habitat of Oil-A Symposium, Oil and Geology in the Permian Basin of Texas and New Mexico, 1958.

24 New Mexico Bureau of Mines and Mineral Resources, New Mexico Institute of Mining and Technology, Oil and Gas Potential of a Proposed Site for the Disposal of High-Level Radioactive Waste, Oak Ridge Nat'l Laboratories, Open-file Report, 1974.

25 Science, 79, Scarps in Tularosa Valley, New Mexico, 1934.

26 Am.J. Sci., Recent Fault Scarps, Organ Mountain District, New Mexico, 1938; U.S. Geol. Surv. Prof. Paper 215, Geology of the Southern Guadalupe Mountains, Texas, 1948.

27 Geology, 6, Quaternary Faulting in Trans-Pecos Texas, 1978.

28 J. Geophys. Res., 83, No. B 11, Contemporary Uplift of the Diablo Plateau, West Texas, from Leveling Measurements, 1978.

29 U.S. Geological Survey, The National Atlas of the United States of America, U.S. Dept. of the Interior, Washington, D.C., 1970.

30 Fourth World Conf. on Earthquake Engineering, Santiago, Chile, Vol. I, The Major Influences on Seismic Risk, 1969.

31 J. Struct. Div., Am. Soc. Civil Eng., 10, Seismic Risk Analysis of Boston, 1975.

32 Dept. of Civil Eng., A Study of Seismic Risk for Nicaragua, Report 11, Stanford Univ., Stanford, California, 1975.

33 Seismol. Soc. Am. Bull., 67, Effects of Uncertainty in Seismicity on Estimates of Seismic Hazard for the East Coast of the United States, 1977.

34 Interscience, London, Probabilistic Analysis of Damage to Structures Under Seismic Load; Dynamic Waves in Civil Engineering, 1971.

35 Seismol. Soc. Am. Bull., 63, Seismic Risk Analysis Based on a Quadratic Magnitude-Frequency Law, 1973.

36 Earthquake Eng. Res. Center, Report no 68-5, Characteristics of Rock Motions during Earthquakes, 1968.

37 Seismol. Soc. Am. Bull., 64, Prediction of Peak Ground Motion from Earthquakes, 1974.

38 Seismol. Soc. Am. Bull., 57, Magnitude Determination at Regional and Near-Regional Distances in the United States, 1967.

39 J. Geophys. Res., 78, Radiation and Attenuation of Rayleigh Waves from the Southeastern Missouri Earthquake of October 21, 1965, 1973.

40 Seismol. Soc. Am. Bull., 63, The Mississippi Valley Earthquakes of 1811 and 1812 - Intensities, Ground Motion and Magnitudes, 1973.

41 U.S. Army Waterways Experiment Station, Vicksburg, Mississippi, Design Earthquakes for the Central United States, Misc. Paper S-73-1, 1973.

42 Seismol. Soc. Am. Bull., 32, Earthquake Magnitude, Intensity, Energy and Acceleration, 1942.

43 Seismol. Soc. Am. Bull., 63, Accelerations in Rock for Earthquakes in the Western United States, 1973.

44 New Mexico Institute of Mining and Technology, Geophysics Open-file Report 26, Earthquake activity in New Mexico (1849 through 1977), 1978.

45 U.S. Department Commerce, United States Earthquakes 1966, Coast and Geodetic Survey, Washington, D.C., 1968.

46 U.S. Geol. Survey Open-file Report 4339-8, Surficial Features and Late Cenozoic History in Southeastern New Mexico, 1973.

47 U.S. Nuclear Regulatory Commission, Guidance on the License Application, Siting, Design, and Plant Protection for an Independent Spent Fuel Storage Installation, Regulatory Guide 3.24, December, 1974.

48 U.S. Nuclear Regulatory Commission, Regulatory Guide 1.60, Design Spectra for Seismic Design of Nuclear Power Plants, Revision 1, December, 1973.

49 Vol. 1 Proceedings 1979 RETC, AIME, Littleton, CO., Earthquake Damage to Underground Facilities, Draft, 1979.

50 SAND 88-0157, UC-70, Sandia National Laboratories, Summary of Site-Characterization Studies conducted From 1983 Through 1987 at the Waste Isolation Pilot Plant (WIPP) Site, Southeastern New Mexico, Reprinted January 1989.

51 SAND 78-1596, Sandia National Laboratories, Geological Characterization Report, Waste Isolation Pilot Plant (WIPP) Site, Volume I, Southeastern New Mexico, August 1978.

52 SAND 78-1596, Sandia National Laboratories, Geological Characterization Report, Waste Isolation Pilot Plant (WIPP) Site, Southeastern New Mexico, Volume II, August 1978.

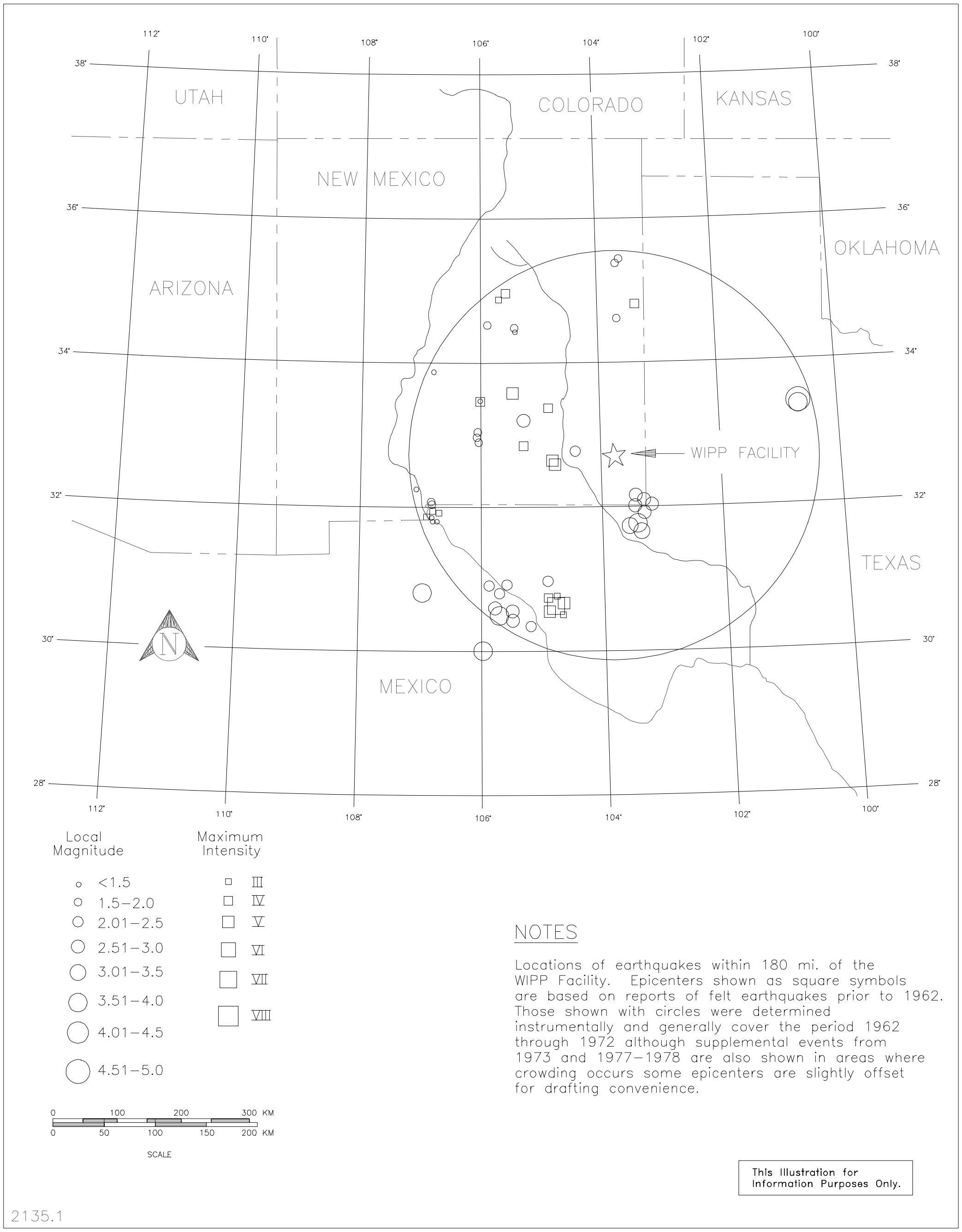


Figure 2.5-1, Earthquakes Located Using Macroseismic or Regional Seismographic Data 1923 - 1977

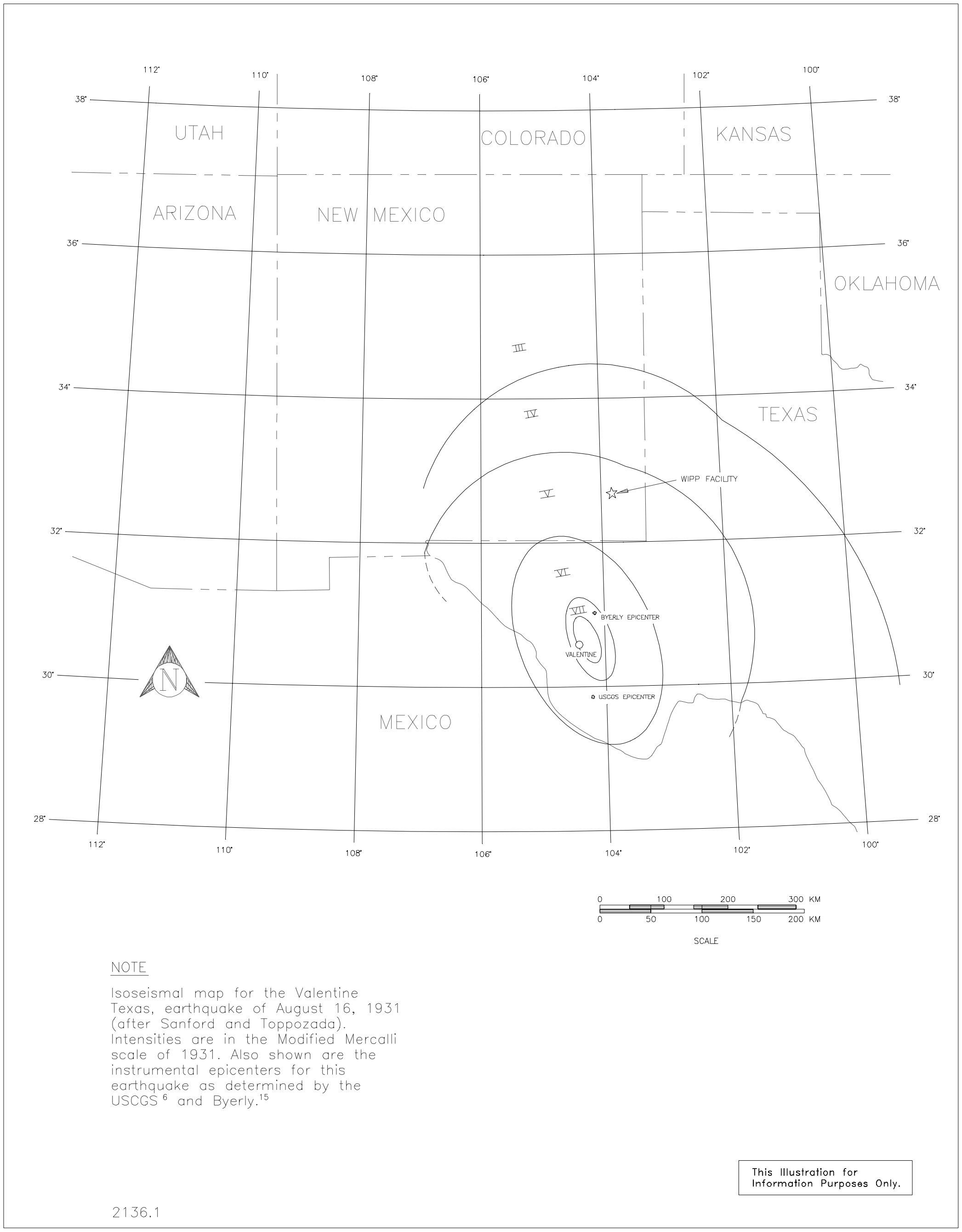


Figure 2.5-2, Valentine, Texas, Earthquake Isoseismals

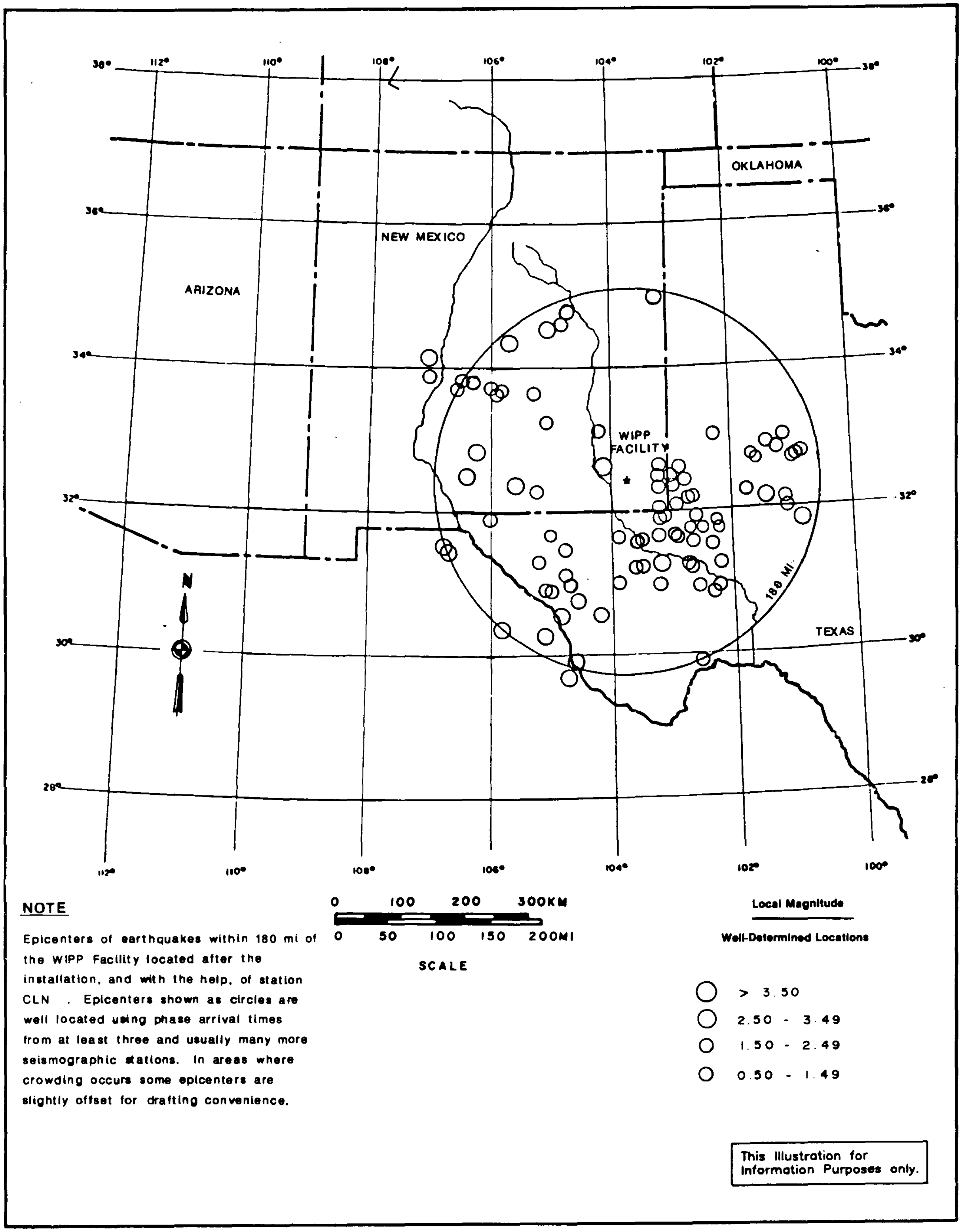


Figure 2.5-3, Earthquakes Located with the Help of Data from Station CLN(April 1974 - February 1979)

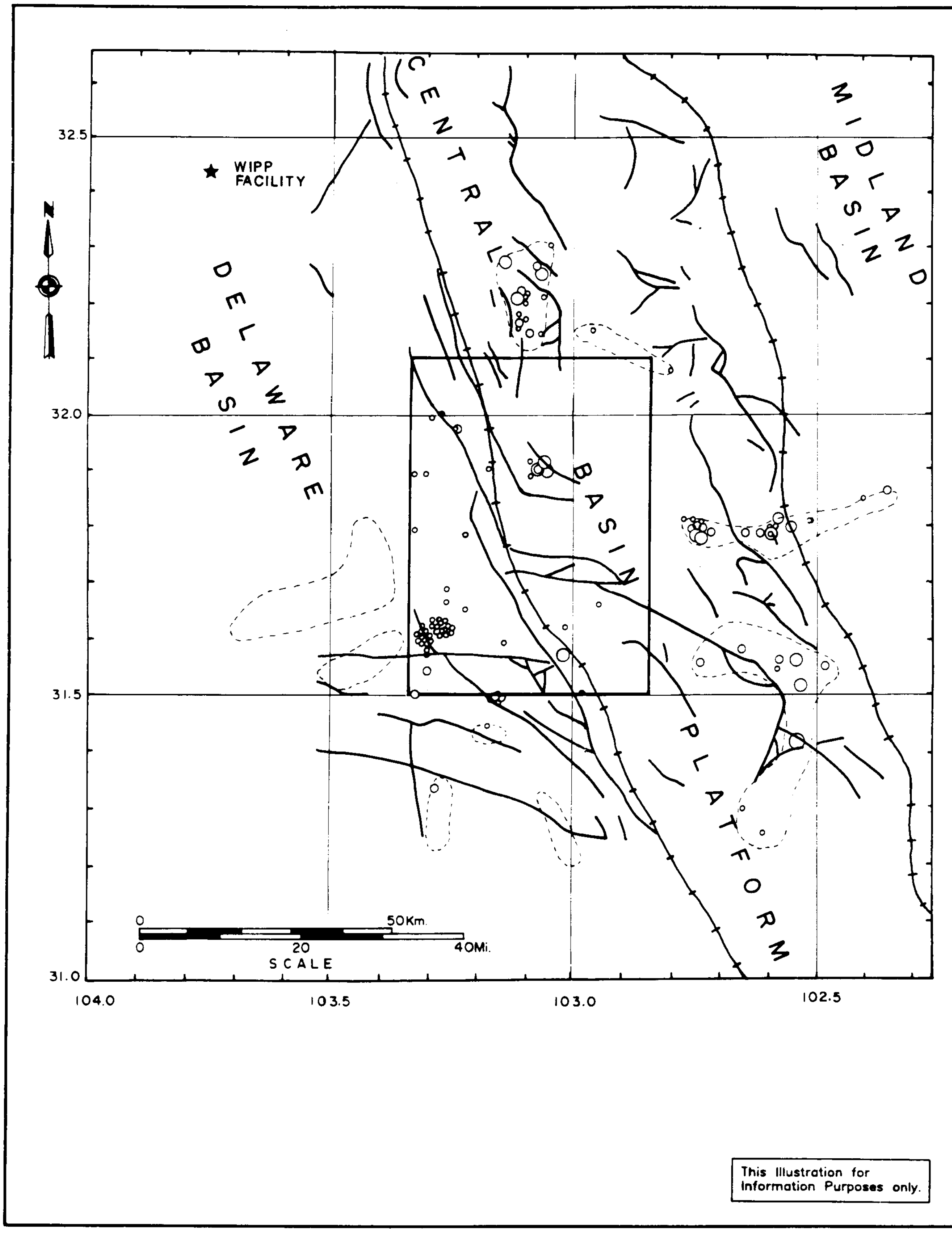


Figure 2.5-4a, Earthquakes Location Using Kermit Array Data November 1975 through July 1977

NOTE

Earthquakes located using the Kemit array network. [15]
All located events within the array (denoted by the small rectangular area in the map to the left and in the regional scale inset above) are shown, as well as those shocks on the array's periphery located by five or more array stations. The light dashed lines enclose peripheral epicenters whether or not they satisfy the five station criterion. Solid lines are pre-Permian faults, and the cross hatched lines the approximate boundary of the Central Basin Platform, both after Rogers and Malkiel. [15] The regional location map below shows the total map area to the left as well as the Kermit array limits in a large scale context.

Magnitude (M_{LD})

○ ≤ 2.35
○ 2.36–2.85
○ 2.86–3.35
○ ≥ 3.36

2139.2

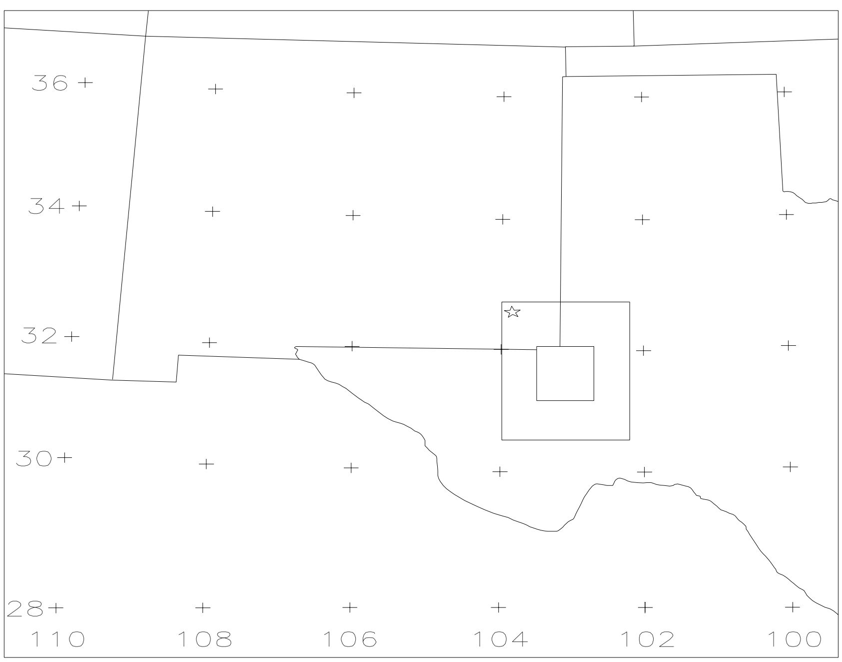
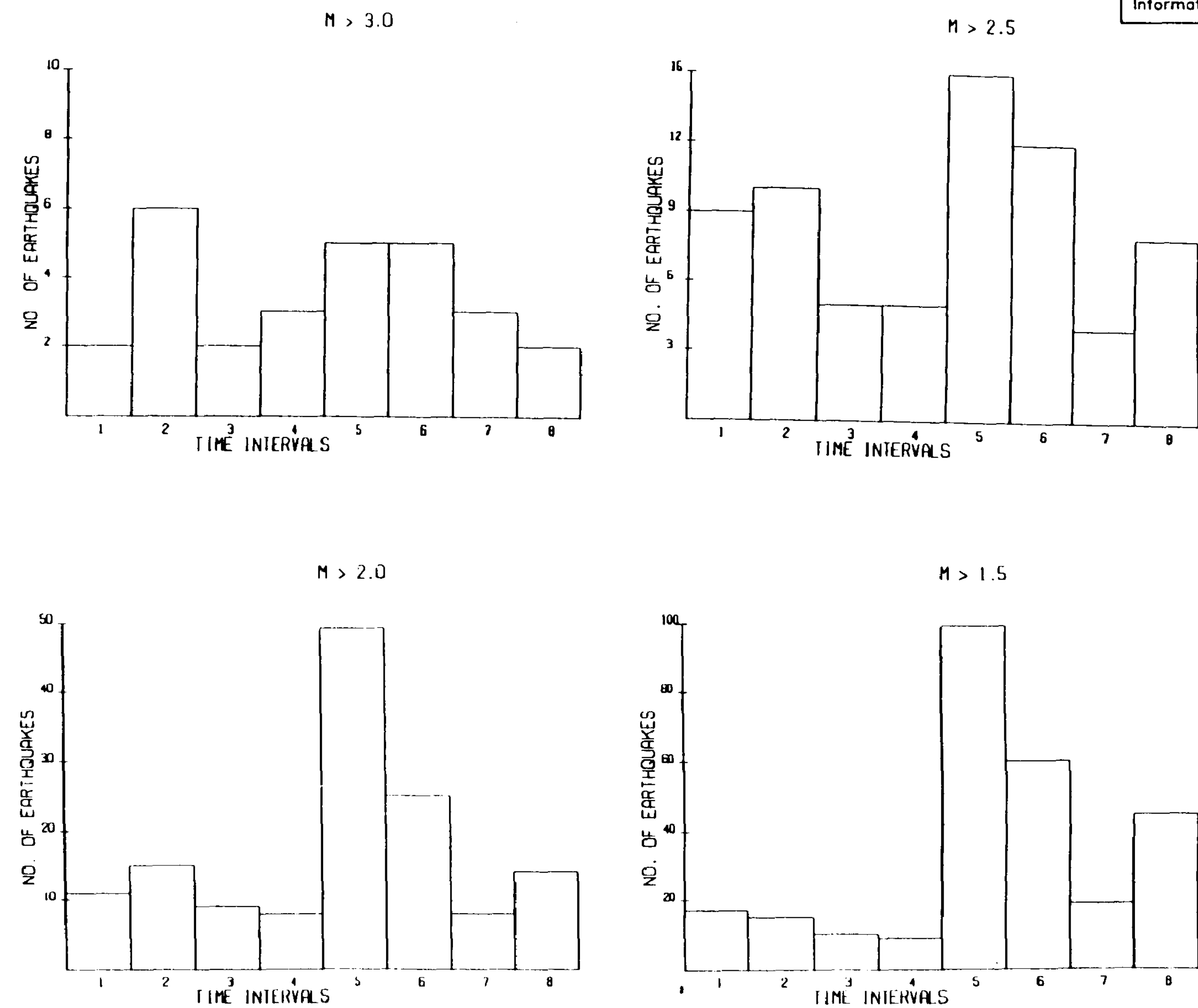


Figure 2.5-4b, Explanation to Figure 2.5-4a

This Illustration for Information Purposes only.



NOTE:

The 24 3/4 year period from 1 January 1962 through 30 September 1986 was divided into eight sequential intervals of 1130 days each. Shown in these four histograms are the numbers of events in each interval with M≥3.0, M≥2.5, M≥2.0 and M≥1.5.

Figure 2.5-5, Histograms of Number of Earthquakes: 1 January 1962 through 30 September 1986

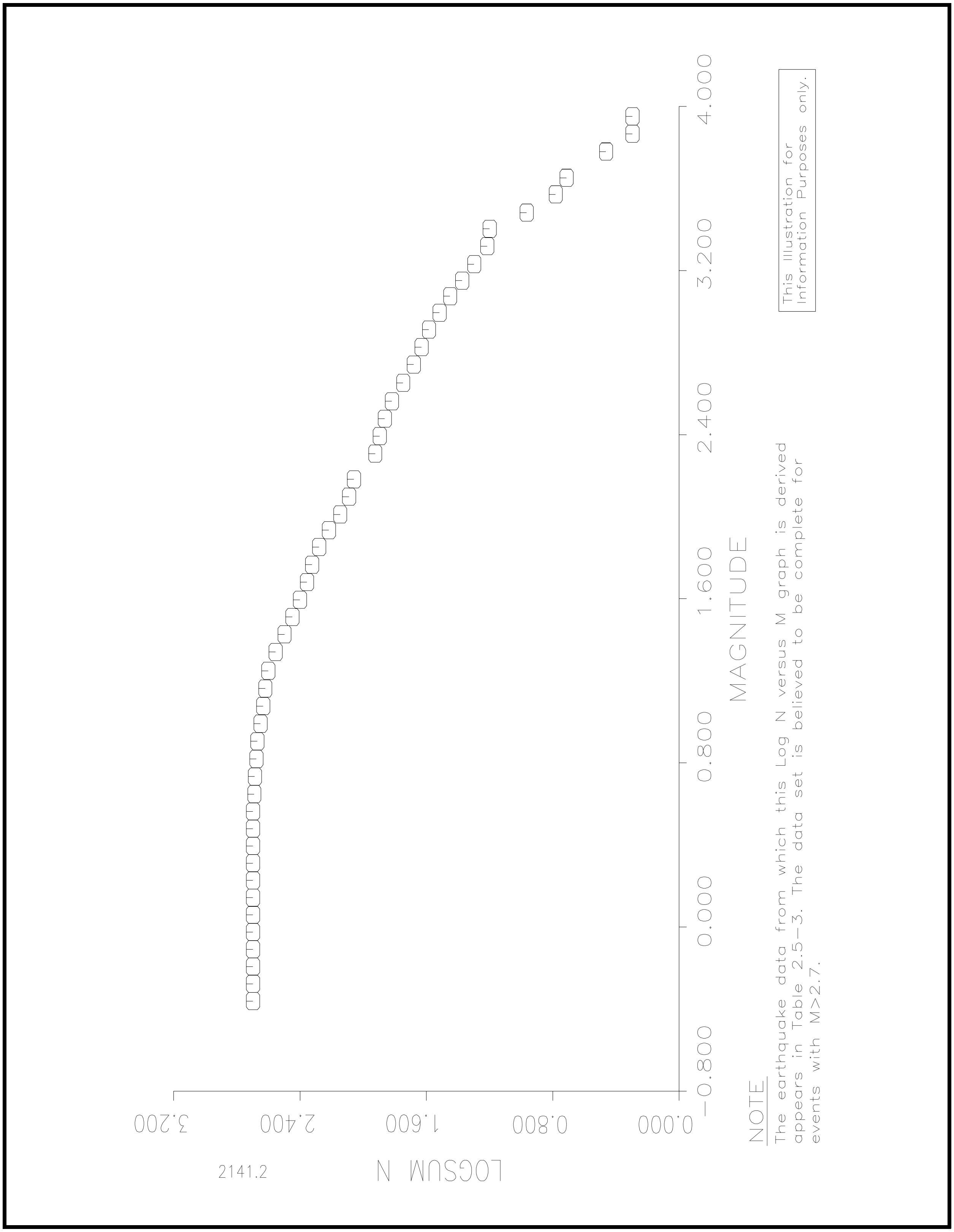


Figure 2.5-6, Earthquakes Recurrence Data (Log N versus M): 1 January 1962 through 30 September 1986

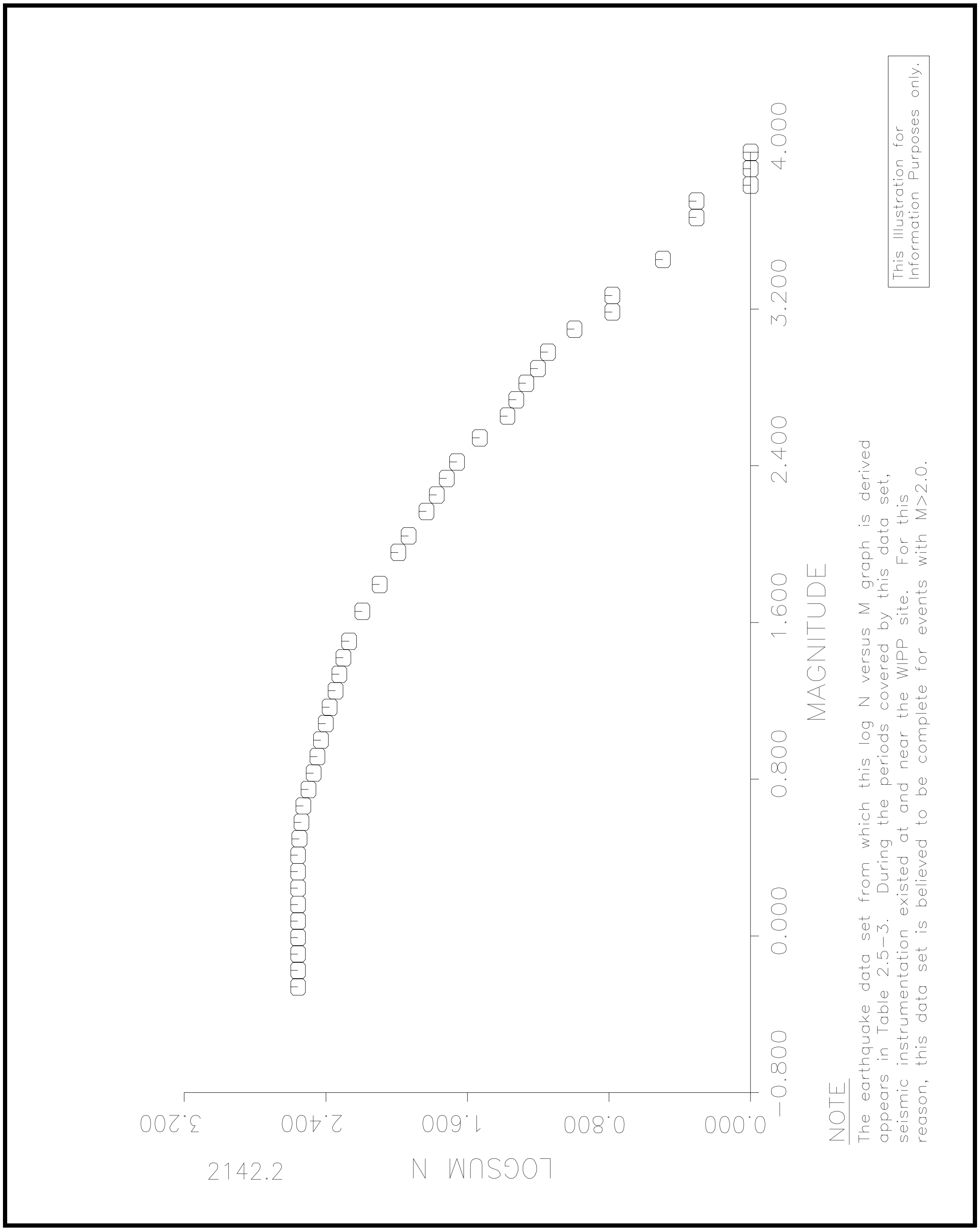


Figure 2.5-7, Earthquake Recurrence Data (Log N versus M): 18 May 1974 through 24 July 1980 and 29 August 1983 through 30 September 1986

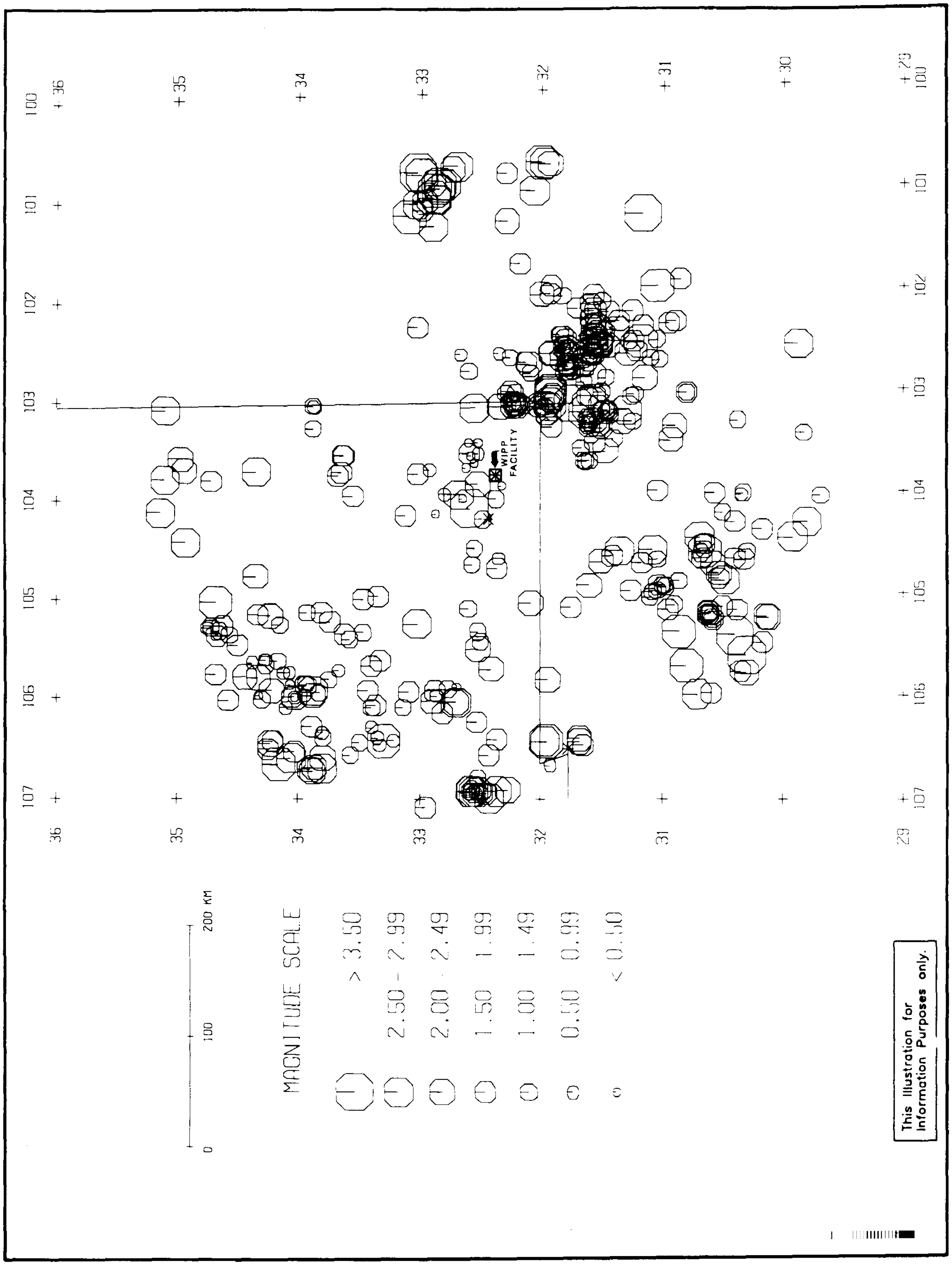


Figure 2.5-8, Epicenters for All Located Earthquakes: 1 January 1962 through 30 September 1986

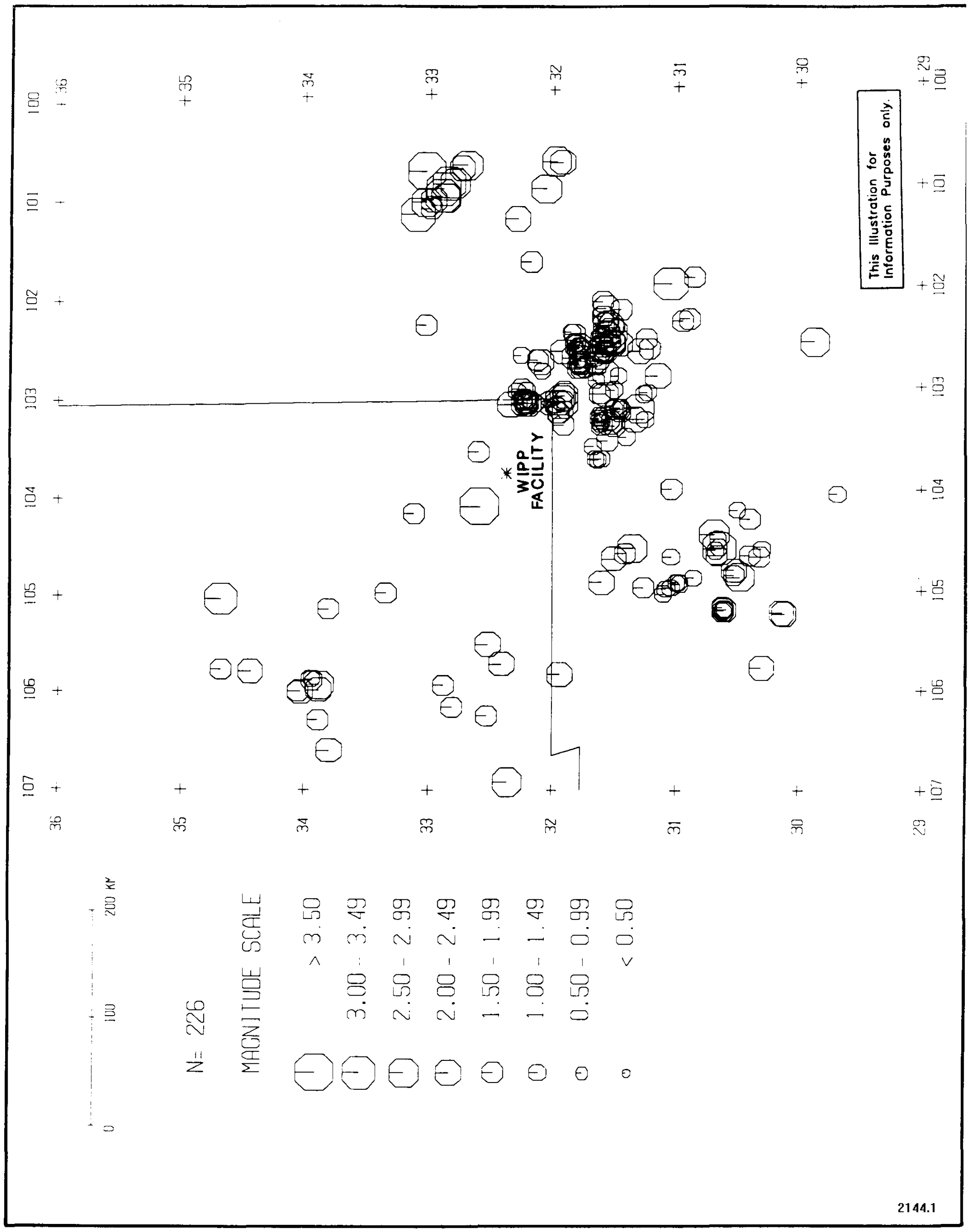


Figure 2.5-9, Epicenters for All Located Earthquakes: 5 April 1974 through 6 October 1978

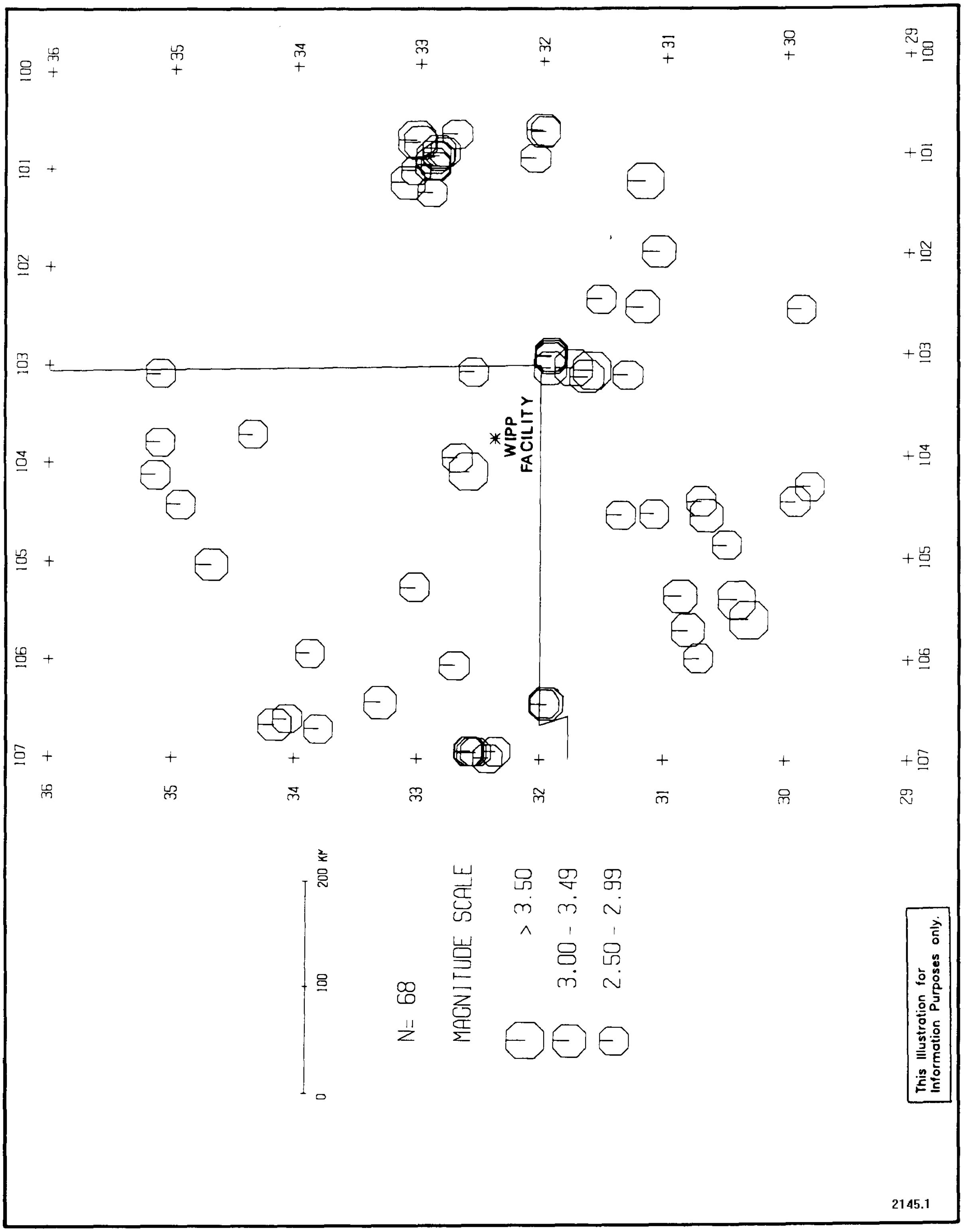


Figure 2.5-10, Epicenters for Located Earthquakes with M≥2.5: 1 January 1962 through 30 September 1986

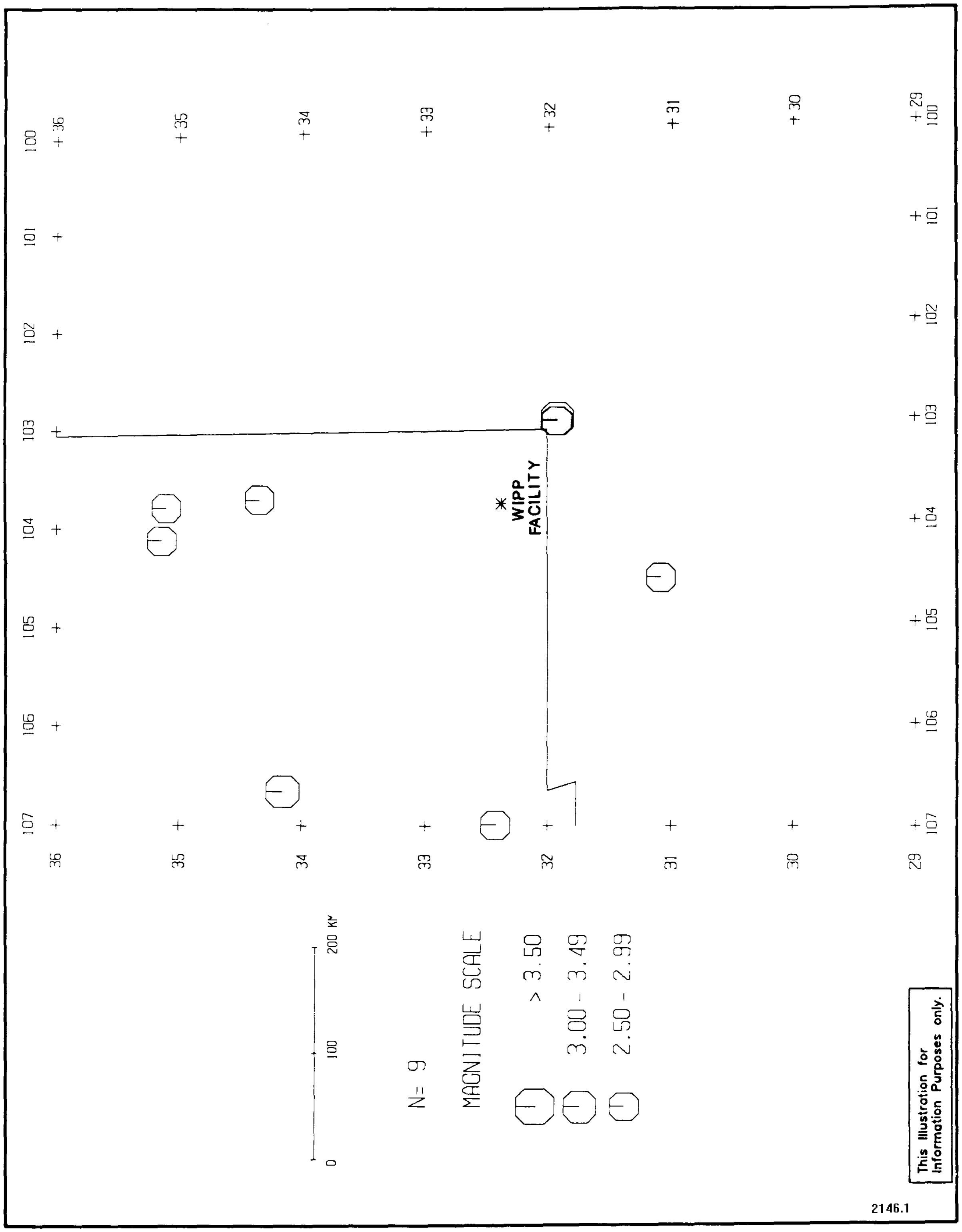


Figure 2.5-11, Epicenters for Located Earthquakes with M≥2.5: 1 January 1962 through 3 February 1965

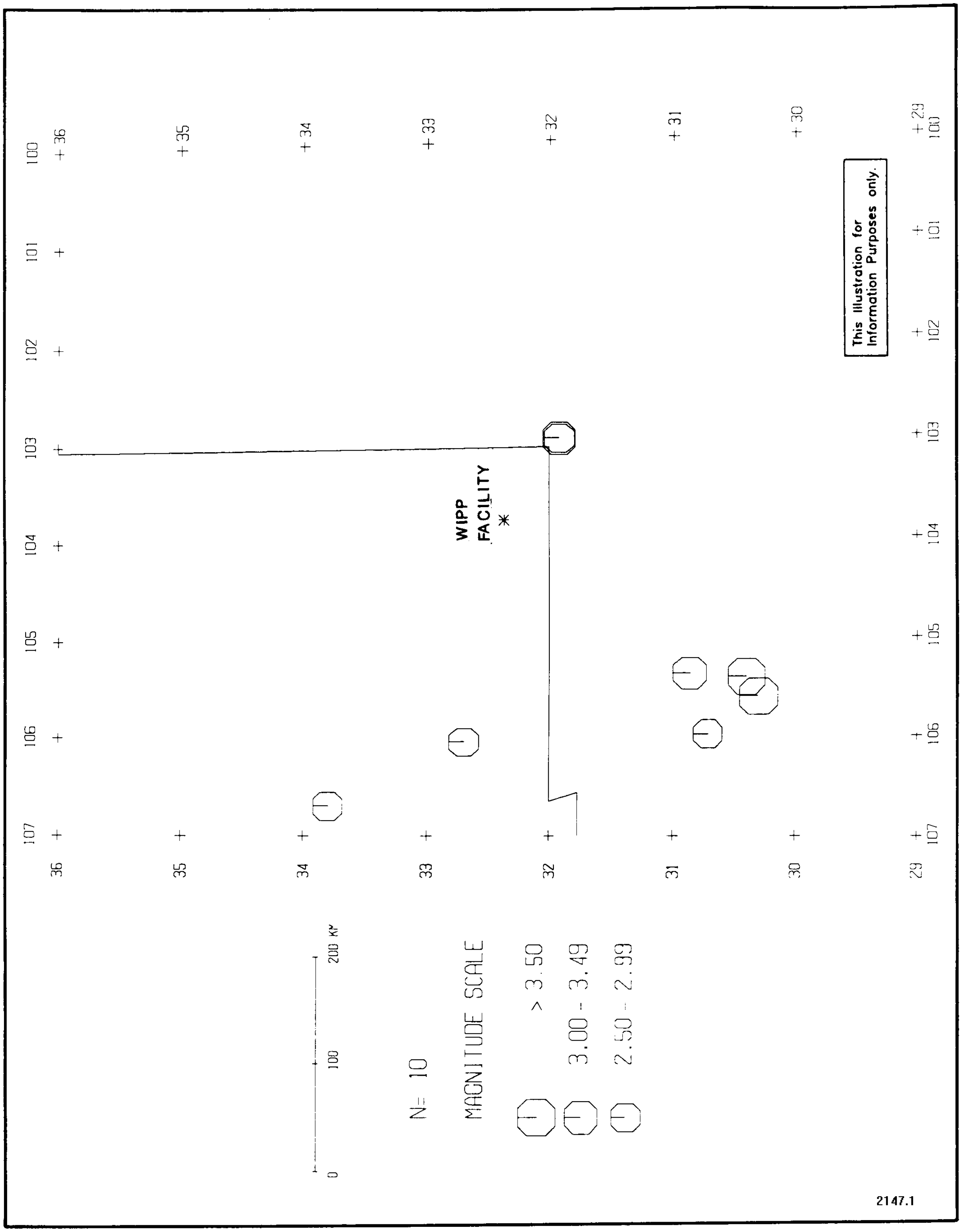


Figure 2.5-12, Epicenters for Located Earthquakes with M≥2.5: 4 February 1965 through 9 March 1968

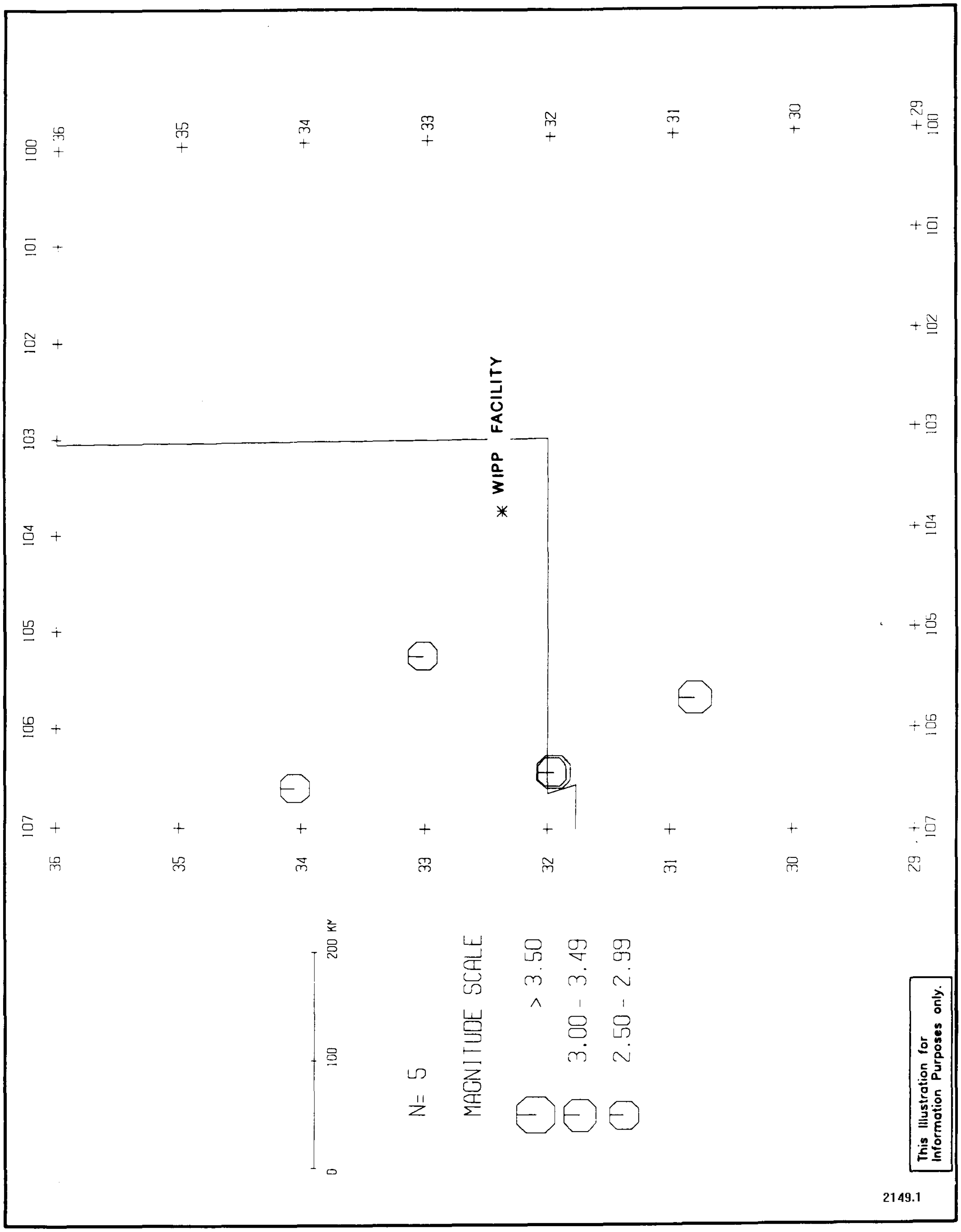


Figure 2.5-13, Epicenters for Located Earthquakes with M≥2.5: 10 March 1968 through 13 April 1971

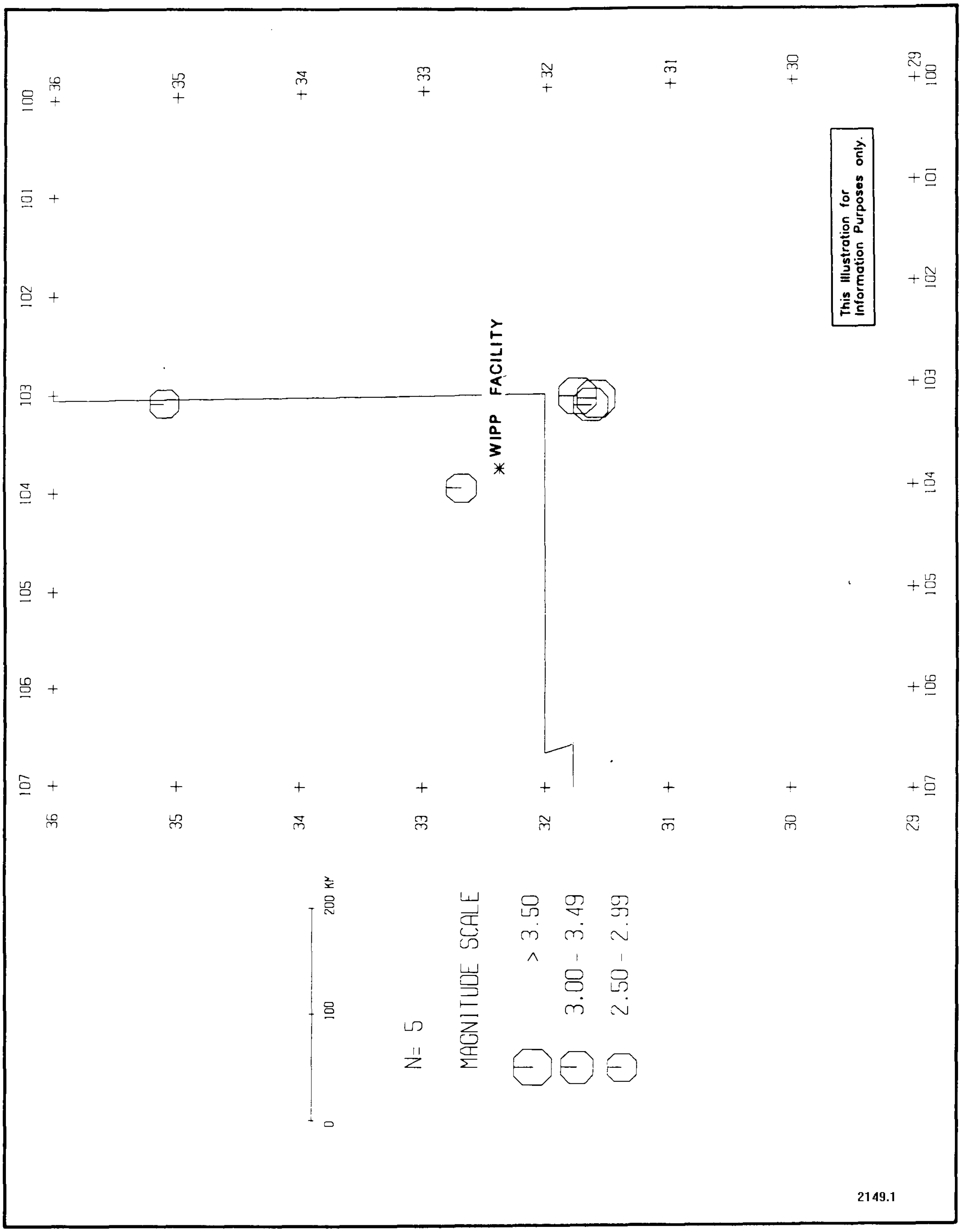


Figure 2.5-14, Epicenters for Located Earthquakes with M≥2.5: 14 April 1971 through 17 May 1974

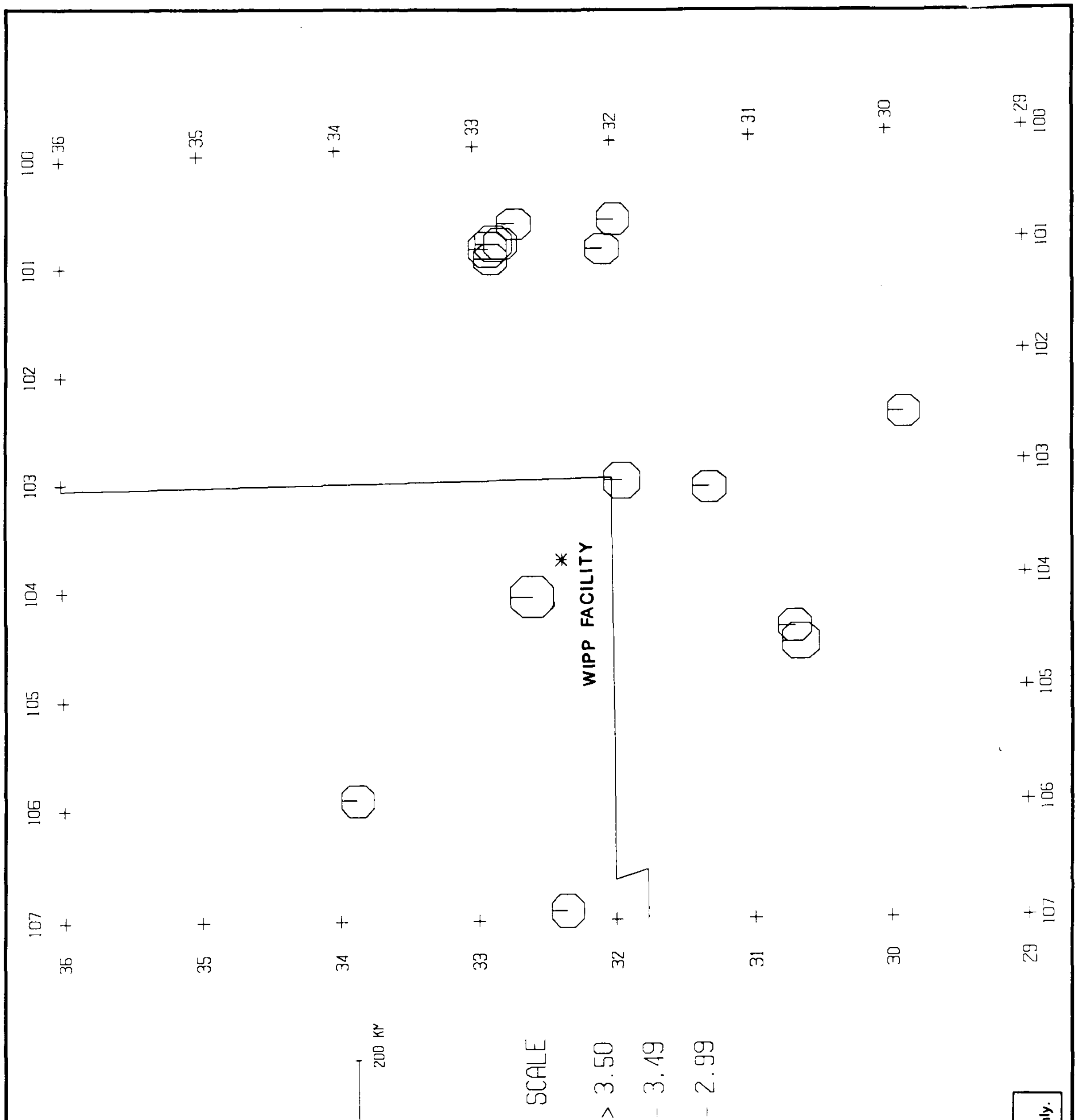


Figure 2.5-15, Epicenters for Located Earthquakes with M≥2.5: 18 May 1974 through June 21, 1977

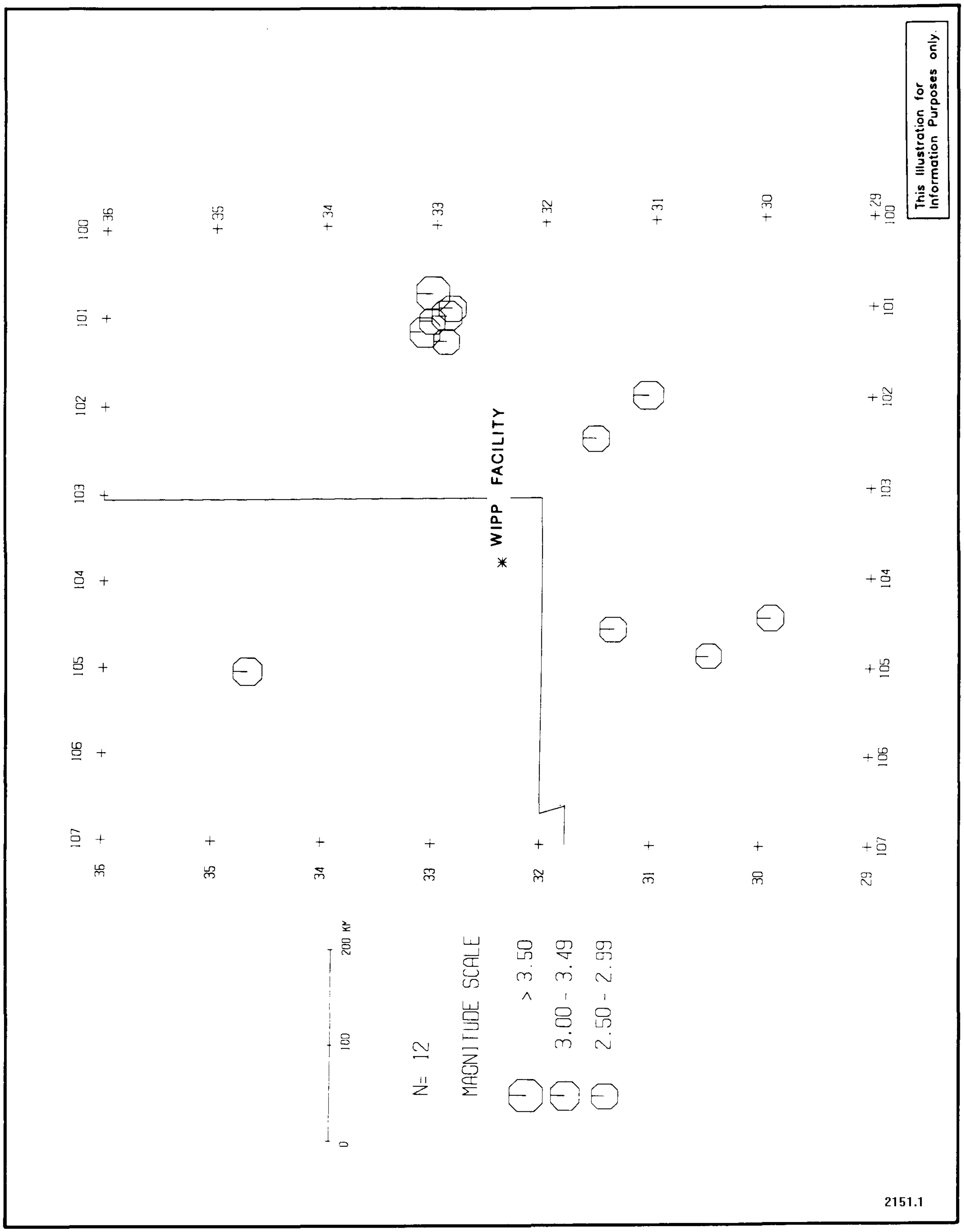


Figure 2.5-16, Epicenters for Located Earthquakes with M≥2.5: 22 June 1977 through 24 July 1980

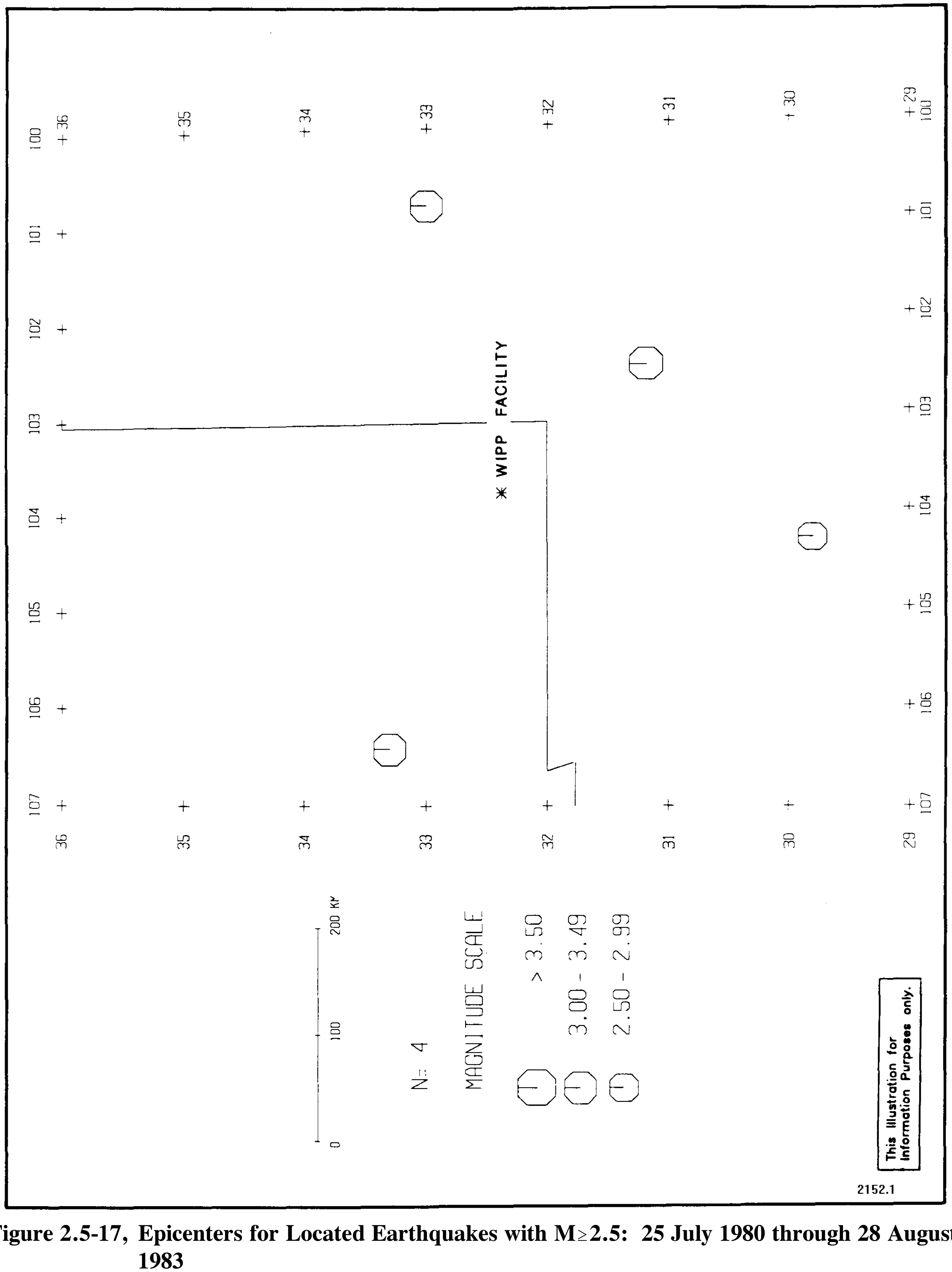


Figure 2.5-17, Epicenters for Located Earthquakes with M≥2.5: 25 July 1980 through 28 August 1983

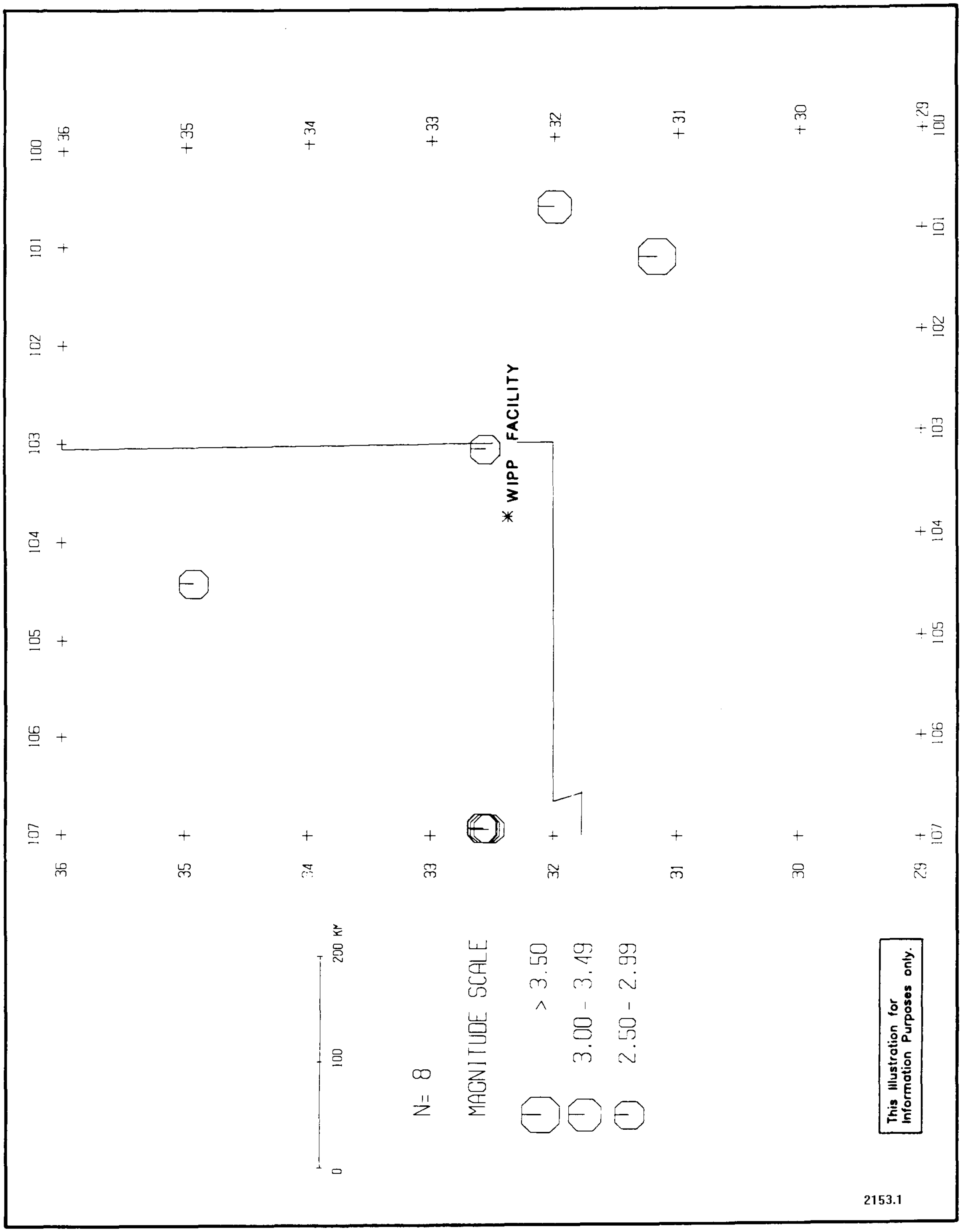


Figure 2.5-18, Epicenters for Located Earthquakes with M≥2.5: 29 August 1983 through 30 September 1986

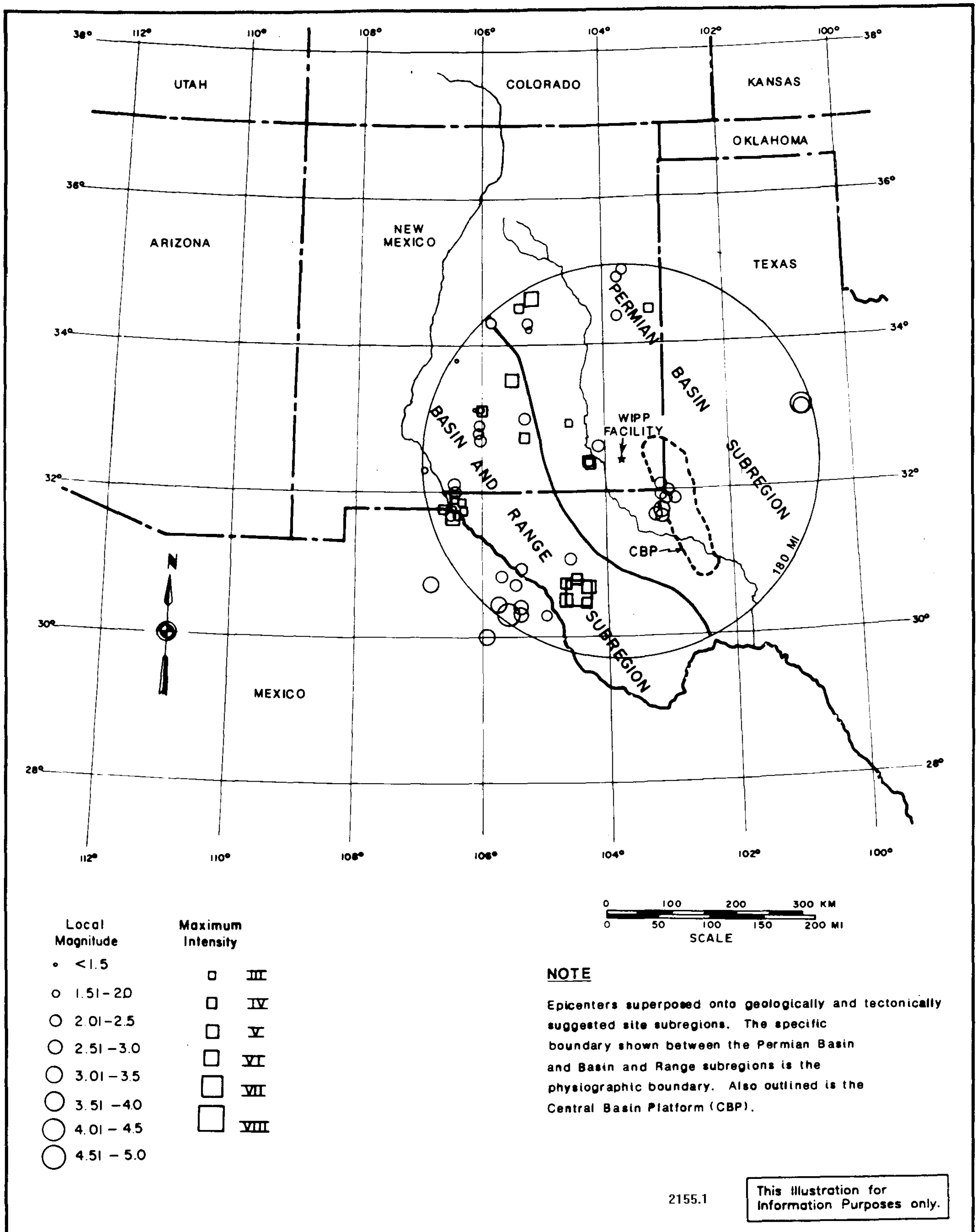


Figure 2.5-19, Earthquakes Located Using Macroseismic or Regional Seismographic Data 1923 - 1977 and Suggested Site Subregions

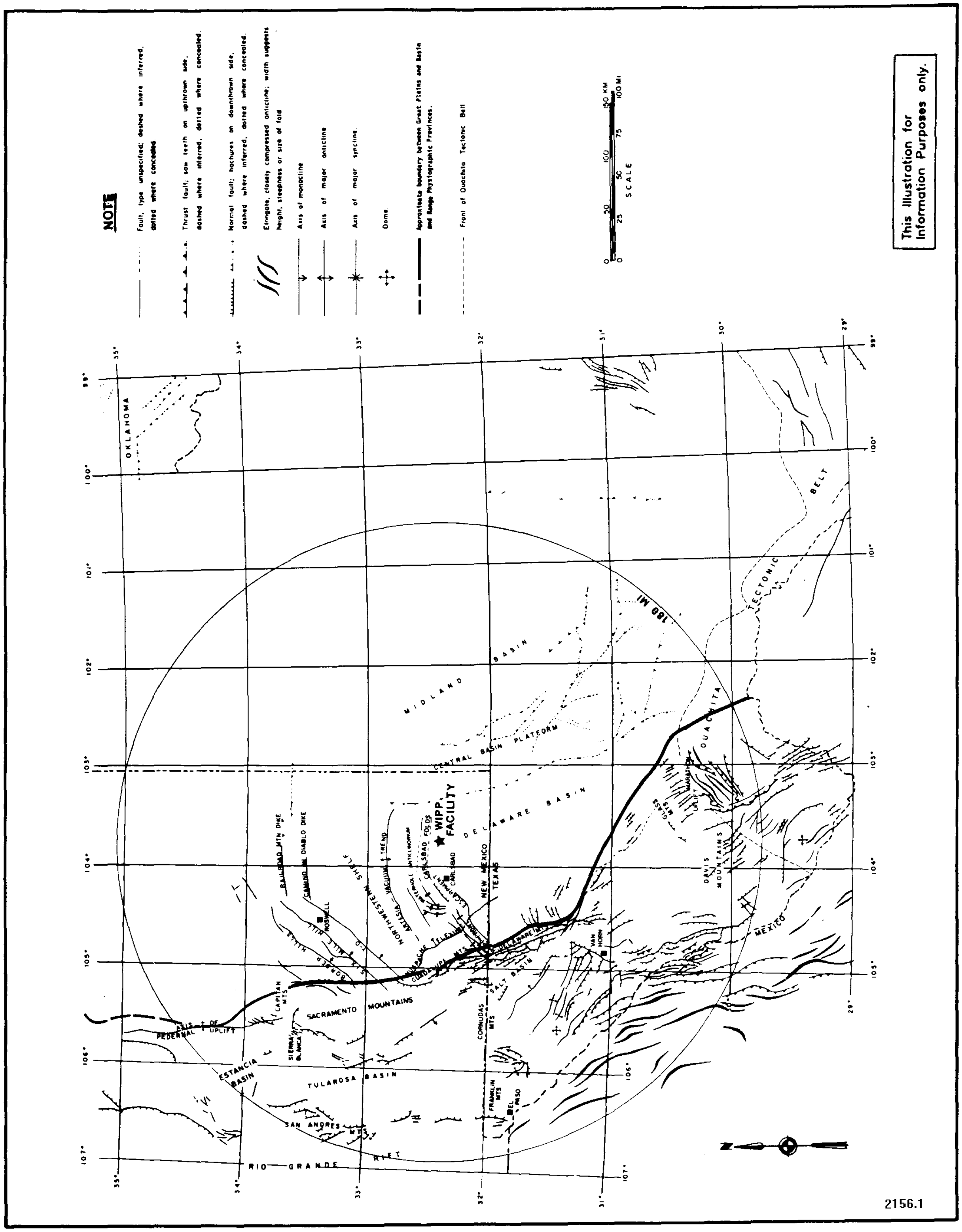


Figure 2.5-20, Site Region Structural Features and the Great Plains-Basin and Range Physiographic Boundary

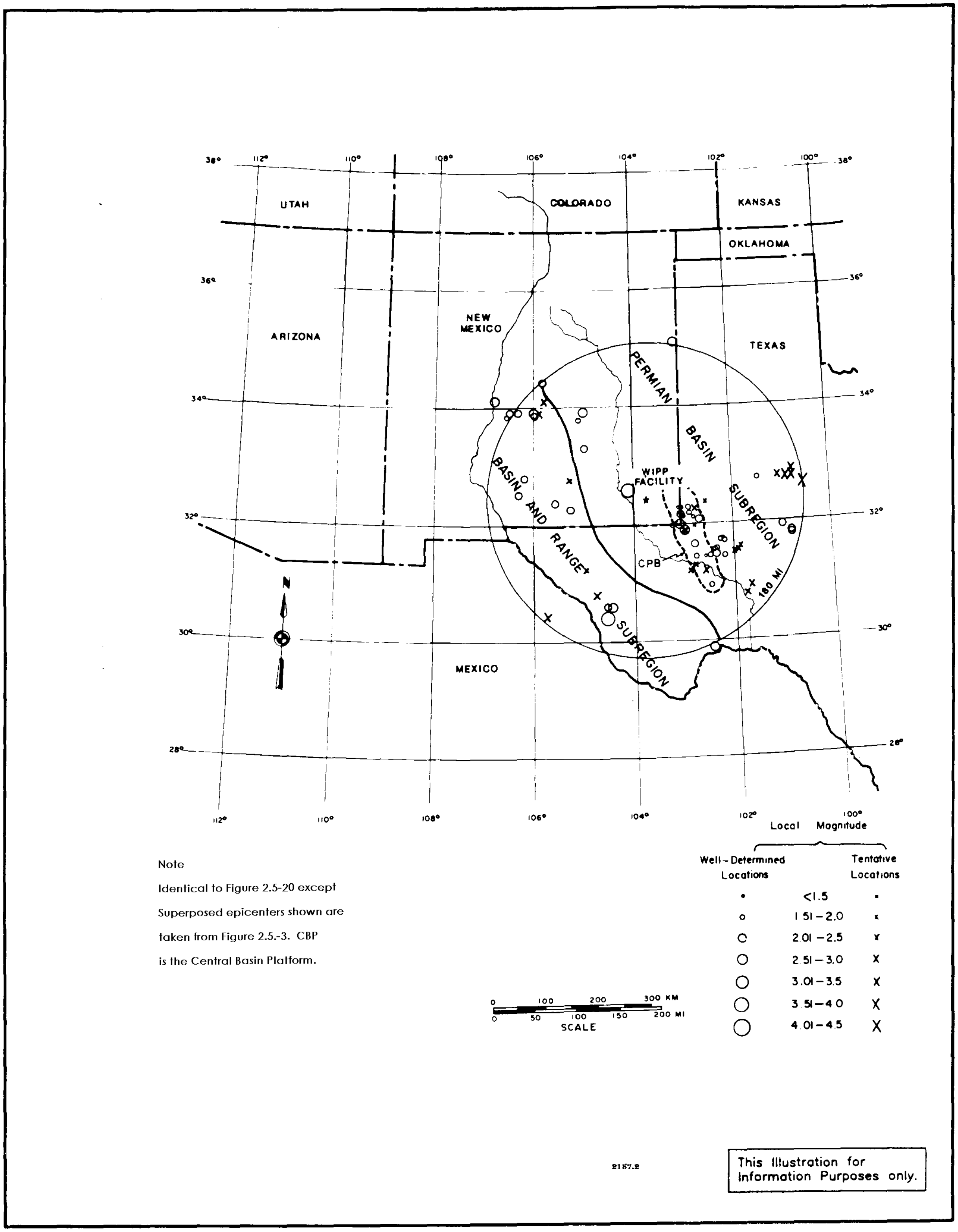


Figure 2.5-21, Earthquakes Located with the Help of Data from Station CLN and Suggested Site Subregions

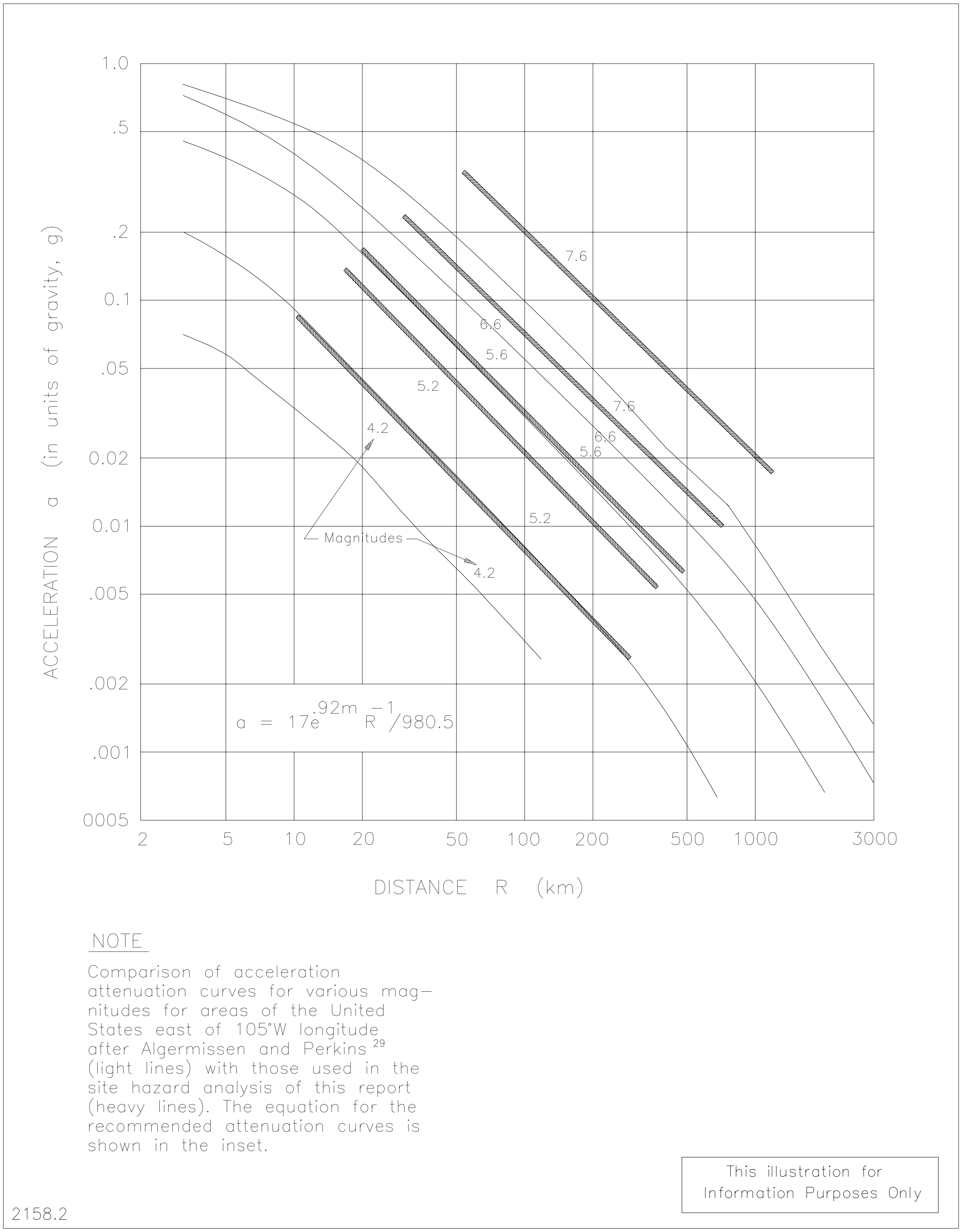


Figure 2.5-22, Recommended Attenuation Curves

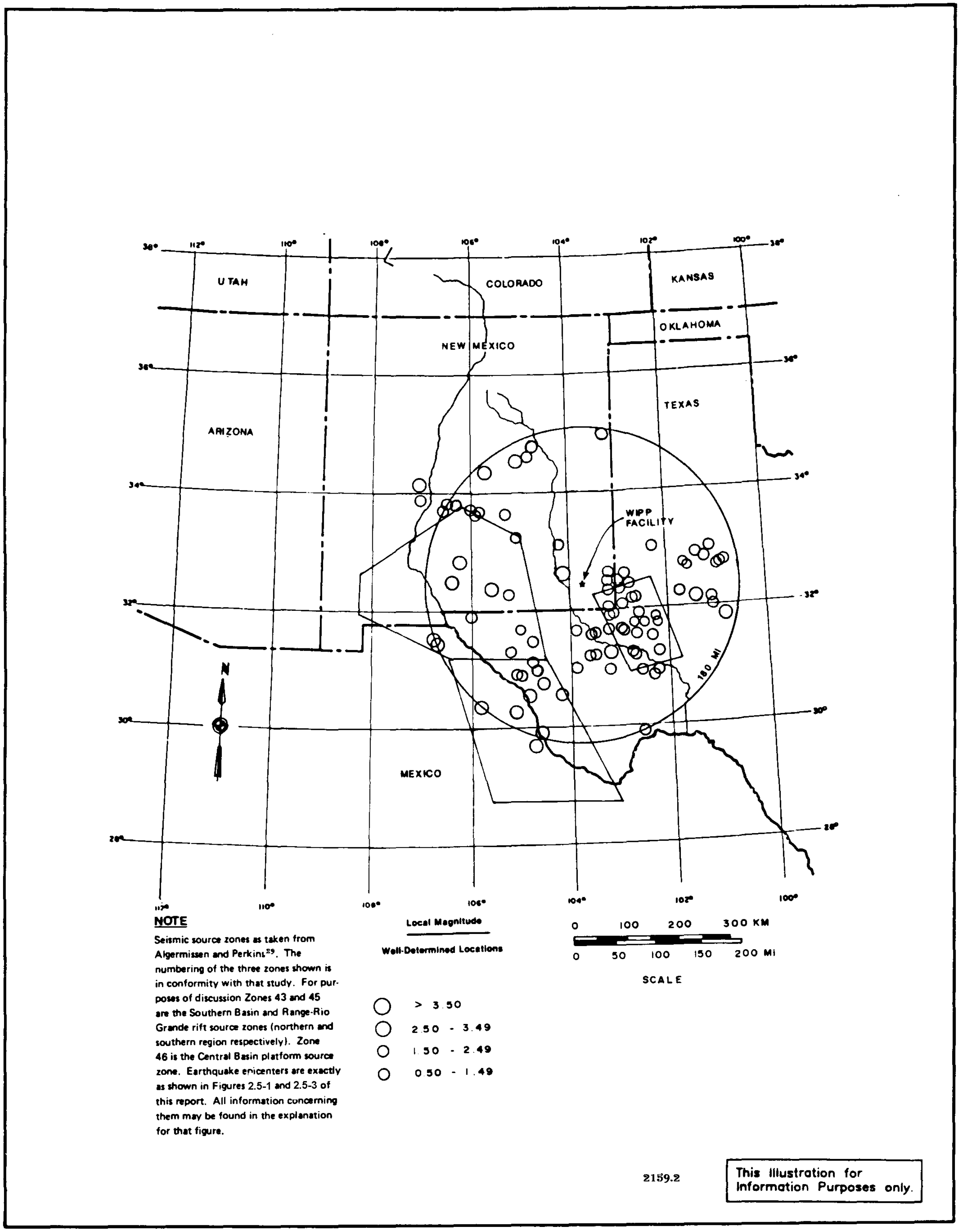
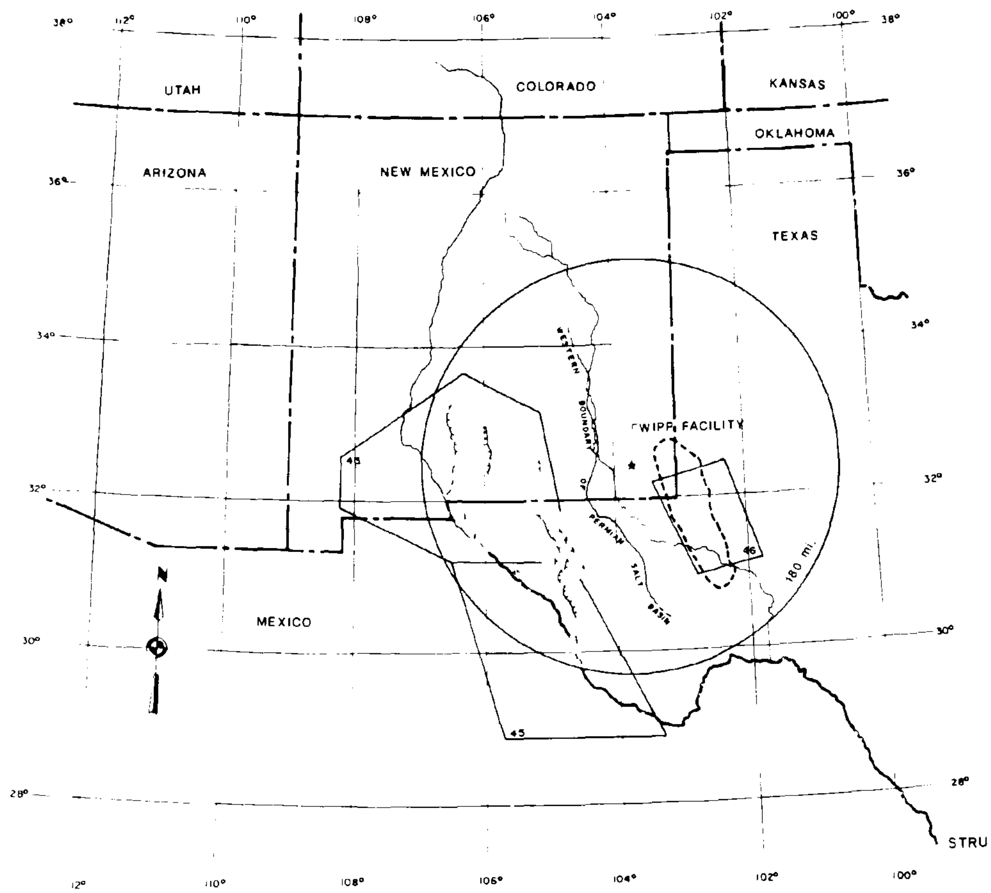
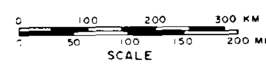


Figure 2.5-23, Algermissen and Perkins Seismic Source Zones



NOTE

Seismic source zones are as shown in Figure 2.5-23. Plotted Quaternary faulting features are taken from Sanford and Toppozada[1] and Muehlberger et al.[46] The western boundary of the Permian Salt Basin as taken from the earlier study is also shown. The outline of the Central Basin platform (CBP) is taken from Rogers and Malkiel.[23]



2160.2

This Illustration for Information Purposes only.

Figure 2.5-24, Structural Features in the WIPP Site Region

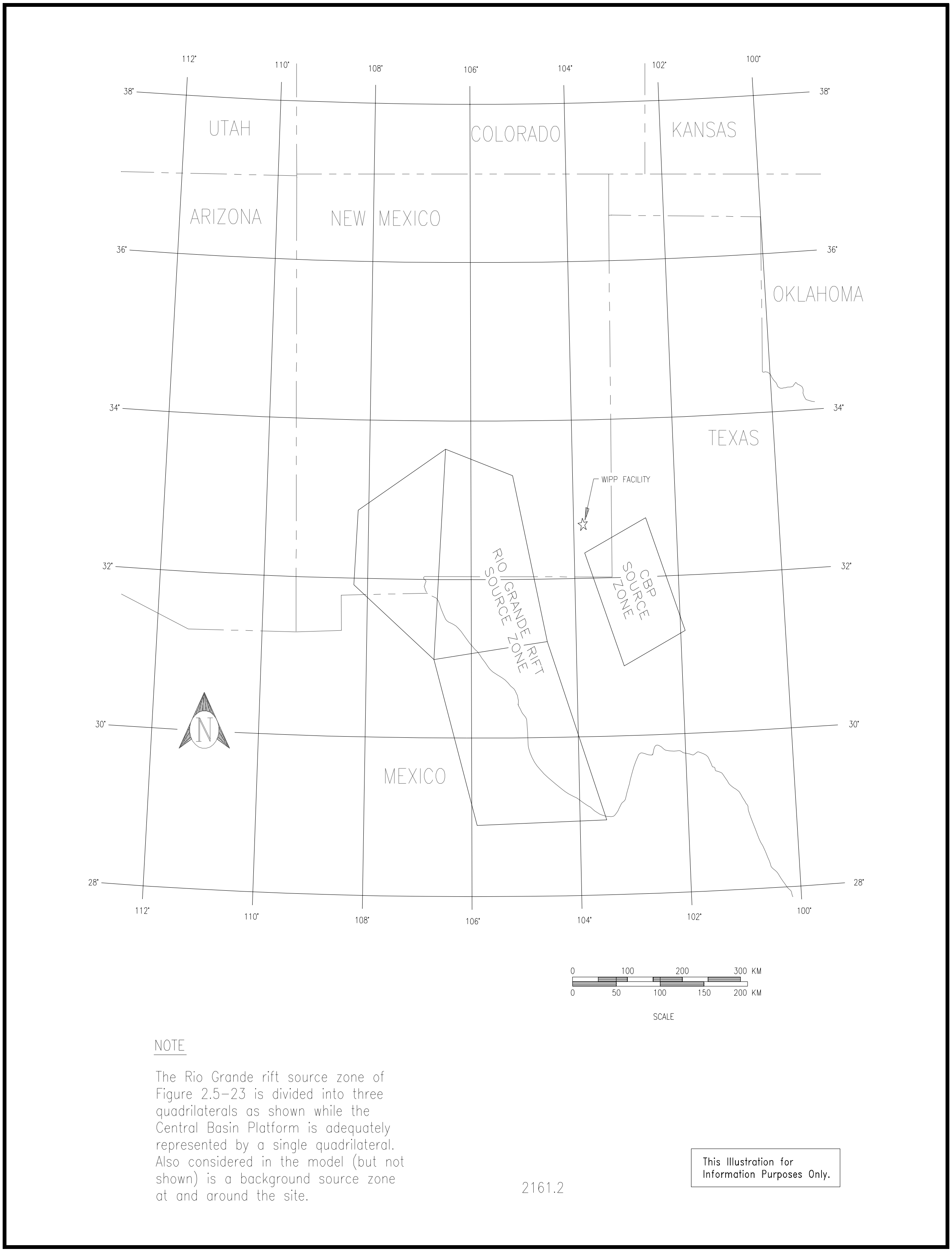


Figure 2.5-25, Quadrilateral Representation of Algermissen and Perkins Source Zones

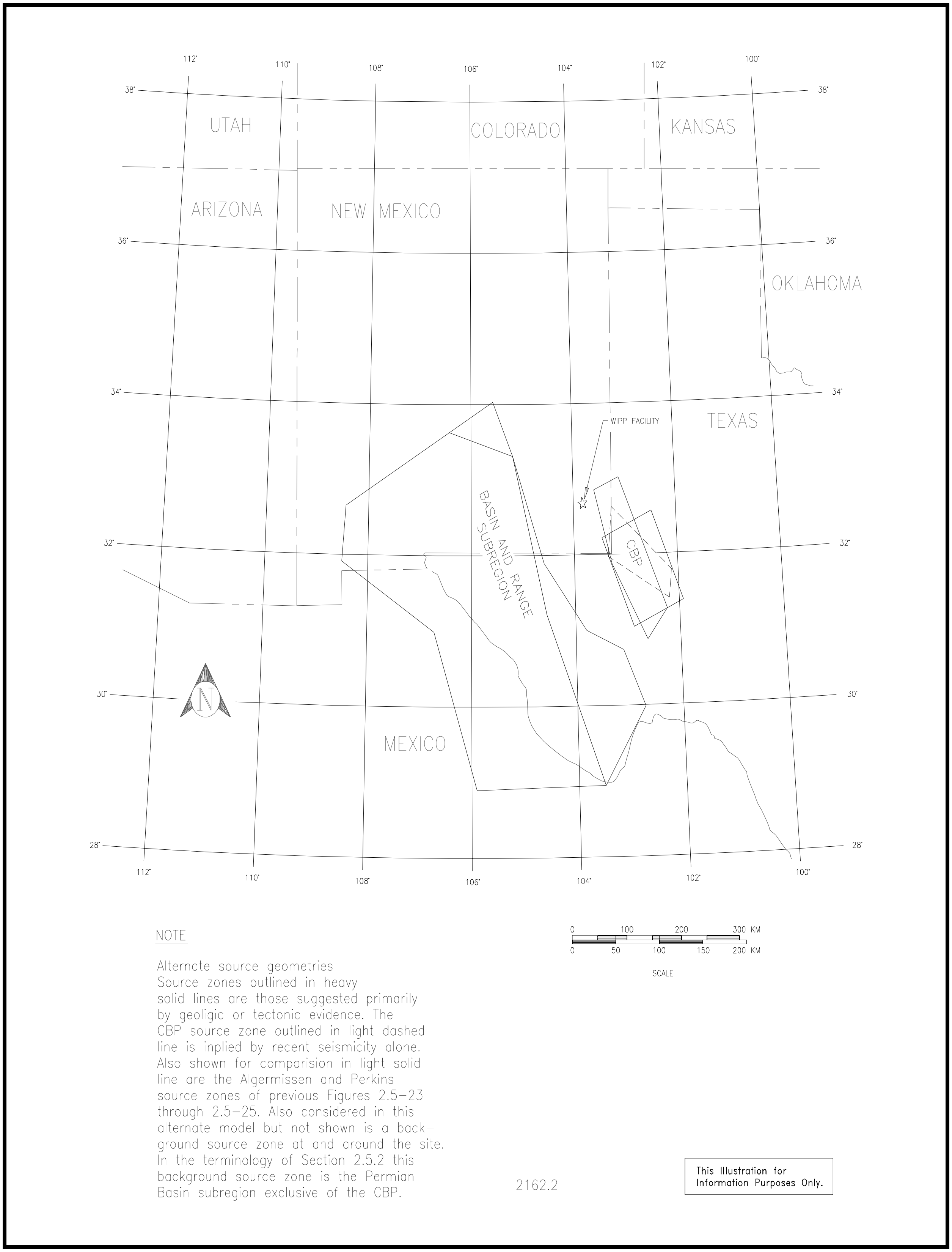


Figure 2.5-26, Alternate Source Geometries

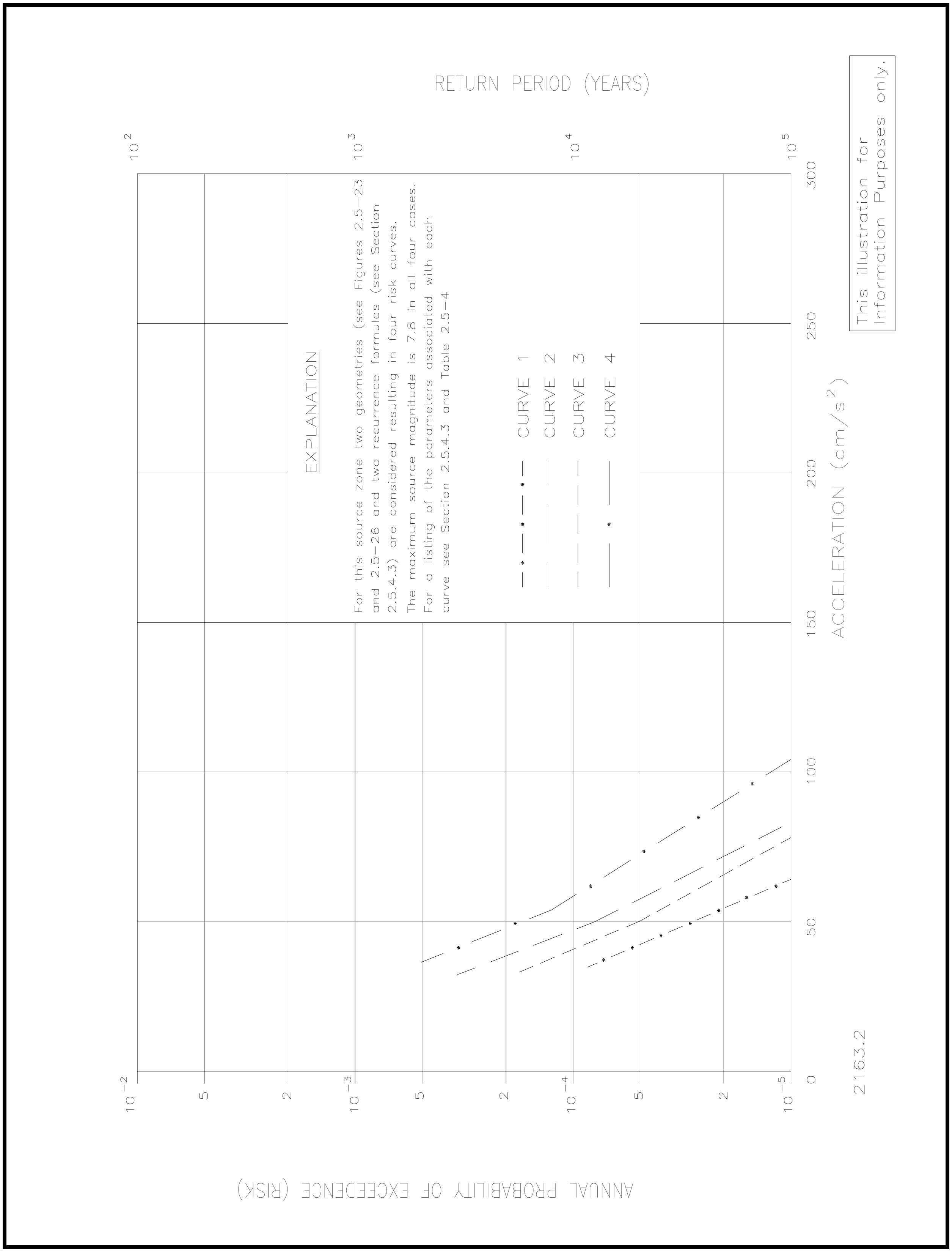


Figure 2.5-27, Risk Curves from Basin and Range or Rio Grande Rift Seismicity

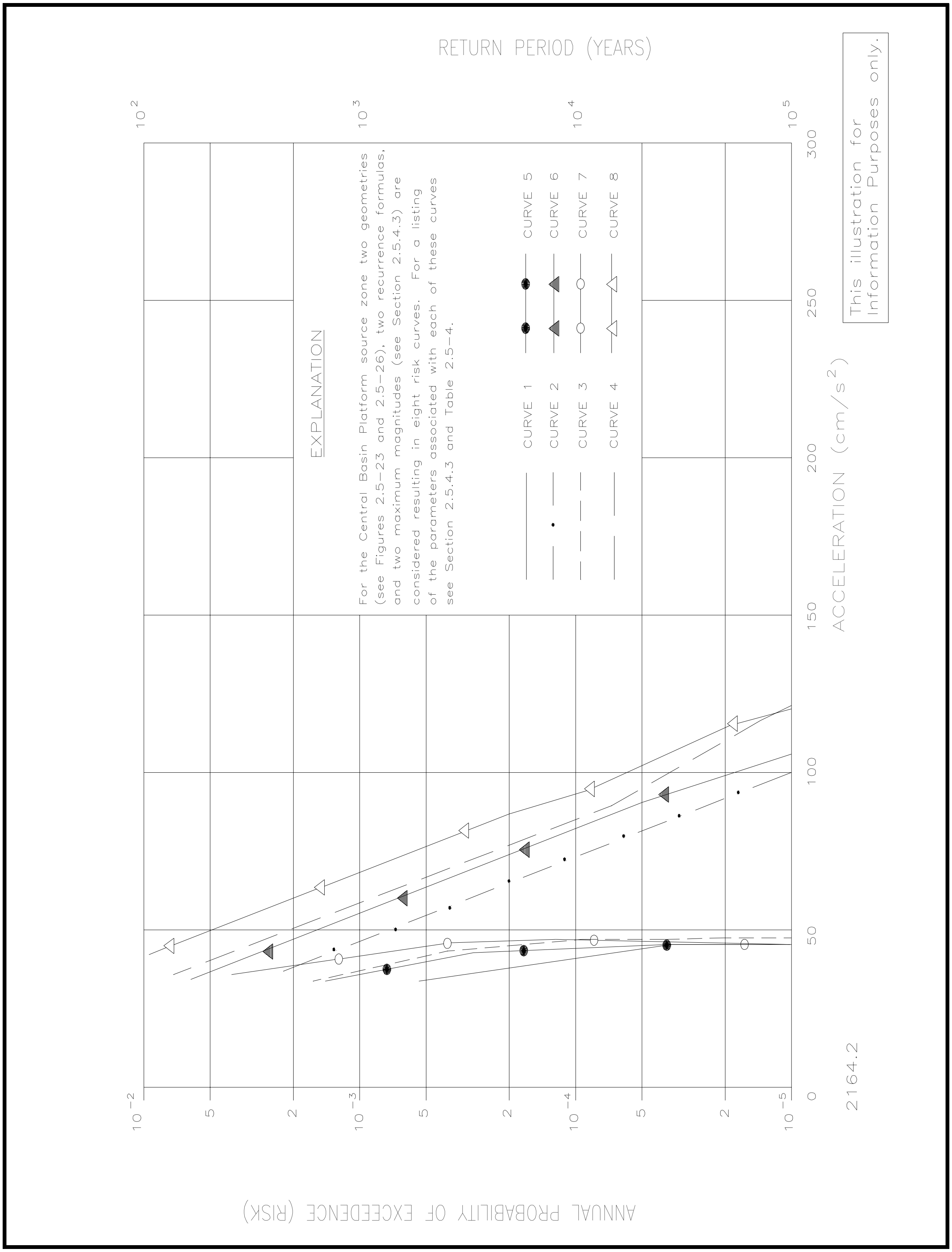


Figure 2.5-28, Risk Curves from Central Basin Platform Seismicity

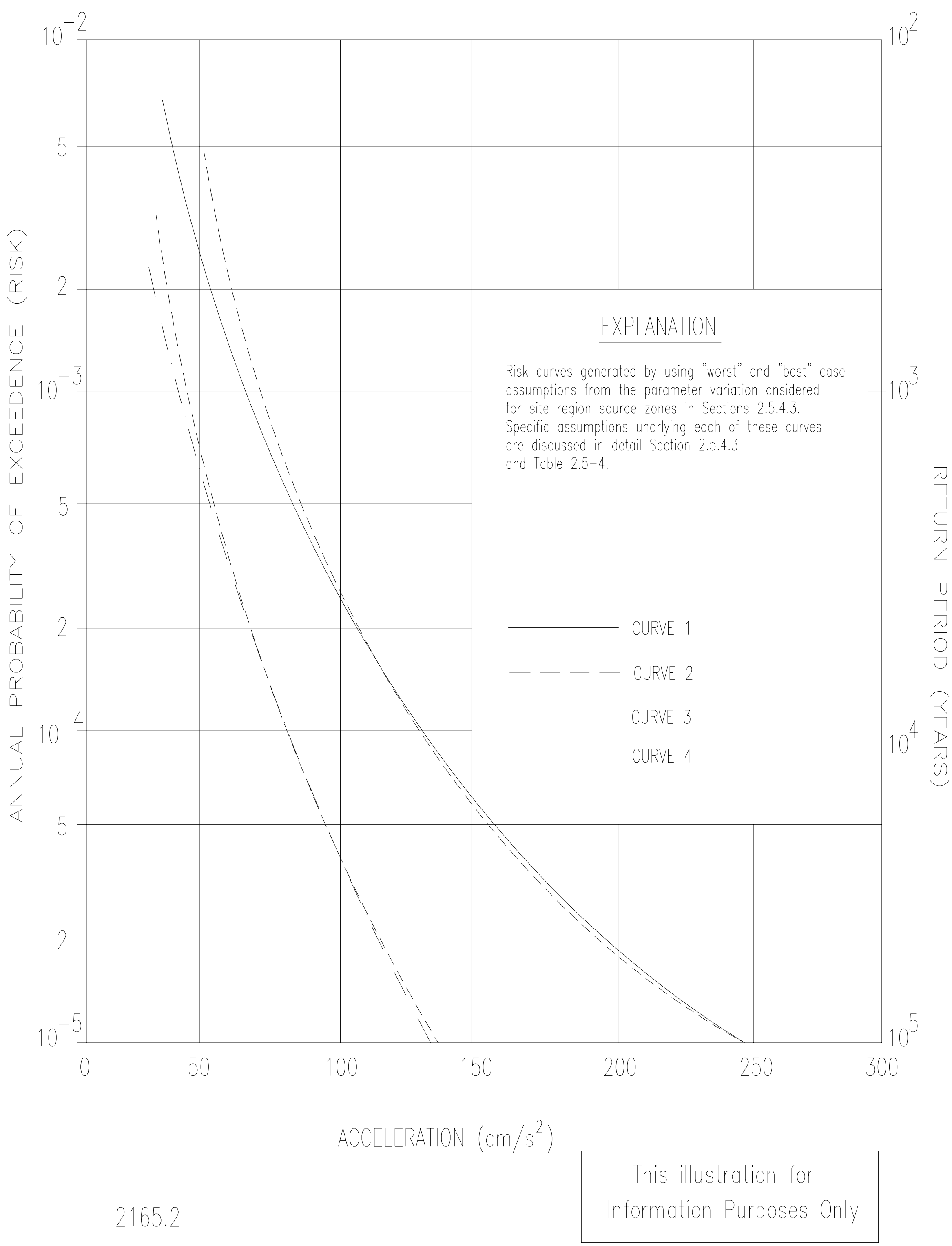


Figure 2.5-29, Risk Curves from WIPP Facility Source Zone Seismicity

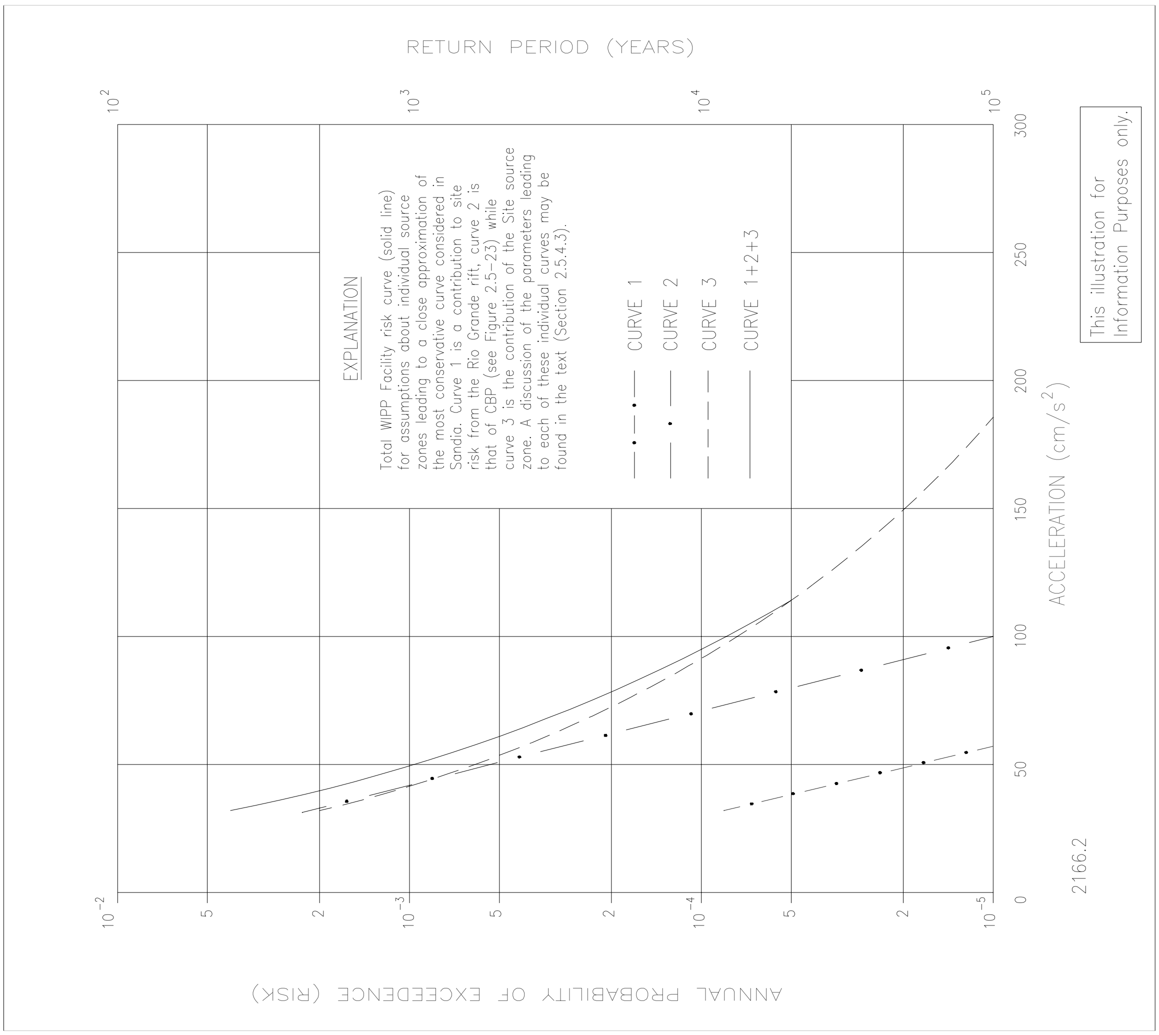


Figure 2.5-30, Generation of Total WIPP Facility Seismic Risk Curve Individual Source Risk Curves

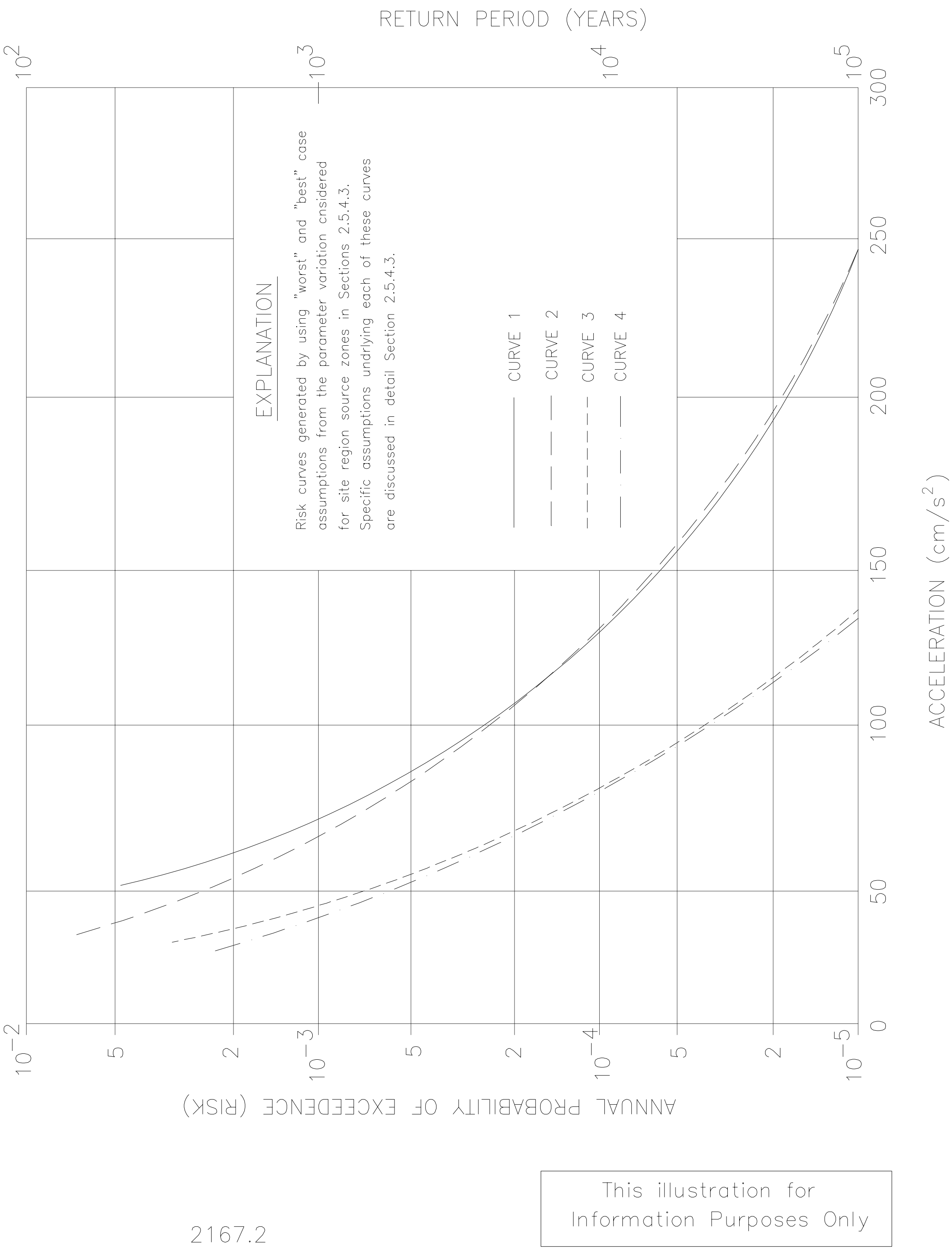


Figure 2.5-31, Total WIPP Facility Risk Curve Extrema

Table 2.5-1, Earthquakes Occurring Before 1962 and Centered Within 300 Km of the WIPP Facility*

Date Yr/Mo/Day	Origin Time, GMT	Location	Intensity	Distance
23/03/07	04:03	El Paso, Tex.	V	260
26/07/17	22:00	Hope and Lake Arthur, N.M.	III	90
30/10/04	03:25	34.5°N 105.4°W	(IV)	280
31/08/16	11:40	Valentine, Tex.	VIII	210
31/08/16	19:33	Valentine, Tex.	(V)	210
31/08/18	19:36	Valentine, Tex.	V	210
31/08/19	01:36	Valentine, Tex.	(V)	210
31/10/02	?	El Paso, Tex.	(III)	260
31/11/03	14:50	29.9°N 104.2°W	(V)	295
35/12/20	05:30	34.4°N 103.2°W	III-IV	230
36/01/08	06:46	Carlsbad, N.M.	(IV)	40
36/08/08	01:40	El Paso, Tex.	(III)	260
36/10/15	18:00	El Paso, Tex.	(III)	260
37/03/31	22:45	El Paso, Tex.	(IV)	260
37/09/30	06:15	Ft. Stanton, N.M.	(V)	200
43/12/27	04:00	Tularosa, N.M.	IV	220
49/02/02	23:00	Carlsbad, N.M.	(IV)	40
49/05/23	07:22	34.6°N 105.2°W	VI	280
52/05/22	04:20	Dog Canyon, N.M.	IV	158
55/01/27	00:37	Valentine, Tex.	IV	210

* A.R. Sandord and T.R. Toppozada, "Seismicity of Proposed Radio- active Waste Isolation Disposal Site in Southeastern New Mexico," New Mexico Bureau of Mines and Mineral Resources, Circ. 143, pp. 1-15 (1974).

Table 2.5-2, Modified Mercalli Intensity Scale of 1931*

(Abridged)

I. Not felt except by a very few under especially favorable circumstances. (I Rossi-Forel scale.)

II. Felt only by a few persons at rest, expecially on upper floors of buildings. Delicately suspended objects may swing. (I to II Rossi-Forel scale.)

III. Felt quite noticeably indoors, expecially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated. (III Rossi-Forel scale.)

IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rock noticeably. (IV to V Rossi-Forel scale.)

V. Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel scale.)

VI. Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel scale.)

VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars. (VIII Rossi-Forel scale.)

VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures.

Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Disturbs persons driving motor cars. (VIII+ to IX Rossi-Forel scale.)

IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX Rossi-Forel scale.)

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel scale.)

XI. Few, if any, (masonry) structures remain standing. Bridges destroyed, broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

---

* H.O. Wood and F. Neumann, "Modified Mercalli Intensity Scale of 1931," Seismal. Soc. Am. Bull., 21, pp. 277-283 (1931).

Table 2.5-3, Instrumental Origin Times, Locations and Magnitudes of Earthquakes Within 180 Mi of the WIPP Facility January 1, 1962 Through September 30, 1986*

Date	Origin Time	Epicenter		Located By						Mag.
Yr/Mo/Da	GMT	Lat. North	Long. West	NMT	USGS	LANL	ASL	UTA	UTEP	
62 03 03	18:16:48.1	33.80	106.40	X						1.2
62 03 06	09:59:09.7	31.08	104.55	X						2.9
62 03 22	04:23:53.4	34.25	106.51	X						1.7
62 04 09	23:42:58.0	34.21	106.44	X						1.8
62 09 01	16:15:07.9	34.16	106.66	X						3.0
63 02 22	07:02:08.1	32.42	106.99	X						2.5
63 02 22	08:53:18.1	32.45	106.94	X						1.5
63 03 08	06:16:40.0	32.95	107.08	X						1.6
63 06 02	05:07:34.6	34.23	106.46	X						2.0
63 12 19	16:47:28.4	35.14	104.13	X						2.9
63 12 30	08:48:14.6	34.03	106.54	X						1.7
64 02 11	09:24:31.0	34.35	103.73	X						2.5
64 03 03	01:26:26.6	34.97	103.59	X						2.2
64 06 18	20:20:18.5	33.14	106.10	X						1.2
64 06 19	05:28:38.8	33.09	105.95	X						1.7
64 11 08	09:26:00.5	31.93	102.98	X						2.9
64 11 21	11:21:23.8	31.92	102.98	X						2.6
65 02 03	11:32:34.4	35.10	103.80	X						2.9
65 02 03	19:59:32.4	31.92	102.96	X						3.2
65 05 27	18:50:53.9	33.88	106.73	X						2.0
65 05 27	18:58:40.9	33.90	106.71	X						2.0
65 05 29	13:01:08.2	33.87	106.69	X						2.0
65 07 28	03:52:07.4	33.80	106.70	X						2.6
65 08 30	05:17:29.8	31.92	102.98	X						2.7
66 08 14	15:25:47.1	31.92	102.98	X						3.1
66 08 17	18:47:21.0	30.71	105.98	X						2.9
66 08 19	04:15:44.6	30.30	105.60		X					4.8
66 08 19	08:38:21.9	30.30	105.60		X					3.8
66 09 17	21:30:13.0	34.94	103.71	X						2.2
66 11 26	20:05:41.0	30.86	105.36	X						3.0
66 11 28	02:20:57.3	30.40	105.40		X					3.5
66 12 05	10:10:37.8	30.40	105.40		X					3.5
67 09 29	03:52:48.0	32.27	106.91	X						2.0
68 03 09	21:54:25.7	32.70	106.05	X						2.9
68 03 23	11:53:38.7	32.70	106.05	X						2.2
68 05 02	02:56:43.8	33.02	105.27	X						2.6
68 08 22	02:22:25.5	34.33	105.80	X						2.0
69 05 12	08:26:18.5	31.95	106.44	X						3.2
69 05 12	08:49:16.3	31.96	106.44	X						2.5
69 06 01	17:18:24.2	34.23	105.18	X						2.0
69 06 08	11:36:01.9	34.23	105.18	X						2.4
69 10 19	11:51:34.4	30.80	105.70		X					3.4
71 01 27	07:56:28.3	34.06	106.60	X						2.6
71 03 25	02:43:02.4	34.58	106.03	X						1.7
71 07 30	01:45:50.3	31.74	103.09	X						3.7
71 07 31	14:53:48.0	31.59	103.12	X						3.6
71 09 24	01:01:54.0	31.63	103.18	X						3.0
72 02 27	15:50:03.9	32.89	106.04	X						2.2
72 07 26	04:35:43.9	32.68	103.98	X						2.9

Table 2.5-3, Instrumental Origin Times, Locations and Magnitudes of Earthquakes Within 180 Mi of the WIPP Facility January 1, 1962 Through September 30, 1986*

Date Yr/Mo/Da	Origin Time GMT	Epicenter Lat. North	Epicenter Long. West	Located By NMT	USGS	LANL	ASL	UTA	UTEP	Mag.
72 12 09	05:58:38.9	31.68	106.44	X						2.2
72 12 10	14:37:50.2	31.68	106.41	X						2.2
72 12 10	14:58:02.5	31.65	106.48	X						1.9
74 02 02	20:39:22.6	35.10	103.10	X						2.9
74 07 31	17:34:48.5	33.12	104.18	X						1.8
74 08 17	07:35:17.3	30.30	105.77	X						2.4
74 08 26	07:33:21.5	34.44	105.79	X						2.3
74 09 26	23:44:08.5	32.81	106.16	X						1.9
74 10 02	02:40:20.0	31.98	100.71	X						2.6
74 10 27	16:18:53.9	30.53	104.79	X						2.2
74 11 01	10:45:49.6	33.80	106.60	X						2.0
74 11 12	02:31:59.0	32.06	100.98	X						2.5
74 11 12	02:35:34.2	32.13	102.67	X						1.8
74 11 12	07:14:27.7	31.93	100.72	X						2.2
74 11 21	16:22:58.6	32.53	106.25	X						1.9
74 11 21	18:59:05.8	32.10	102.69	X						2.3
74 11 22	08:54:00.1	32.99	101.14	X						1.9
74 11 22	14:11:13.2	33.81	105.15	X						1.5
74 11 28	03:35:20.5	32.59	104.12	X						3.7
75 01 30	16:00:39.9	31.15	102.85	X						2.1
75 04 08	15:29:42.4	32.18	101.70	X						1.6
75 04 20	16:59:56.4	31.29	102.60	X						2.0
75 07 25	08:11:40.0	29.88	102.54	X						2.8
75 08 01	07:27:41.2	30.65	104.57	X						3.2
75 08 03	03:26:53.1	31.04	103.97	X						1.9
75 10 10	11:16:55.5	33.35	104.99	X						1.9
76 01 10	01:49:58.5	31.74	102.75	X						1.9
76 01 15	20:43:57.6	30.95	102.31	X						1.8
76 01 19	04:03:31.4	31.95	103.10	X						2.4
76 01 21	23:11:17.2	30.90	102.29	X						1.7
76 01 22	07:21:57.7	31.92	103.05	X						2.0
76 01 25	04:48:27.3	31.93	103.09	X						3.1
76 01 28	07:37:54.7	32.29	101.27	X						2.1
76 02 04	16:15:30.0	31.67	103.54	X						1.3
76 02 14	05:35:22.1	31.61	102.47	X						1.6
76 02 19	08:23:58.4	31.60	103.66						X	1.2
76 02 19	08:45:31.5	31.63	103.67						X	1.2
76 02 19	09:23:36.6	31.65	103.66						X	1.0
76 03 05	02:58:18.0	31.92	102.59	X						2.1
76 03 20	12:42:20.4	31.26	104.95	X						1.8
76 03 20	16:15:58.1	32.20	103.10	X						1.7
76 03 27	22:25:21.9	32.21	103.10	X						1.7
76 04 01	14:40:27.7	33.94	105.88	X						1.8
76 04 01	14:46:58.2	33.88	105.98	X						2.2
76 04 01	14:51:16.5	33.94	105.87	X						1.3
76 04 03	20:40:51.4	31.30	103.17	X						2.5
76 04 06	18:09:00.3	33.88	105.93	X						2.6
76 04 12	08:02:34.9	32.25	103.11	X						1.5
76 04 18	03:48:18.5	32.88	105.94	X						1.6

Table 2.5-3, Instrumental Origin Times, Locations and Magnitudes of Earthquakes Within 180 Mi of the WIPP Facility January 1, 1962 Through September 30, 1986*

Date	Origin Time	Epicenter		Located By						Mag.
Yr/Mo/Da	GMT	Lat. North	Long. West	NMT	USGS	LANL	ASL	UTA	UTEP	
76 04 21	08:40:07.5	32.23	103.06	X						1.8
76 04 30	19:28:34.8	31.96	103.20	X						1.5
76 04 30	19:51:12.5	31.91	103.32	X						1.5
76 05 01	11:13:40.1	32.34	103.11	X						2.3
76 05 03	06:52:59.3	32.52	105.52	X						2.0
76 05 03	08:00:38.9	32.03	103.14	X						1.3
76 05 03	11:27:39.3	32.03	103.06	X						1.2
76 05 06	17:18:24.0	31.95	103.20	X						1.8
76 05 06	17:28:45.1	31.90	103.17	X						1.1
76 05 08	11:46:40.8	31.97	103.12	X						1.0
76 05 11	23:04:40.2	32.25	102.96	X						1.9
76 05 21	13:17:27.8	32.41	105.72	X						2.0
76 06 14	23:29:59.5	31.59	102.59	X						1.7
76 06 15	02:19:56.3	31.55	102.29	X						1.7
76 06 15	08:50:20.6	31.56	102.42	X						2.2
76 07 28	12:21:50.6	33.03	102.30	X						1.9
76 08 05	18:53:09.2	31.57	103.02						X	2.2
76 08 06	21:12:38.6	31.78	102.59						X	1.8
76 08 10	09:03:14.3	31.83	102.42	X						1.7
76 08 10	09:12:28.6	31.77	102.61						X	1.3
76 08 10	10:15:18.7	31.79	102.54	X						2.0
76 08 15	19:12:04.3	30.14	105.22	X						2.2
76 08 25	01:21:23.5	31.65	102.88	X						1.1
76 08 25	01:27:47.5	31.57	102.42	X						2.0
76 08 26	15:22:18.1	31.79	102.57	X						1.6
76 08 29	19:49:24.4	30.12	105.23	X						2.1
76 08 30	11:51:24.8	31.57	102.58	X						1.8
76 08 30	13:07:47.5	33.89	106.29	X						1.6
76 08 31	12:46:22.2	31.57	102.81	X						2.0
76 09 03	21:00:24.7	31.55	103.48						X	1.7
76 09 05	10:39:43.4	32.26	102.62	X						1.1
76 09 05	16:10:27.7	31.61	103.31						X	1.4
76 09 10	19:18:43.4	31.91	103.09						X	1.5
76 09 17	02:47:46.5	32.20	103.10	X						2.2
76 09 17	03:56:29.5	31.46	102.52	X						2.3
76 09 19	10:23:23.3	32.14	103.10	X						1.2
76 09 19	10:40:48.0	30.69	104.43	X						2.7
76 10 14	11:02:59.0	32.29	102.98	X						1.2
76 10 22	05:06:11.1	31.57	102.17	X						2.0
76 10 23	12:51:35.8	31.59	102.32	X						1.5
76 10 25	00:27:04.8	31.83	102.65	X						2.1
76 10 25	10:52:27.3	31.85	102.40						X	1.3
76 10 26	10:44:44.1	31.33	103.28						X	2.0
76 11 03	23:24:06.4	30.86	101.88	X						1.8
76 12 12	23:00:14.2	31.52	102.50	X						2.4
76 12 12	23:25:57.6	31.57	102.61	X						1.5
76 12 15	08:51:45.1	31.64	102.75	X						1.1
76 12 18	18:27:45.7	31.62	103.02						X	1.5
76 12 19	21:26:15.8	31.78	102.56	X						1.8

Table 2.5-3, Instrumental Origin Times, Locations and Magnitudes of Earthquakes Within 180 Mi of the WIPP Facility January 1, 1962 Through September 30, 1986*

Date	Origin Time	Epicenter		Located By						Mag.
Yr/Mo/Da	GMT	Lat. North	Long. West	NMT	USGS	LANL	ASL	UTA	UTEP	
76 12 19	23:54:23.3	32.22	103.09	X						1.5
76 12 19	23:56:47.4	32.23	103.10						X	2.1
76 12 23	08:36:58.0	34.68	105.77	X						1.9
77 01 04	18:31:37.6	32.36	106.92		X					2.7
77 01 04	23:41:58.0	34.03	106.00				X			2.4
77 01 05	12:19:02.0	34.05	106.00				X			1.7
77 01 08	20:20:27.2	31.50	102.98						X	1.1
77 01 29	09:40:40.1	30.53	104.84	X						1.9
77 02 04	07:48:16.2	30.67	104.64	X						1.7
77 02 10	01:22:50.8	32.21	103.07	X						1.1
77 02 18	14:10:36.5	32.24	103.07	X						1.2
77 03 01	11:50:45.9	31.25	103.28						X	1.2
77 03 05	22:56:14.6	31.47	102.84	X						1.4
77 03 12	00:05:23.8	31.62	103.29						X	1.1
77 03 14	10:10:25.6	32.97	101.06	X						2.4
77 03 20	07:54:08.4	32.23	103.07	X						1.6
77 03 23	11:02:51.8	31.81	102.51						X	1.1
77 03 29	00:35:34.7	31.60	103.28	X						1.0
77 04 03	12:39:57.4	31.26	103.03						X	1.1
77 04 03	13:48:09.2	31.49	103.17						X	1.6
77 04 03	14:24:07.3	31.45	103.20	X						1.5
77 04 04	00:44:05.3	31.48	103.17						X	1.6
77 04 04	01:47:50.4	31.44	103.18						X	1.3
77 04 04	04:35:56.8	31.50	103.17						X	1.3
77 04 04	04:47:30.4	31.46	103.18	X						1.3
77 04 04	05:01:29.8	31.23	103.01						X	1.3
77 04 07	05:45:40.3	32.23	103.07	X						1.9
77 04 07	18:56:55.1	31.53	103.29	X						1.4
77 04 12	23:18:26.7	31.22	102.58	X						1.7
77 04 16	06:44:22.2	31.61	103.22	X						0.8
77 04 17	21:47:09.9	31.55	102.30	X						1.3
77 04 18	18:08:24.1	31.60	103.28	X						1.4
77 04 22	22:56:34.8	32.21	102.97	X						1.0
77 04 25	10:12:51.4	32.09	102.78	X						1.4
77 04 26	09:03:07.3	31.90	103.03	X						2.1
77 04 28	12:54:38.2	31.81	102.53	X						0.9
77 04 28	12:55:40.1	31.80	102.53	X						2.2
77 04 28	15:22:36.8	31.78	102.53	X						1.3
77 04 29	03:09:41.3	31.81	102.58	X						1.3
77 05 01	21:33:58.7	31.45	103.16						X	1.1
77 06 07	23:01:20.9	32.85	100.90	X						3.2
77 06 08	00:51:26.0	32.70	100.72	X						2.6
77 06 08	13:29:12.0	32.89	100.95	X						3.0
77 06 08	13:39:25.	32.8	100.9	X						2.6
77 06 17	03:37:05.9	32.87	101.04	X						2.7
77 06 28	23:59:46.6	31.54	103.30						X	2.0
77 07 01	01:06:19.2	31.50	103.34						X	1.7
77 07 05	10:40:27.4	31.60	102.10	X						1.7
77 07 11	12:31:55.7	31.79	102.69	X						1.7

Table 2.5-3, Instrumental Origin Times, Locations and Magnitudes of Earthquakes Within 180 Mi of the WIPP Facility January 1, 1962 Through September 30, 1986*

Date Yr/Mo/Da	Origin Time GMT	Epicenter Lat. North	Epicenter Long. West	Located By NMT	USGS	LANL	ASL	UTA	UTEP	Mag.
77 07 11	13:29:49.7	31.77	102.68	X						1.3
77 07 11	17:19:37.6	30.98	104.90					X		1.2
77 07 12	17:06:06.8	31.78	102.72	X						1.5
77 07 18	12:37:31.7	31.77	102.76	X						1.8
77 07 22	04:01:10.6	31.80	102.75	X						1.9
77 07 22	04:18:10.7	31.79	102.71	X						1.5
77 07 22	04:36:50.8	31.77	102.69	X						0.9
77 07 24	09:23:00.7	31.79	102.70	X						1.5
77 07 26	02:01:08.7	31.78	102.68	X						0.7
77 07 28	12:17:17.8	31.10	105.02					X		1.1
77 07 28	23:35:43.1	31.00	104.91					X		1.0
77 08 01	16:44:51.1	30.97	104.92					X		1.0
77 08 06	20:43:59.7	31.04	104.96					X		1.2
77 08 09	16:07:00.5	31.04	104.65					X		1.1
77 08 12	07:49:11.4	31.40	103.45						X	1.2
77 08 20	02:29:22.2	31.60	103.33						X	1.5
77 08 21	03:01:09.7	30.48	104.86	X						2.6
77 10 13	21:36:11.0	32.74	100.75	X						2.2
77 10 17	21:24:43.2	31.57	102.46						X	1.5
77 10 24	22:50:04.6	31.54	102.51						X	1.3
77 10 25	01:02:32.2	31.52	102.51						X	1.0
77 10 29	00:49:11.6	30.50	104.19					X		1.1
77 11 05	12:28:53.7	31.08	104.97					X		1.1
77 11 14	07:26:27.4	31.60	104.90	X						2.2
77 11 27	20:48:18.1	33.03	101.08	X						2.5
77 11 28	01:40:50.3	32.90	101.02	X						3.4
77 12 07	23:14:19.5	31.56	102.51						X	1.2
77 12 16	11:56:41.9	31.57	102.54	X						1.4
77 12 21	01:36:20.9	31.49	102.36	X						1.4
77 12 29	10:50:55.0	31.62	103.26						X	1.2
77 12 31	13:19:04.5	31.60	102.46						X	1.7
78 01 02	10:10:47.1	31.60	102.53						X	1.8
78 01 12	14:55:02.3	31.45	102.18	X						1.9
78 01 15	23:18:08.2	31.66	102.64	X						1.6
78 01 18	08:53:19.5	31.62	103.23	X						1.2
78 01 19	03:42:35.1	32.60	103.58	X						1.8
78 01 21	01:17:02.4	31.50	104.66					X		2.4
78 01 24	14:26:22.4	30.68	104.59					X		1.1
78 02 04	15:35:48.4	31.62	103.26						X	1.0
78 02 05	10:46:25.0	31.63	103.26						X	1.0
78 02 05	14:19:53.0	31.41	104.61	X						1.8
78 02 10	14:02:29.9	31.63	103.26						X	1.2
78 02 18	14:22:37.1	31.35	104.56	X						2.8
78 02 18	14:29:20.3	30.62	105.16					X		1.7
78 02 18	15:29:37.0	30.60	105.18					X		1.1
78 02 18	16:44:04.7	30.61	105.19					X		1.0
78 02 18	17:30:08.5	30.61	105.19					X		2.1
78 02 18	17:54:09.8	30.61	105.19					X		1.5
78 02 18	18:45:16.5	30.62	105.20					X		1.3

Table 2.5-3, Instrumental Origin Times, Locations and Magnitudes of Earthquakes Within 180 Mi of the WIPP Facility January 1, 1962 Through September 30, 1986*

Date	Origin Time	Epicenter		Located By						Mag.
Yr/Mo/Da	GMT	Lat. North	Long. West	NMT	USGS	LANL	ASL	UTA	UTEP	
78 02 19	07:05:18.7	30.61	105.18					X		1.1
78 02 19	12:12:00.0	30.61	105.19					X		2.1
78 02 20	02:52:55.4	30.62	105.20					X		1.1
78 03 02	08:57:51.8	32.18	103.07	X						1.2
78 03 02	10:04:50.1	31.52	102.41	X						2.8
78 03 02	11:27:09.4	31.61	102.69						X	1.2
78 03 02	11:55:57.1	31.59	102.61						X	1.8
78 03 19	10:48:49.1	31.50	102.51	X						1.8
78 03 28	05:51:35.4	29.69	104.04					X		1.1
78 04 06	09:13:27.4	30.86	104.86					X		1.2
78 04 07	00:57:41.6	31.94	105.33	X						2.3
78 04 12	23:05:00.0	30.66	104.48					X		1.1
78 05 30	13:19:31.7	30.65	104.56					X		1.4
78 06 03	11:40:18.2	30.40	104.64					X		1.6
78 06 06	20:05:00.1	30.30	104.58					X		1.4
78 06 16	11:46:54.2	33.03	100.77		X					4.4
78 06 16	11:53:33.0	33.10	101.20					X		3.4
78 06 29	20:58:45.1	31.05	101.94	X						3.4
78 07 05	02:45:06.7	31.78	102.55	X						1.2
78 07 05	10:40:28.9	31.60	102.25	X						1.7
78 07 18	12:07:32.8	30.40	104.28	X						1.8
78 07 21	05:02:36.2	34.68	105.04	X						3.1
78 07 21	20:35:41.6	31.24	102.48	X						1.7
78 08 12	12:45:27.7	31.62	103.27	X						0.9
78 08 14	13:29:43.7	31.61	102.56	X						2.2
78 08 19	19:44:36.5	31.57	103.21	X						0.8
78 09 29	17:59:41.4	30.32	104.66				X			1.9
78 09 29	20:07:43.3	31.52	102.51	X						2.3
78 09 30	23:31:47.5	31.66	102.71	X						1.9
78 10 02	09:35:06.9	31.54	102.51	X						1.7
78 10 02	09:58:33.4	31.60	102.55	X						1.7
78 10 02	11:25:09.9	31.51	102.52	X						2.0
78 10 03	06:12:17.2	31.91	102.99	X						1.8
78 10 06	15:23:46.3	31.53	102.34	X						2.2
79 01 19	09:07:55.1	30.50	105.12					X		1.5
79 02 13	19:02:13.4	30.17	104.36					X		1.5
79 02 16	23:50:32.5	31.03	104.90					X		1.7
79 03 28	15:20:02.8	31.10	102.65	X						1.0
79 04 25	00:19:26.0	31.93	101.99	X						1.6
79 04 28	01:01:40.0	30.58	104.69	X						2.1
79 06 09	01:28:59.1	30.65	104.50					X		1.6
79 06 28	19:23:45.4	30.38	105.15					X		1.6
79 07 05	01:05:05.9	32.90	101.31	X						2.7
79 07 17	07:26:14.4	32.52	103.88	X						2.0
79 08 03	05:29:38.3	32.85	100.94	X						2.6
80 02 05	23:56:54.7	29.92	104.44						X	2.9
80 03 21	08:35:23.7	31.56	102.41	X						1.0
81 08 13	23:39:52.4	31.91	102.58	X						2.2
81 09 16	03:08:53.8	33.74	105.24	X						1.8

Table 2.5-3, Instrumental Origin Times, Locations and Magnitudes of Earthquakes Within 180 Mi of the WIPP Facility January 1, 1962 Through September 30, 1986*

Date Yr/Mo/Da	Origin Time GMT	Epicenter Lat. North	Epicenter Long. West	Located By NMT	USGS	LANL	ASL	UTA	UTEP	Mag.
82 01 04	16:56:08.1	31.18	102.49							3.4
82 07 22	14:38:55.6	34.27	105.62	X						0.5
82 08 28	08:04:18.2	32.55	104.52	X						1.1
82 09 22	15:41:52.5	34.10	106.10	X						0.5
82 10 26	00:37:49.8	33.64	103.58	X						1.5
82 11 03	23:23:50.0	32.86	105.99	X						0.6
82 11 25	18:50:08.6	32.90	100.88	X						2.3
82 11 28	02:36:48.0	33.00	100.80					X		3.3
83 01 09	11:49:04.0	30.35	105.76	X						1.9
83 01 12	10:11:12.5	34.33	105.17	X						1.5
83 01 29	11:44:52.2	31.38	102.36	X						2.2
83 03 03	18:13:44.7	29.80	104.29	X						2.8
83 03 31	20:51:21.2	32.36	106.42	X						1.7
83 04 04	09:57:21.0	30.58	105.25	X						1.2
83 04 11	11:19:15.0	31.28	102.48	X						1.2
83 04 17	19:39:02.0	33.43	105.93	X						1.7
83 04 24	05:13:02.0	32.32	103.90	X						-1.5
83 04 30	07:34:18.8	33.30	106.43	X						3.4
83 05 14	01:35:00.0	31.92	106.67	X						0.8
83 05 17	01:40:20.0	31.47	103.57	X						2.0
83 05 20	03:44:29.0	31.50	102.08	X						1.2
83 06 03	20:31:21.0	29.83	103.42	X						1.1
83 06 05	06:17:22.0	32.52	105.35	X						1.3
83 06 18	23:52:22.0	31.05	102.47	X						1.1
83 06 21	23:01:13.0	33.63	103.58	X						1.6
83 07 06	22:17:02.0	30.38	103.28	X						1.2
83 07 09	04:31:19.0	30.33	104.00	X						1.0
83 07 09	17:06:02.0	30.35	104.02	X						0.7
83 07 13	20:38:00.0	32.87	104.17	X						0.2
83 07 21	15:35:26.0	30.95	105.15	X						1.6
83 08 02	08:16:11.0	32.58	103.60	X						0.0
83 08 02	09:23:17.0	32.55	103.67	X						0.0
83 08 04	00:50:31.0	32.60	105.12	X						1.3
83 08 14	13:35:59.0	33.47	105.35	X						1.1
83 08 19	03:17:02.0	31.92	101.92	X						1.5
83 08 19	03:31:07.0	31.58	102.17	X						1.3
83 08 23	15:05:02.0	30.58	105.25	X						1.9
83 08 26	04:56:40.0	31.37	102.28	X						1.9
83 08 30	21:16:01.0	32.35	104.62	X						0.9
83 08 31	11:10:07.0	32.52	103.58	X						0.6
83 08 31	22:25:58.0	31.80	102.45	X						1.9
83 09 06	11:12:48.0	33.75	105.82	X						1.0
83 09 29	07:44:11.0	34.93	104.43	X						2.7
83 09 30	11:42:35.0	30.57	104.00	X						1.6
83 11 09	00:12:49.0	32.67	102.58	X						0.9
83 11 12	03:11:18.0	32.60	102.75	X						1.3
83 11 16	21:01:50.0	32.52	103.47	X						-0.4
83 12 01	10:05:59.0	31.83	102.02	X						1.4
83 12 03	23:46:51.0	30.90	103.33	X						2.1

Table 2.5-3, Instrumental Origin Times, Locations and Magnitudes of Earthquakes Within 180 Mi of the WIPP Facility January 1, 1962 Through September 30, 1986*

Date	Origin Time	Epicenter		Located By						Mag.
Yr/Mo/Da	GMT	Lat. North	Long. West	NMT	USGS	LANL	ASL	UTA	UTEP	
83 12 26	11:05:11.0	31.17	102.33	X						1.5
84 01 02	10:29:36.0	31.70	102.15	X						1.8
84 01 03	09:38:18.0	30.80	103.00	X						1.5
84 01 03	10:20:00.0	30.80	103.00	X						1.5
84 01 03	10:28:33.0	30.80	103.00	X						1.3
84 01 16	08:49:03.0	33.88	103.08	X						0.8
84 01 16	12:09:44.0	33.88	103.08	X						1.1
84 02 23	05:43:30.0	32.65	104.02	X						-0.7
84 03 02	09:08:56.0	30.90	105.10	X						1.4
84 03 12	12:37:10.0	32.62	103.72	X						0.2
84 03 23	01:37:36.0	32.30	100.80	X						1.5
84 03 24	22:58:00.0	34.75	105.30	X						0.5
84 04 17	16:16:46.0	32.43	106.57	X						1.5
84 05 12	17:29:55.0	34.17	105.63	X						1.1
84 05 21	20:25:26.0	32.37	104.03	X						1.2
84 05 26	00:57:16.0	32.60	103.47	X						-0.2
84 06 28	01:58:29.0	34.33	105.98	X						0.1
84 07 17	08:24:06.0	32.77	105.92	X						1.3
84 07 20	21:56:58.0	34.68	105.38	X						0.3
84 08 01	04:04:07.0	32.70	105.90	X						0.4
84 08 14	06:32:22.0	33.50	106.45	X						1.3
84 08 18	12:46:18.0	31.53	103.12	X						1.8
84 08 21	05:39:23.0	33.57	106.57	X						1.4
84 08 25	00:01:32.0	32.92	103.73	X						0.9
84 08 28	12:13:54.0	34.27	105.67	X						1.0
84 08 31	02:49:02.0	34.72	105.30	X						1.3
84 09 11	14:47:34.0	32.00	100.70	X						3.0
84 09 21	01:44:21.0	34.67	105.38	X						1.5
84 09 25	23:23:02.0	32.35	102.58	X						0.8
84 10 03	08:09:56.0	32.80	103.98	X						0.7
84 10 04	05:15:06.0	33.88	103.30	X						1.3
84 11 10	23:10:00.0	34.57	105.37	X						1.1
84 11 27	19:06:03.0	33.62	105.37	X						1.6
84 12 04	20:36:30.0	32.55	103.12	X						2.5
84 12 08	00:37:37.0	34.72	105.28	X						1.4
84 12 12	23:53:40.0	33.33	105.63	X						1.5
85 01 06	14:30:45.0	34.35	104.78	X						2.3
85 01 06	22:49:30.0	33.58	105.42	X						1.1
85 03 09	22:53:28.0	33.93	105.15	X						1.3
85 03 12	04:01:41.0	33.40	106.10	X						1.3
85 03 18	05:37:39.9	32.36	104.72	X						1.6
85 04 16	12:26:02.0	34.03	106.00	X						0.8
85 04 16	12:27:06.0	34.03	106.00	X						0.4
85 05 03	15:28:20.0	31.17	104.68	X						1.9
85 05 04	04:05:50.0	33.35	106.40	X						0.5
85 05 17	03:08:09.0	34.72	105.30	X						1.2
85 05 30	19:54:13.0	32.57	106.93	X						1.0
85 05 30	23:13:12.0	32.55	106.95	X						1.1
85 05 30	23:22:50.0	32.48	106.92	X						1.2

Table 2.5-3, Instrumental Origin Times, Locations and Magnitudes of Earthquakes Within 180 Mi of the WIPP Facility January 1, 1962 Through September 30, 1986*

Date Yr/Mo/Da	Origin Time GMT	Epicenter Lat. North	Epicenter Long. West	Located By NMT	USGS	LANL	ASL	UTA	UTEP	Mag.
85 06 02	13:54:54.0	31.25	102.18	X						1.6
85 06 04	23:06:49.0	34.65	105.33	X						1.4
85 06 05	10:36:01.0	32.57	106.92	X						2.9
85 06 05	11:15:09.0	32.58	106.92	X						1.2
85 06 05	11:47:30.0	32.52	106.80	X						1.1
85 06 10	04:53:03.0	33.83	105.95	X						1.0
85 06 10	21:23:24.0	34.22	105.93	X						2.0
85 06 12	01:58:31.0	34.72	103.82	X						1.8
85 07 28	16:45:53.0	34.07	105.87	X						0.4
85 08 02	01:39:57.0	32.48	104.23	X						1.4
85 08 04	13:57:27.0	33.40	106.30	X						0.9
85 08 12	19:55:12.0	34.30	106.02	X						1.2
85 08 27	04:58:59.0	33.37	106.08	X						1.8
85 09 05	06:56:49.0	33.65	103.75	X						1.8
85 09 05	17:57:52.0	32.55	106.95	X						1.4
85 09 06	05:22:03.0	32.52	106.90	X						0.9
85 09 06	05:22:46.0	32.55	106.93	X						2.6
85 09 09	08:57:58.0	33.95	105.98	X						0.5
85 09 18	14:49:39.0	30.93	103.47	X						2.0
85 09 19	00:37:48.0	32.57	106.90	X						1.0
85 09 22	22:59:30.0	32.57	106.93	X						1.2
85 09 23	01:35:07.0	32.57	106.93	X						1.1
85 09 25	02:13:22.0	33.33	106.47	X						0.8
85 09 25	19:23:22.0	32.52	106.93	X						2.5
85 09 25	20:35:07.0	32.52	106.93	X						0.8
85 09 25	23:01:38.0	32.52	106.93	X						1.1
85 09 26	01:04:23.0	32.52	106.93	X						0.6
85 10 23	02:28:29.0	33.22	106.43	X						0.6
85 11 13	06:17:58.0	32.02	103.12	X						1.8
85 11 13	08:47:19.0	33.67	105.73	X						0.6
85 11 13	23:07:58.0	33.80	106.35	X						0.9
85 11 28	19:39:05.0	31.57	102.02	X						1.8
86 01 15	21:01:41.0	34.50	105.47	X						1.8
86 01 28	03:52:37.0	34.15	105.27	X						1.2
86 01 30	19:07:18.0	33.55	103.98	X						1.9
86 01 30	22:26:37.0	31.17	101.23	X						3.5
86 02 07	12:36:09.0	32.50	105.45	X						1.4
86 03 11	05:57:07.0	32.08	105.07	X						2.0
86 03 21	00:36:13.0	33.40	105.68	X						1.6
86 03 26	05:19:08.0	34.62	105.28	X						1.5
86 04 05	13:41:48.0	34.07	105.75	X						0.9
86 04 17	21:04:30.0	32.58	106.92	X						2.7
86 04 29	23:14:03.0	31.03	102.67	X						1.2
86 04 30	01:28:02.0	31.03	102.67	X						1.1
86 05 11	10:35:44.0	30.60	105.97	X						1.9
86 05 18	14:06:43.0	34.38	105.65	X						0.8
86 05 28	22:15:24.0	31.75	105.12	X						1.6
86 06 07	02:29:50.0	30.17	105.48	X						1.9
86 06 19	05:06:08.0	32.50	106.95	X						1.4

Table 2.5-3, Instrumental Origin Times, Locations and Magnitudes of Earthquakes

Within 180 Mi of the WIPP Facility January 1, 1962 Through September 30, 1986*

Date	Origin Time	Epicenter		Located By						Mag.
Yr/Mo/Da	GMT	Lat. North	Long. West	NMT	USGS	LANL	ASL	UTA	UTEP	
86 06 27	09:47:24.0	32.00	102.00	X						2.2
86 07 09	19:51:02.0	31.50	102.48	X						1.6
86 07 20	19:31:26.0	33.47	105.02	X						1.5
86 08 02	17:51:43.0	33.68	103.78	X						1.7
86 08 14	21:26:52.0	32.57	104.68	X						1.3
86 08 15	07:59:20.0	33.02	103.77	X						1.7
86 09 10	16:50:49.0	34.12	105.75	X						0.8

* REFERENCES 1, 2, 3, 19, 20

Table 2.5-4, Risk Curve Parameters

#	Figure	Curve	Source Zone	Recurrence Formula	M_{max}
1	2.5-27	1	Algermissen & Perkins* Rio Grande rift (see Figure 2.5-12)	$\log N = 2.56 - M_L$	7.8
2	2.5-27	2	Algermissen & Perkins* Rio Grande rift (see Figure 2.5-12)	$\log N = 3.06 - M_{CORR}$	7.8
3	2.5-27	3	Basin & Range subregion (Figure 2.5-15)	$\log N = 2.75 - M_L$	7.8
4	2.5-27	4	Basin & Range subregion (Figure 2.5-15)	$\log N = 3.25 - M_{CORR}$	7.8
5	2.5-28	1	Algermissen & Perkins* Cen. Basin Plat. (see Figure 2.5-12)	$\log N = 2.74 - 0.9M_L$	5.0
6	2.5-28	2	Algermissen & Perkins* Cen. Basin Plat. (see Figure 2.5-12)	$\log N = 2.74 - 0.9M_L$	6.0
7	2.5-28	3	Algermissen & Perkins* Cen. Basin Plat. (see Figure 2.5-12)	$\log N = 3.19 - 0.9\ M_{CORR}$	5.0
8	2.5-28	4	Algermissen & Perkins* Cen. Basin Plat. (see Figure 2.5-12)	$\log N = 3.19 - 0.9\ M_{CORR}$	6.0
9	2.5-28	5	Cen. Basin Plat. geometry suggested by geology (see Figure 2.5-15)	$\log N = 2.74 - 0.9\ M_L$	5.0
10	2.5-28	6	Cen. Basin Plat. geometry suggested by geology (see Figure 2.5-15)	$\log N = 2.74 - 0.9\ M_L$	6.0
11	2.5-28	7	Cen. Basin Plat. geometry suggested by geology (see Figure 2.5-15)	$\log N = 3.19 - 0.9\ M_{CORR}$	5.0
12	2.5-28	8	Cen. Basin Plat. geometry suggested by geology (see Figure 2.5-15)	$\log N = 3.19 - 0.9\ M_{CORR}$	6.0
13	2.5-29	1	WIPP Facility	$\log N = 1.93 - M_L$	4.5
14	2.5-29	2	WIPP Facility	$\log N = 1.93 - M_L$	5.5
15	2.5-29	3	WIPP Facility	$\log N = 2.43 - M_{CORR}$	4.5
16	2.5-29	4	WIPP Facility	$\log N = 2.43 - M_{CORR}$	5.5

* S. T. Algermissen and D. M. Perkins, "A Probabilistic Estimate of Maximum Ground Acceleration in the Contiguous United States," U.S. Geol. Surv. open-file Report 76-416, pp. 1-45, (1976).21

PRINCIPAL DESIGN AND SAFETY CRITERIA
TABLE OF CONTENTS

SECTION TITLE PAGE NO.

PRINCIPAL DESIGN AND SAFETY CRITERIA
TABLE OF CONTENTS

SECTION TITLE PAGE NO.

PRINCIPAL DESIGN AND SAFETY CRITERIA
LIST OF FIGURES

FIGURE **TITLE** **PAGE NO.**

PRINCIPAL DESIGN AND SAFETY CRITERIA
LIST OF TABLES

PRINCIPAL DESIGN AND SAFETY CRITERIA

This chapter discusses principal design and safety criteria for structures, systems, and components (SSCs) that protect the public, workers, and the environment from hazards posed by Waste Isolation Pilot Plant (WIPP) operations. For the WIPP, SSCs are categorized as Design Class I, II, and III in the WIPP System Design Descriptions (SDDs). Criteria for the selection of Design Class I, II, and III SSCs are identified in the General Plant SDD (GPDD)[1] and are discussed in Section 3.1, General Design Criteria. Design information for WIPP Design Class I, II, and III SSCs is provided in Chapter 4, Facility Design and Operation.

3.1 General Design Criteria

The mission of the WIPP is to permanently dispose of transuranic waste left from the research and production of nuclear weapons. The WIPP facility was designed and constructed according to DOE Order 6430, General Design Criteria Manual for Department of Energy Facilities, draft, dated June 10, 1981,[2] and codes and standards applicable at the time of construction. Facility modifications since that time have been designed according to the revision of DOE Order 6430 and codes and standards applicable at the time of modification. All future modifications shall be designed according to DOE Orders O 420.1, Facility Safety, dated October 1995[3] and O 430.1, Life-Cycle Asset Management, dated August 1995[4], and all applicable codes and standards as described by the SDDs.

The Department of Energy - Carlsbad Area Office (DOE-CAO) and appropriate regulatory agencies determined that permanent disposal in the WIPP facility protects human health and the environment. The placement of waste in the WIPP began in March 1999 and will be for the purpose of permanent disposal with no intent to retrieve. However, if in the future it is determined that recovery of disposed waste is required, prior to commencement of recovery operations: (1) principal design and safety criteria for SSCs that protect the public, workers, and the environment from hazards posed by recovery shall be developed, and (2) those hazards associated with the recovery design and process shall be analyzed and result in a change to this SAR to address recovery.

3.1.1 TRU Waste Criteria

The acceptance criteria of contact-handled (CH) and remote-handled (RH) transuranic (TRU) waste received and disposed at the WIPP facility is defined in this section. CH waste has a relatively low surface dose rate, lending itself to direct handling, while RH waste requires remote handling.

The WIPP shall provide disposal capacity of 6.2 million cubic ft (175,460 cubic meters) of TRU waste in TRU waste containers for underground disposal over an operating life of 35 years.

The WIPP shall have the capacity to process up to a maximum of 500,000 cubic ft (14,150 cubic meters) of CH TRU waste per year, and 10,000 cubic ft (283 cubic meters) of RH TRU waste per year.

The acceptance criteria for TRU waste to be accepted for disposal at the WIPP facility, and the basis for the criteria, are presented in the TRU Waste Acceptance Criteria[6] (WAC) for the WIPP.

The WAC[6] incorporates three related sets of requirements: WIPP Operations and Safety Criteria, Transportation Requirements, and Environmental Compliance Requirements. Table 3.1-1 provides a summary of those waste acceptance criteria and requirements. WAC[6] RH TRU Criteria are preliminary, and will be included in a RH TRU Preliminary Safety Analysis Report currently scheduled for FY-1999.

3.1.2 Facility By-Products

3.1.2.1 Nonradioactive By-Products

The major nonradioactive by-product at the WIPP facility is mined salt. The basic design criterion is the mined salt shall be free of radioactive contamination. Other regulated nonradioactive hazardous by-products shall be handled in compliance with applicable codes and standards.

3.1.2.2 Site-Derived Radioactive Waste

Site-derived radioactive waste shall be treated as radioactive mixed waste unless proof is available that wastes are not mixed. The mixed waste shall be handled in accordance with the regulations of the RCRA, as implemented by the State of New Mexico Environmental Department. Because derived wastes can contain only those materials present in the waste from which they were derived and any materials or processes applied at WIPP, no additional chemical analysis of the derived waste is required for disposal purposes. Characterization of derived waste shall primarily be based on information provided by the generator and knowledge of the processes and materials at WIPP.

3.1.3 Design/Functional Classification of Structures, Systems, and Components

3.1.3.1 Design Classification of SSCs

The design classification system shall be used for categorizing SSCs of the WIPP facility, and to determine the proper level of design and quality assurance requirements specified for each SSC. These requirements shall be used to ensure that each SSC will perform its required design function reliably when subjected to: (1) design basis accidents, (2) operating loads, (3) environmental operating conditions, and (4) natural phenomena.

Classification categories shall be identified as Design Class I, II, or III, with Design Class III subdivided into Design Class IIIA and IIIB, as defined in Section 3.1.3.1.1.

Where a single item performs two or more functions, and may be assigned to more than one design classification, the more stringent class shall be assigned. Portions of an item performing different functions may be assigned to different classes if the item contains a suitable interface boundary meeting the requirements of Section 3.1.3.1.2, Design Class Interfaces.

The basic design codes and standards applicable to each class are shown in Table 3.1-2. SSCs are assigned a Design Class on an item-by-item basis, in accordance with the WIPP WP 09-CN series Engineering Procedures.[7]

3.1.3.1.1 Design Class Definitions

3.1.3.1.1.1 Design Class I

Design Class I shall apply to SSCs for the prevention or mitigation of the consequences of an accident or severe natural phenomena that could result in a 50-year dose commitment beyond the WIPP Exclusive Use Area in excess of 25 rem (0.25 Sv) Total Effective Dose Equivalent (TEDE).[7] Currently there are no Design Class I SSCs at the WIPP.

3.1.3.1.1.2 Design Class II

Design Class II shall apply to SSCs that:

- Provide permanent confinement
- Provide permanent shielding
- Monitor variables to:
  - Verify that essential WIPP operational limits are not exceeded
  - Indicate the status of safety system bypasses that are not automatically removed as a part of safety system operation
  - Indicate the status of Design Class I items during all plant conditions
  - Verify that off-normal radiological dose limits are not exceeded following accidental releases of radioactive material

3.1.3.1.1.3 Design Class III

This classification shall be divided into Design Class IIIA and IIIB as follows:

Design Class IIIA shall be applied to those SSCs not included in Design Class I or Design Class II, requiring a different level of quality, beyond that expected in commercial-industrial practice, and includes any of the following functional areas:

- Airborne radioactivity monitoring following accidental releases of radioactive materials
- Major sustained stoppage of waste handling and disposal operations due to failure
- Design and fabrication complexity or uniqueness
- Potential for contamination due to component failure
- Special considerations are required beyond those contained in nationally recognized codes and standards to ensure the health and safety of operating personnel
- Equipment failure could be of special significance to the health and safety of operating personnel

- Equipment with unique subassemblies, when replaced, shall be identical in terms of function, form, and fit

Design Class IIIB: Class IIIB shall be applied to all other items.

3.1.3.1.2 Design Class Interfaces

When the failure of less-stringently classified SSCs could prevent more-stringently classified SSCs from accomplishing their required function, then one of the following options shall be followed:

- Change the design to preclude consequential failure of the more-stringently classified item.

- Reclassify the less stringently classified item to correspond to that of the more-stringently classified SSC.

- Provide an interface barrier to protect the more-stringently classified SSC.

Exceptions to these criteria shall be addressed on a case-by-case basis and described in the design documents.

3.1.3.2 Functional Classification of SSCs

The SSC functional classifications, definitions, and applicability to WIPP are as follows:

- Safety Class. SSCs whose preventive or mitigative function is necessary to keep hazardous material exposure to the maximally exposed individual (MEI) below off-site risk evaluation guidelines defined in the WIPP SAR.

- Safety Significant. SSCs not designated as Safety Class, but whose preventive or mitigative function is a major contributor to defense in depth (i.e. prevention of uncontrolled material releases) and/or worker safety as determined from hazards analysis.

  For WIPP, "prevention of uncontrolled material releases" applies to SSCs whose preventive or mitigative function is necessary to keep hazardous material exposure to a non-involved worker below on-site risk evaluation guidelines defined in the WIPP SAR. These guidelines apply to personnel located at 100 meters from a discharge point. As discussed in DOE-STD-3009,[8] these SSCs are often not developed based on calculations and do not normally have numerical evaluation guidelines. However, these calculations and guidelines are currently included in the WIPP SAR, and are therefore used as the basis for designation of this classification.

  As discussed in DOE-STD-3009-94,[8] Safety Significant SSC designation based on worker safety are limited to those SSCs whose failure is estimated to result in an acute worker fatality or serious injury to workers. For WIPP, Safety Significant designation based on worker safety applies to SSCs that prevent acute worker fatality or serious injury from hazardous material release that is outside the protection of standard industrial practice, OSHA regulation, or mine safety regulation (MSHA) (e.g. potentially explosive waste containers, accidental nuclear criticality).

- Defense in Depth. SSCs that fulfill a defense-in-depth safety function important to accident scenarios evaluated in the WIPP SAR.

- Balance of Plant. This category includes facility SSCs not identified above. SSCs or functions required by OSHA and mine safety regulation are included in this category.

3.1.3.3 Severe Natural Events

3.1.3.3.1 Design Basis Tornado (DBT)

The DBT is the most severe credible tornado that could occur at the WIPP site as described in Chapter 2. DBT SSCs shall be designed to withstand the highest winds generated by this tornado (183 mi/h [293 km/h]), based on a 1,000,000-year recurrence period, and retain their safety function.

3.1.3.3.2 Design Basis Earthquake (DBE)

The DBE is the most severe credible earthquake that could occur at the WIPP site as described in Chapter 2. DBE SSCs shall be designed to withstand a free-field horizontal and vertical ground acceleration of 0.1g, based on a 1,000-year recurrence period, and retain their safety functions.

3.1.4 Decontamination and Decommissioning

Design of equipment and areas of facilities that may become contaminated with radioactive or other hazardous material shall incorporate features to simplify decontamination. Examples of features to be incorporated are identified in DOE Order 420.1A.[3]

The WIPP shall be designed to have the capability of being decommissioned, shall have a documented closure plan, and shall provide for the surveillance, maintenance, and decommissioning of the facility as required by DOE Order 430.1A[4] and DOE O 4330.4B,[5] Maintenance Management Program. The WIPP equipment and facilities in which radioactive or hazardous materials are utilized shall be designed to simplify decommissioning and to increase the potential for reuse of the facilities, equipment, and materials.

3.1.5 Backfill

The DOE has concluded that it is desirable to add magnesium oxide (MgO) to the repository to improve the performance of the disposal system. The backfill and associated handling system shall be designed: (1) to provide ease of handling, (2) to provide protection from premature exposure to atmospheric carbon dioxide (CO_2) prior to panel closure, and (3) to provide a backfill distribution such that reasonable exposure to any brine or CO_2 within the panel occurs.

References for Section 3.1

1. Waste Isolation Pilot Plant General Plant Design Description (GPDD), Rev. 1, April 1995.
2. DOE Order 6430, General Design Criteria Manual for Department of Energy Facilities, June 10, 1981 draft (For reference only, superceded by DOE O 420.1 and DOE O 430.1A).
3. DOE Order O 420.1, Facility Safety, October 1995.
4. DOE Order O 430.1A, Life-Cycle Asset Management, August 1995.
5. DOE Order 4330.4B, Maintenance Management Program, February 1994.
6. WIPP-DOE-069, TRU Waste Acceptance Criteria for the Waste Isolation Pilot Plant, Rev. 5, April 1996.
7. WP 09-CN, series Engineering Procedures.
8. DOE-STD-3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports, July 1994.

Table 3.1-1, Summary of CH-TRU Waste Acceptance Criteria Requirements and Compliance Methods

CRITERIA	REQUIREMENTS/LIMITS	COMPLIANCE METHODS
CONTAINER AND PHYSICAL PROPERTIES		
Container Description	• DOT Type A 55-gallon Drums, SWBs, Ten-drum Overpack	Procurement or fabrication documentation or examination records demonstrating compliance to Type A requirements; or testing records showing compliance with 49 CFR 173.461
Container/Assembly Weight	• ≤ 1000 lbs/55-gallon Drum • ≤ 4000 lbs/SWB • ≤ 6450 lbs/TDOP • ≤ TRUPACT-II Weight [(4)] Limits shown in Table 3.2.2.2 of WAC	Record of loaded container/assembly weights. [Weighing individual containers and totaling is acceptable.]
Removable Surface Contamination	• ≤ 20 dpm/100 cm^2 Alpha • ≤ 200 dpm/100 cm^2 Beta-Gamma	Record of contamination surveys taken prior to shipment
Container Marking	• Bar Code • Shipping Category [(1)]	Records of compliance inspection at time of shipment
Dunnage	• Empty 55-gallon Drums or empty SWBs	Labeled and applicable WWIS date reported
Filter Vents	• Payload containers vented	Records of visual inspection
Liquids	• No Liquid Wastes • < 2 Liters total residual liquid per 55-gallon Drum • < 8 Liters per SWB • < 1 in. (2.5 cm) in the bottom of any container	Radiography records, visual examination records, or acceptable knowledge documentation; Site policies/procedures restricting liquids in newly generated waste
NUCLEAR PROPERTIES		
Nuclear Critically (Pu-239 FGE)	• < 200 g/55-gallon Drum • < 325 g/SWB • TRUPACT-II limits shown in Table 3.3.1.2 of WAC	Records of assay data or acceptable knowledge documentation, and records of conversion and calculations using the table in CH-TRAMPAC
Pu-239 Equivalent Activity (PE-Ci)	Derived in Chapter 5 of the SAR	Records of assay data or acceptable knowledge documentation, and records of conversion and calculations using Appendix A of WAC
Contact Dose Rate	• ≤ 200 mrem/hr	Records of radiation surveys taken prior to shipment
Thermal Power	• Report if > 0.1 watts/ft^3 • < 40 watts per TRUPACT-II	Records of assay data or acceptable knowledge documentation, and records of conversion and calculations using the tables in Appendix C of WAC

Table 3.1-1, Summary of CH-TRU Waste Acceptance Criteria Requirements and Compliance Methods

CRITERIA	REQUIREMENTS/LIMITS	COMPLIANCE METHODS
TRU Alpha Activity	• > 100 nCi/g of waste matrix	Records of assay data or acceptable knowledge documentation, and records of calculations showing concentrations of the total TRU radionuclides in the waste matrix
CHEMICAL PROPERTIES		
Pyrophoric Materials	• < 1% Radionuclide pyrophorics • No nonradionuclide pyrophorics	Records of procedures, processes or evidence which shows no presence of pyrophorics; or treatment to eliminate the characteristic
Mixed Waste	• Characterization per the QAPP • Limited to EPA Waste Codes listed in Table 3.4.2.3-2 of the WAC	Hazardous waste characterization records; records showing types and quantities of hazardous constituents; and approved QAPjPs
Chemical Compatibility	• All chemicals must be allowable per the CH-TRAMPAC	Records showing chemical constituents listed per CH-TRUCON content codes and chemical lists
Hazardous Constituents	• Target analytes and TICs to be reported per the QAPP	Records showing types and quantities of hazardous constituents in the waste
Explosives, Corrosives and Compressed Gases	• No compressed gases • No ignitable, reactive or corrosive wastes	Radiography records, visual examination records or acceptable knowledge documentation; Site policies/procedures prohibiting these items in newly generated wastes; and/or treatment to eliminate the characteristic
PCBs Concentration	• < 50 ppm	Records of sampling and analysis; or acceptable knowledge of waste that may contain PCBs
GAS GENERATION		
Decay Heat (1)	• ≤ Wattages listed in CH-TRUCON Tables	Records of assay data or acceptable knowledge documentation; records of conversion and calculations showing compliance
Flammable VOCs	• ≤ 500 ppm in container headspace	Records of acceptable knowledge or headspace gas analysis
VOC Concentration	• ≤ Limits shown in Table 3.5.3.3 of WAC	Records showing container headspace gas VOC concentrations are below limits
Aspiration (1)	• ≥ Times shown in CH-TRUCON tables	Records of unvented container aspiration times
Shipping Category (1)	• Content Codes listed in CH-TRUCON tables; and one category per TRUPACT-II	Records showing only one Content Code per payload container and only one shipping category per TRUPACT-II

Table 3.1-1, Summary of CH-TRU Waste Acceptance Criteria Requirements and Compliance Methods

CRITERIA	REQUIREMENTS/LIMITS	COMPLIANCE METHODS
Confinement Layers [1]	• Liner punctured/vented • Number of layers known • Bags closed by approved methods • Sealed containers > 4 liters prohibited (except for waste material type II.2)	Records showing compliance with Section 8.0, Appendix 1.3.7 of the TRUPACT-II SARP
DATA		
Acceptance Data	• Auditable package of data with signed Certification Statement on file • WWIS data transmitted	Auditable record of waste characterization data on file; signed waste Certification Statement on file; WWIS data entered and approved by WIPP
RCRA Data	• Waste Stream Profile Form • Uniform Hazardous Waste Manifest [2] • Land Disposal Restriction notification [2]	Waste Stream Profile Form generated by Site and accepted by WIPP; Uniform Hazardous Waste Manifest and Land Disposal Restriction notification generated
Shipping Data	• TRUPACT-II Payload Container Transportation Certification Documents • Bill of Lading [3]	TRUPACT-II Payload Container Transportation Certification Documents on file; Bill of Lading [3] generated

NOTES
(1) Applies to TRUPACT-II payload control only
(2) Applies to mixed wastes only
(3) A Uniform Hazardous Waste Manifest may be substituted
(4) ≤ 900 lbs for material form 1 (see WHC-EP-0558)

Table 3.1-2, Basic Design Requirements

Page 1 of 3

Principal Codes and Standards

	Typical Equipment	Applicable Codes & Standards	Design Class I (7)	Design Class II	Design Class IIIA	Design Class IIIB
Structure/ Supports		DBE, DBT, ACI-318, AISC	X	(1), (2)	(1)	
		UBC, ANSI A58.1		X	X	X
		SITE SPECIFIC	(1)	(1)	(1)	(1)
Liquid and Process Air Handling Processing and Storage Equipment	Vessel	ASME VIII, NFPA (5)	X, (6)	X	(1)	(1)
	Piping and Valves Pumps	ANSI B31.1, NFPA (5)		X	X	(1)
		UPC				X
	Pumps	API-610, NFPA (5)	X	X	(1)	
	Storage & Tanks	API-650 or API-620	X	X		
	Heat Exchangers	ASME VIII, TEMA	X	X	(1)	(1)
	All Other Equip.	MFR's STD			X	X
Air Handling Ducting & Fans		ARI, SMACNA, AMCA	X, (3)	X, (3)	X, (3)	X
HVAC Filters	Pre Filters	ASHRAE 52.68	X, (3), (4)	X, (3)	X, (3)	X
	HEPA Filters	MIL F 51068C, ANSI N 509, ANSI N 510	X, (3)	X, (3)	X, (3)	X
Mechanical Handling Equipment	Crane & Related Equip.	CMAA	X	X	(1)	
		CMAA, AISC, AWS	X	X	(1)	
		MFR's STD			X	X
Instrumentation and Electrical		IEEE-NE	X			
		ANSI STDS or NEC	X	X	X	X
		ISA/MFR'S STD		X	X	X

Table 3.1-2, Basic Design Requirements Page 2 of 3

Principal Codes and Standards

	Typical Equipment	Applicable Codes & Standards	Design Class I (7)	Design Class II	Design Class IIIA	Design Class IIIB
Quality Assurance Program		ASME NQA-1 & SUPPLEMENTS	X	X	X	
		COMMERCIAL AND INDUSTRY PRACTICES				X

X - Minimum Requirements

NOTES

(1) Requirements shall be determined on case-by-case basis.
(2) Required for structure and supports needed for confinement and control of radioactivity.
(3) Except structures and supports that are designed to withstand DBE/DBT when specified in column 1 of this table. (See Section 3.2 for specific criteria.)
(4) Underwriter's Laboratory (UL) class I listed.
(5) For fire protection systems.
(6) ASME III for other class I vessels.
(7) Currently there are no Design Class I structures, systems, or components at the WIPP.

Definitions

ACI-318	American Concrete Institute. Building Code Requirements for Reinforced Concrete (ACI-318-77)	ASHRAE 52.68	American Society of Heating, Refrigeration and Air Conditioning Engineers, Inc. Standard 52.68. Method of Testing Air Cleaning Devices Used in Central Ventilation for Removing Particulate Matter
AISC	Specification for Design Fabrication and Erection of Structural Steel for Buildings	ASME VIII	American Society of Mechanical Engineers. Section VIII Division I Pressure Vessel
AMCA	Air Moving and Conditioning Association Fan Performance and Sound Testing Requirements AMCA 210.67 and 300	AWS	American Welding Society
ANSI B31.1	American National Standards Institute, Power Piping	CMAA	Crane Manufactures Association of America. Specification No. 70 Specification for Electric Overhead
ANSI A58.1	Building Code Requirements for Minimum Design Loads in Building and Other Structures	IEEE	Institute of Electrical and Electronic Engineers
ANSI N 509	Nuclear Power Plant Air Cleaning Units and Components	MFR'S STD.	A Commercial Catalogue Item Built to the Manufacturer's Design Standard
ANSI N 510	Testing of Nuclear Air Cleaning Systems	MIL-F-51068C	Military Specification, Fire Resistant High Efficiency Particulate Air Filters
API-610	American Petroleum Institute. Centrifugal Pumps for General Refinery Services	NFPA	National Fire Protection Association

Table 3.1-2, Basic Design Requirements Page 3 of 3

Principal Codes and Standards			
Definitions			
API-620	Recommended Rules for Design and Construction of Large, Welded Low and Pressure Storage Tanks	NEC	National Electrical Code
API-650	Welded Steel Tanks for Oil Storage Atmospheric Tanks	SMACNA	Sheet Metal and Air Conditioning Contractors National Association, Inc
ARI	Air Conditioning and Refrigeration Institute	TEMA	Tubular Exchanger Manufacturer's Association
ASME-NQA-1	Quality Assurance Program for Nuclear Power Plant NQA 1 1979	UBC	Uniform Building Code
		UPC	Uniform Plumbing Code. (American Standard National Plumbing Code ANSI A40.8)

3.2 Structural Design Criteria

3.2.1 Wind Loadings

The design wind velocity for Design Class II structures shall be 110 mi/h (177 km/h) at 30 ft (9.1 m) above ground. The wind velocity selected, with a 1,000-year mean recurrence interval, is adopted from the results of a site specific wind and tornado study.[1] The design wind velocity exceeds the basic wind velocity specified in American National Standard Institute (ANSI) Standard A58.1[2] for the geographical location of the WIPP facility.

The design wind velocity for Design Class III structures shall be 91 mi/h (146.5 km/h), with a 50-year mean recurrence interval, except for the Support Building and Exhaust Filter Building, which is 99 mi/h (159.3 km/h) with a 100-year mean recurrence interval.

3.2.1.1 Vertical Velocity Distribution and Gust Factors

The vertical velocity distribution used shall be as given in Section 6 of ANSI Standard A58.1[2] using exposure C (flat, open country; flat, open coastal belts; and grassland) for the design wind velocity, including the appropriate gust factors. The ANSI standard contains the effective wind velocity pressures for the overall design of structures in Table 5 of the standard. The ANSI standard contains the effective wind velocity pressures for the design of parts and portions of structures in Table 6, and the effective wind velocity pressures for calculating internal pressures in Table 12.

3.2.1.2 Determination of Applied Forces

The procedures used to convert the wind velocity into applied forces on structures shall be as outlined in ANSI Standard A58.1.[2] Velocity pressures shall be determined from the tables using the design wind velocity. The design wind loads shall be obtained by multiplying the effective velocity pressures by the appropriate pressure coefficients in Sections 6.5 through 6.9, in accordance with Section 6.4 of ANSI Standard A58.1.[2] The design wind loads for enclosed structures are shown in Table 3.2-1.

3.2.2 Tornado Loadings

Tornado loadings applicable to certain Design Class II surface facilities are described in the following sections. For purposes of structural design, the effects of a tornado are described in Section 3.0 of Bechtel topical report BC-TOP-3-A.[3]

3.2.3 Applicable Design Parameters

Tornado-resistant structures shall be designed for tornado loadings (not coincident with any accident condition or earthquake) as outlined in Sections 3.3 and 3.4 of BC-TOP-3-A.[3] The parameters used for the DBT are the result of a site-specific wind and tornado study for the WIPP facility,[1] and the loadings shall be calculated based on the following tornado characteristics:

Maximum wind speed (Including effects of suction vortices)	183	mi/h	(294.5 km/h)
Translational velocity	41	mi/h	(66 km/h)
Tangential velocity	124	mi/h	(199.6 km/h)

Radius of maximum wind	325	ft	(99 m)
Pressure drop	0.5	lb/in^2	($0.035\ kg/cm^2$)
Rate of pressure drop	0.09	$lb/in^2/s$	($0.006\ kg/cm^2/s$)

The above tornado parameters are based on a 1,000,000-year recurrence period, and the maximum wind speed shall be the vector sum of all velocity components.

3.2.3.1 Determination of Forces on Structures

The methods used to convert the tornado wind and atmospheric pressure change into forces and the distribution of these forces across the structures shall be as outlined in Section 3.5 of BC-TOP-3-A.[3] Combinations of loadings are discussed in Section 3.2.11 below.

The idealized pressure-time function shown in Figure 3.2-1 shall be used to determine the differential pressure loading resulting from atmospheric change. The atmospheric differential pressure, with a maximum value of 0.5 lb/in^2 ($0.035\ kg/cm^2$), tends to force external surfaces of enclosed structures outward.

3.2.3.2 Plant Structures not Designed for Tornado Loads

Structures not resistant to tornados, whose collapse could result in the loss of required function of tornado-resistant structures, or systems that are under tornado loading conditions shall be analyzed for their mode of failure. This is to ensure that such a collapse does not cause any tornado-resistant structure or system to lose its intended function.

3.2.4 Water Level (Surface Flood) Design

The WIPP facility nominal grade elevation is more than 400 ft (122 m) above the probable maximum flood (PMF) level of the Pecos River, and the WIPP facility is separated from the river by about 12 mi (19.3 km) of gradually rising land. Since there are no perennial or intermittent streams near the WIPP facility that have the potential for sustained flooding of the site, neither buoyancy nor static water forces due to flood elevations shall be considered in the WIPP facility design.

3.2.4.1 Phenomena Considered in Design Load Calculations

Phenomena such as flood currents or wind-induced waves shall not apply, because the grades for the WIPP facility structures are more than 400 ft (122 m) above the PMF level on the Pecos River, and none of the local drainage ways has the potential for sustained flooding of the WIPP facility.

3.2.4.2 Flood Force Application

As stated above, the WIPP facility structures are above the PMF level, and are not subjected to flood loadings.

3.2.4.3 Flood Protection

Protection against the PMF level on the Pecos River shall not be required for WIPP facility SSCs.

The on-site storm drainage system shall be based on a 10-year frequency storm. Culverts shall be designed to discharge a 25-year storm, utilizing the head available at entrance. At on-site roads, the static head shall not exceed the subgrade. Minimum design concentration time shall be five minutes. The site drainage system shall include and provide the following:

- Peripheral ditches
- Culverts
- Ditches
- Under drains

The design shall be such that local probable maximum precipitation does not flood any of the on-site facilities of Design Class IIIA and higher.

3.2.5 Groundwater Design

3.2.5.1 Groundwater Forces

Forces exerted by water in the geological formations overlying the salt shall be considered as lateral loads on the shafts caused by the piezometric heads in the water-bearing zones of the Rustler Formation, and shall be sealed to prevent seepage into the salt formations.

Surface water shall be prevented from entering the shafts by sloped shaft collars.

3.2.5.2 Design Loads

Groundwater forces shall be combined with other types of loads for structural design, as described in Section 3.2.11, Combined Load Criteria.

3.2.5.3 Protection From Groundwater

Shaft linings and structures shall minimize water seepage, and shall be designed against hydrostatic pressure since the water-bearing unit above the waste disposal level will not be drained. Chemical seals shall be constructed, as required, around the shafts, under the water-bearing unit area to minimize water migration to lower elevations, and water collection rings shall be provided to collect seepage that might enter through the shaft lining.

Since there are no significant sources of moisture or groundwater in the Salado Formation underground mined area, no additional humidity or moisture controls beyond those described shall be required.

3.2.6 Protection Against Dynamic Effects

To prevent plant equipment failures from generating internal missiles, rotating equipment shall be designed, wherever possible, to preclude that possibility. Equipment identified as potential missile sources shall be arranged and oriented so that any missile generated would impact a structure or barrier capable of withstanding that impact, preventing damage to Design Class II SSCs.

3.2.7 Seismic Design

Design Class II confinement SSCs shall be designed to withstand a Design Basis Earthquake (DBE). The DBE, based on a 1,000-year earthquake has been established through a seismic study of the WIPP facility region, as discussed in Chapter 2. This section summarizes the seismic input from Chapter 2, and describes the methods and procedures of seismic analysis.

3.2.7.1 Input Criteria

The maximum ground acceleration for the DBE is 0.1g in both horizontal and vertical directions, and shall be used in analysis and design of surface facilities and equipment. As described in Chapter 2, several WIPP facility region seismic zone characterizations have been taken into account in establishing the maximum ground motion.

3.2.7.1.1 Design Response Spectra

The design response spectra for horizontal and vertical components of the DBE shown in Figure 3.2-2 and Figure 3.2-3, are based on a statistical analysis of the existing strong ground motion earthquake records of various durations, recorded at sites having various geologic conditions and located at various epicentral distances.

3.2.7.1.2 Derivation of Design Response Spectra

Synthetic earthquake time histories shall not be required for seismic design of the WIPP facility since actual response spectra were used.

3.2.7.1.3 Critical Damping Values

The range of damping values (percent of critical) for SSCs shall be as given in Sections 2.2 and 3.2 of BC-TOP-4-A,[4] and are shown in Table 3.2-2.

Damping values of soil and foundation materials are determined by laboratory tests.

The formulas used to determine the equivalent foundation damping coefficient shall be as given in Section 3.3 of BC-TOP-4-A.[4] They are used when a lumped parameter approach is appropriate for soil structure interaction considerations.

3.2.7.1.4 Soil Supported Structures

The Design Class II surface structures shall be constructed either directly on caliche or compacted sandstone, or on a sand layer above the caliche. The foundation support materials shall be designed to withstand the pressures imposed by the appropriate loading combinations, with an adequate safety factor.

3.2.7.1.5 Soil-Structure Interaction

Structural systems affected by soil-structure shall be analyzed, as applicable, in accordance with Section 3.3 and Appendix D of BC-TOP-4-A.[4]

3.2.7.2 Seismic System Analysis

The structures and systems shall be designed for either DBE or Uniform Building Code[5] (UBC) earthquake loads, as specified in Section 3.1.3.

3.2.7.2.1 Seismic Analysis Method

Analytical methods used for seismic analysis shall be as described in Sections 1.0 and 3.0 of BC-TOP-4-A.[4]

The structural mode shapes and frequencies shall be calculated for the models for the fixed base cases. Whenever appropriate, foundation structure interaction shall be analyzed in accordance with the methods given in Section 3.3 of BC-TOP-4-A.[4] A response spectrum analysis shall be conducted for the structure using the above calculated parameters. The results of the analysis shall include acceleration, displacements, shears, moments, and other related information necessary for structural design. Design allowables shall be as given in Section 3.2.11 of this document, for the various loading combinations including seismic loadings.

The simplified method of analysis shall be used for frame type structures in lieu of the analytical method described above. The simplified method shall be acceptable for verifying the structural integrity of frame structures that can be represented by a simple model. No determination of natural frequencies shall be made, but rather the design acceleration shall be assumed to be 1.5 times the peak of the required response spectrum.

3.2.7.2.2 Methods Used to Couple Soil with Seismic Structures

If a detailed design and soil investigation determines that a structure is founded on a sand layer of a depth comparable to its plane dimension, foundation impedances based on elastic half-space theory shall be developed and used to account for the soil-structure interaction as described in Section 3.3.1, of BC-TOP-4-A.[4]

3.2.7.2.3 Development of Floor Response Spectra

A simplified method shall be used to generate the approximate floor response spectra without the need of performing a time history analysis of structures. The method used shall be as developed by Tsai and Tseng,[6] which derives spectrum peak envelopes from the design response spectra shown in Figure 3.2-2 and Figure 3.2-3. Subsequently, the floor response spectra for equipment design shall be developed using these peak envelopes and the frequencies of the soil-structure systems.

3.2.7.2.4 Effects of Variations on Floor Response Spectra

Section 5.2 of BC-TOP-4-A[4] describes the various considerations that shall be used in the seismic analyses, including the effects on floor response spectra of expected variations of structural properties, damping, soil properties, and foundation-structure interaction. These calculations shall include the details of the effects of variations on the floor response spectra.

3.2.7.2.5 Use of Constant Vertical Load Factors

The method of analysis used for both the vertical and horizontal directions shall be the re-spectrum method. The induced forces, moments, and resulting stresses due to motions in the vertical and the two horizontal directions shall be combined by the square root of the sum of the squares (SRSS) technique.

3.2.7.2.6 Method Used to Account for Torsional Effects

Torsional effects, if significant, shall be included in the horizontal models at locations of major mass and/or structural eccentricity. The techniques in Section 3.2 and Appendix C of BC-TOP-4-A[4] shall be used to account for torsional effects.

3.2.7.2.7 Analysis Procedure for Damping

The analysis procedure employed to account for damping in various elements of the model of a coupled system shall be as described in Sections 3.2 and 3.3 of BC-TOP-4-A,[4] including the criteria for evaluating the composite model damping of the system, and accounting for the damping of various structural elements and foundations.

3.2.7.3 Seismic Subsystem Analysis

This section covers the seismic analysis of Design Class II equipment and subsystems essential to confinement.

3.2.7.3.1 Determination of the Number of Earthquake Cycles

During the plant life, one DBE shall be assumed to occur. For the DBE, about 10 maximum stress cycles shall be assumed to be induced in the SSCs, and the SSCs shall be designed on the basis of analytical results. In general, the design of structures and equipment for the WIPP facility shall not be fatigue controlled since most stress and strain changes occur only a small number of times, or produce only minor stress-strain fluctuations or both. Earthquake and Design Basis Accident (DBA) full-design strains occur too infrequently and with too few cycles to generally require fatigue design of structures and equipment.

3.2.7.3.2 Basis for the Selection of Forcing Frequencies

Structural fundamental frequencies shall be calculated in accordance with Section 4.2.1 of BC-TOP-4-A.[4]

3.2.7.3.3 Root-Mean Square Basis

The term "root-mean square basis" used for a combination of modal responses shall be the same equation as SRSS given as follows:

$$Q\ max = (Q_1{}^2\ max + Q_2{}^2\ max + \ldots + Q_n{}^2\ max)^{1/2}, \text{ where } Q\ max = SRSS$$

3.2.7.3.4 Procedure for Combining Modal Responses

The procedure for combining modal responses (shear, moments, stresses, and deflections or accelerations or both) when a response spectrum modal analysis is used, shall be as follows:

- The SRSS method of combining modal responses shall be used, if modes are not closely spaced.
- All significant modes up to 33 Hz shall be used in the analysis; however, the lowest three modes shall always be used. Above 33 Hz the element acts as a rigid body, and the calculations would be trivial.
- Where closely spaced frequencies of two or more modes occur, these modal responses shall be combined in an absolute sum; the resulting sum is treated as that of a pseudo-mode, then combined with the remaining modes by SRSS.

3.2.7.3.5 Significant Dynamic Response Modes

Seismic designs of subsystems (i.e., floor or wall-mounted components, etc.) shall be based on modal analysis by using the appropriate floor response spectra and the procedures in Section 3.2.7.2.3. The static loads equivalent to the peak of the floor spectrum curve shall be used only for: (1) a subsystem that can be idealized as a single degree-of-freedom system, or (2) a multiple degree-of-freedom system whose fundamental frequency is far from all the other natural frequencies. In such cases, only the fundamental mode shall be considered.

3.2.7.3.6 Basis for Computing Combined Response

The basis for the methods used to determine the possible combined (two-component) horizontal and vertical amplified response loading for seismic design of equipment, including the effect of seismic response of the supports, equipment, and structures and components, shall be as described in BC-TOP-4-A.[4]

3.2.7.3.7 Amplified Seismic Responses

The dynamic analysis method used to analyze subsystems shall be as described in Section 3.2.7.2.1.

3.2.7.3.8 Modal Period Variation

The peaks of floor response spectra shall be widened, by an amount to be determined by the procedure given in Section 5.2 of BC-TOP-4-A,[4] on both sides of the peak, to account for modal period variations due to the variation of structural and foundation properties and idealization in mathematical modeling.

3.2.7.3.9 Torsional Effects of Eccentric Masses

The torsional effects of valves and other eccentric masses shall be included.

3.2.7.3.10 Seismic Analysis for Overhead Cranes

All overhead cranes used for waste handling shall have seismic retainer attachments to prevent them from dislodging during a seismic event.

3.2.8 Snow Loadings

Design Class II structures shall be designed for a snow load of 27 lb/ft.^{2} (0.013 kg/cm^2)

The design snow load is derived by using the 100-year recurrence snow load of 10 lb/ft^2 (0.005 kg/cm^2) specified in ANSI Standard A58.1,[2] and by determining the quantity of standing water from winter precipitation required to arrive at a threshold condition.

Roof snow loads shall be calculated by multiplying the design snow load by the appropriate coefficients (C_s) specified in Figure 5, Figure 6, and Figure 7 of ANSI A58.1.[2]

In the combined loading calculations given in Section 3.2.11, the roof snow loads shall be used in place of the minimum roof live load, where such loading is more critical in governing the design.

3.2.9 Equipment and Materials-Derived Loads

Equipment and materials-derived loads in this section are discussed by first defining loading nomenclature, then presenting the loading criteria.

3.2.9.1 Nomenclature

D Dead Load - The dead load shall consist of the weight of the structure, permanent equipment, piping, conduits, cables, and other permanent static loads.

L Live Load - The live load shall consist of uniformly distributed occupancy loads, moving vehicle loads, crane or its related equipment loads, snow and ice loads, and other loads which vary with intensity and occurrence. The minimum uniformly distributed live loads, concentrated loads, and minimum roof live loads shall be those specified in ANSI A58.1,[2] Table 1, Table 2, and Table 3. The live load arrangement design shall use the highest stresses in the supporting members. Structures carrying live loads that can induce dynamic, vibratory, or impact forces shall be designed for those forces, as specified in Section 3.4 of the ANSI A58.1,[2] or as determined by appropriate analysis.

S Snow Load - A snow load shall be used in the design of structures, and shall be applied in accordance with Section 7 of ANSI A58.1.[2] Snow load shall be used instead of roof live load, when such loading is more critical to the design.

W Wind Load - A wind speed of 110 mi/h (176 km/h), with a 1,000-year mean recurrence interval, shall be used in the design of Design Class II structures. A wind speed of 99 mi/h (158 km/h), with a 100-year mean recurrence interval, shall be used in the design of the structural portions of the Support Building, Exhaust Filter Building, and Building 412. All other Design Class IIIA and IIIB structures shall be designed for a basic wind speed of 91 mi/h (145.6 km/h) with a 50-year mean recurrence interval. Conversion of wind speed to wind pressure shall be per Sections 6.1 thru 6.11 of ANSI A58.1[2] and the DOE Guide for Calculation of Design Wind Pressures,[7] Sections A and B.

W_t Total Tornado Load - The loads generated by the design basis tornado, W_t, shall include the effect of tornado wind and pressure differential. The most critical case of the following combinations governs the design.

W_t = Tornado Wind Load (W_w)
W_t = Tornado Differential Pressure (W_p)
$W_t = W_w + 0.5\ W_p$

E′ Seismic Load - Load generated by the DBE.

F Hydrostatic Load - Vertical liquid pressure shall be considered as dead load with regard to variation in liquid depth.

H Soil Pressure - Structures or parts of structures which retain fills, excluding shafts, shall be proportioned to withstand the lateral soil pressure, as given in the WIPP Soils Design Report - Volume I, DR-22-V-01.[8]

Salt Creep - Provisions shall be made for eliminating or accommodating stresses, deformations, and/or movements in structures, such as brattice walls, bulkheads, etc., adjacent to the salt. An adequate gap shall be provided between the salt and structure to accommodate creep effect. For structures, walls, or bulkheads that require sealing, the gap shall be bridged with a fire-resistant or noncombustible flexible material.

T Thermal Load - Provisions shall be made for stresses, deformations, or movements resulting from variations in temperature. For surface structures, the ambient temperature rise or fall from that at the time of erection, is assumed to be 60°F (15.6° C) for metal structures and 40°F (4.5° C) for concrete or masonry structures. For underground structures, the ambient temperature rise or fall from that at the time of erection is assumed to be 30°F (-1.1° C) for metal structures and 20°F (-7.5° C) for concrete structures.

3.2.10 Thermal Loadings (Salt)

Waste shall be emplaced so thermal loading (heat generation) does not exceed an average of 10 kW/acre (24.7 kW/hectare).[10] Thermal analyses of geologic waste isolation in salt,[10] show that more than 150 kW (142.3 BTU/s) of heat generating waste can be emplaced in an acre of a storage facility without unacceptable impacts on the salt beds or the surrounding environment. However, a conservative design limit of 10 kW/acre (24.7 kW/hectare) shall be established.

3.2.11 Combined Load Criteria

Design Class II confinement structures and supports shall be designed for dead, live, thermal, wind, earthquake, tornado, and soil pressure loads.

The Design Class III structures, and those Design Class II structures and supports not required for confinement, shall be designed in accordance with the UBC.[5]

3.2.11.1 Nomenclature

Nomenclature is defined in Section 3.2.9.1, and additional symbols related to the design of steel and concrete structures shall be defined as follows:

Note: The 33 percent increase in allowable stresses for concrete and steel due to seismic or wind loadings shall not be permitted.

S For steel structures, S shall be the required strength based on the elastic design method and the allowable stresses defined in Part I of the American Institute of Steel Construction (AISC) Specification.[9]

U For concrete structures, U shall be the required strength to resist the design loads. This is based on the strength design method described in America Concrete Institute Standard 318-77.[11]

3.2.11.2 Load Combinations

3.2.11.2.1 Design Requirements

All structures shall be designed to have strengths at all sections at least equal to the structural effects of the design loads as listed in Table 3.2-3 in such combinations as shown below.

Design Class II - Reinforced Concrete Structures

$U = 1.4D + 1.4F + 1.7L + 1.7H$
$U = 1.4D + 1.4F + 1.7L + 1.7H + 1.7W$
$U = 1.05D + 1.05F + 1.3L + 1.3H + 1.3T$
$U = 1.05D + 1.05F + 1.3L + 1.3H + 1.3W + 1.3T$
$U = D + F + L + H + T + E'$
$U = D + F + L + H + T + W_t$

Design Class II - Steel Structures

$S = D + L$
$S = D + L + W$
$1.5S = D + L + T$
$1.5S = D + L + T + W$
$1.6S = D + L + T + E'$
$1.6S = D + L + T + W_t$

Where the structural effects of differential settlement may be significant, it shall be included with the dead load (D) in load combination. An estimation of this effect shall be based on a realistic assessment of such effect occurring in service. When any load reduces the effects of other loads, the corresponding coefficient for that load shall be taken as 0.9, if it can be demonstrated that the load is always present or occurs simultaneously with the other loads, else the coefficient for that load shall be taken as zero.

Design Class IIIA - Reinforced Concrete and Steel Structures

Design Class IIIA structures shall be designed in accordance with the provisions of UBC,[5] except that the design loads shall comply with ANSI A58.1,[2] unless otherwise specified in Table 3.2-3.

Design Class IIIB - Reinforced Concrete, Steel, and Masonry Structures

Design Class IIIB structures shall be designed in accordance with the provisions of UBC,[5] except that the design loads shall comply with ANSI A58.1,[2] unless otherwise specified in Table 3.2-3.

Design Class IIIB - Pre-engineered Metal Building Structures

The pre-engineered metal building shall be designed in accordance with the Metal Building Systems Manual of Metal Building Manufacturers Association,[12] except that the design loads shall comply with ANSI A58.1[2] with the following exceptions:

Wind load shall be calculated based on a basic wind speed, V, of 91 mi/h (145.5 km/h). For building height less than 30 ft (9.15 m), the effective velocity pressures q_F, q_M, and q_P in ANSI A58.1,[2] shall be reduced using the following formulas.

$$q_F = 0.00268\ V^2\ (H/30)^{2/7}$$
$$q_M = 0.00246\ V^2\ (H/30)^{2/7}$$
$$q_P = 0.00377\ V^2\ (H/30)^{2/7}$$

Where H = Mean height of the roof or 15 ft (4.6 m), whichever is greater.

Seismic load shall be in accordance with the requirements set forth in UBC,[5] Seismic Zone No. 1.

Snow load shall be calculated based on a basic snow load of 10 lb/ft^2 (0.005 kg/cm^2).

3.2.11.2.2 Minimum Factors of Safety with Respect to Overturning, Sliding, and Floatation

In addition to the above load combinations, the following combinations and factors of safety shall apply to structures when being checked for overturning, and sliding:

Minimum Factors of Safety

Load Combination	Overturning	Sliding
D + H + W	1.5	1.5
D + H + E′	1.1	1.1
D + H + W_t	1.1	1.1

Where Section 3.2.9.1 describes H, D, E′, W, and W_t except that, for conservatism, only the weight of a structure and the components permanently attached to it shall be accounted for in D. The factor of safety against floatation, defined as the ratio of dead load divided by the hydrostatic uplift, shall be 1.1 minimum.

3.2.12 Soil Erosion Control

The design control measures to minimize soil erosion and to control sediment-laden runoff at the WIPP facility shall be in accordance with the amended Water Control Commission regulations, Water Quality Control Commission, State of New Mexico, and applicable federal regulations.

References for Section 3.2

1. The University of Chicago, SMPR Research Paper No. 155, A Site Specific Study of Wind and Tornado Probabilities at the WIPP Site in Southeast New Mexico, UN000075, February 1978.

2. ANSI A58.1-1972, American National Standard Building Code Requirements for Minimum Design Loads in Buildings and other Structures.

3. BC-TOP-3-A, Tornado and Extreme Wind Design Criteria for Nuclear Power Plants, August 1974.

4. BC-TOP-4-A, Seismic Analyses of Structures and Equipment for Nuclear Power Plants, November 1974.

5. Uniform Building Code, 1979 edition.

6. Tsai and Tseng, Standardized Seismic Design Spectra for Nuclear Plant Equipment, Nuclear Engineering and Design, Vol. 45, UN000169, 1978.

7. DOE Guide for Calculation of Design Wind Pressures.

8. DR-22-V-01, WIPP Soils Design Report, Volume I, Bechtel, Inc., 1979.

9. American Institute of Steel Construction, Specification for Design, Fabrication, Erection of Structural Steel for Buildings, November 1, 1978.

10. Y/OWI/SUB-76/07220, *The Selection and Evaluation of Thermal Criteria for a Geological Waste Isolation Facility in Salt,* Science Applications, Incorporated, Oak Ridge, TN, September 1976.

11. American Concrete Institute Standard 318-77, Building Code Requirement for Reinforced Concrete, December 1977.

12. Metal Building Systems Manual of Metal Building Manufacturers Association, Cleveland, OH.

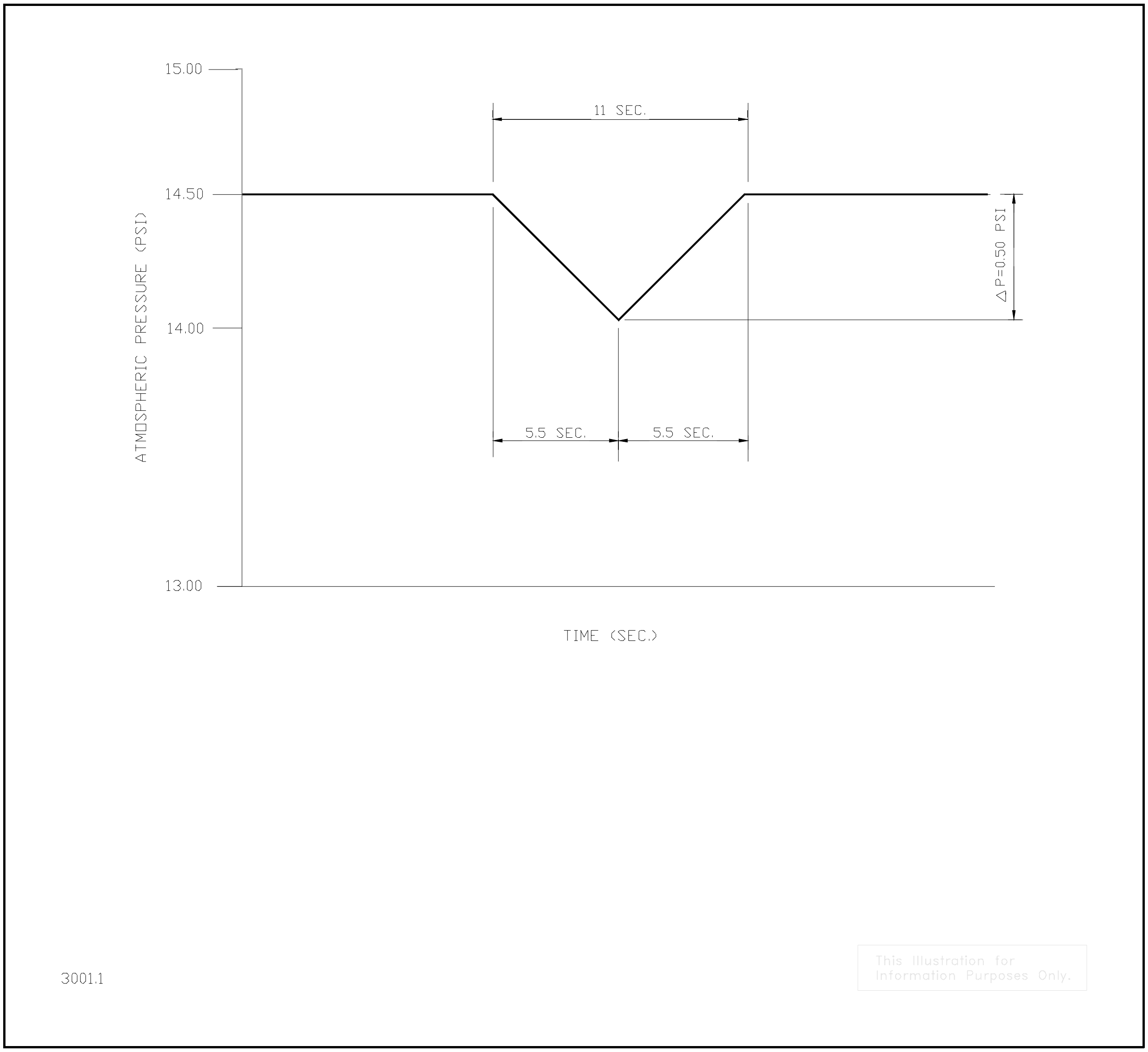


Figure 3.2-1, Idealized Function of Atmospheric Pressure Change vs. Time

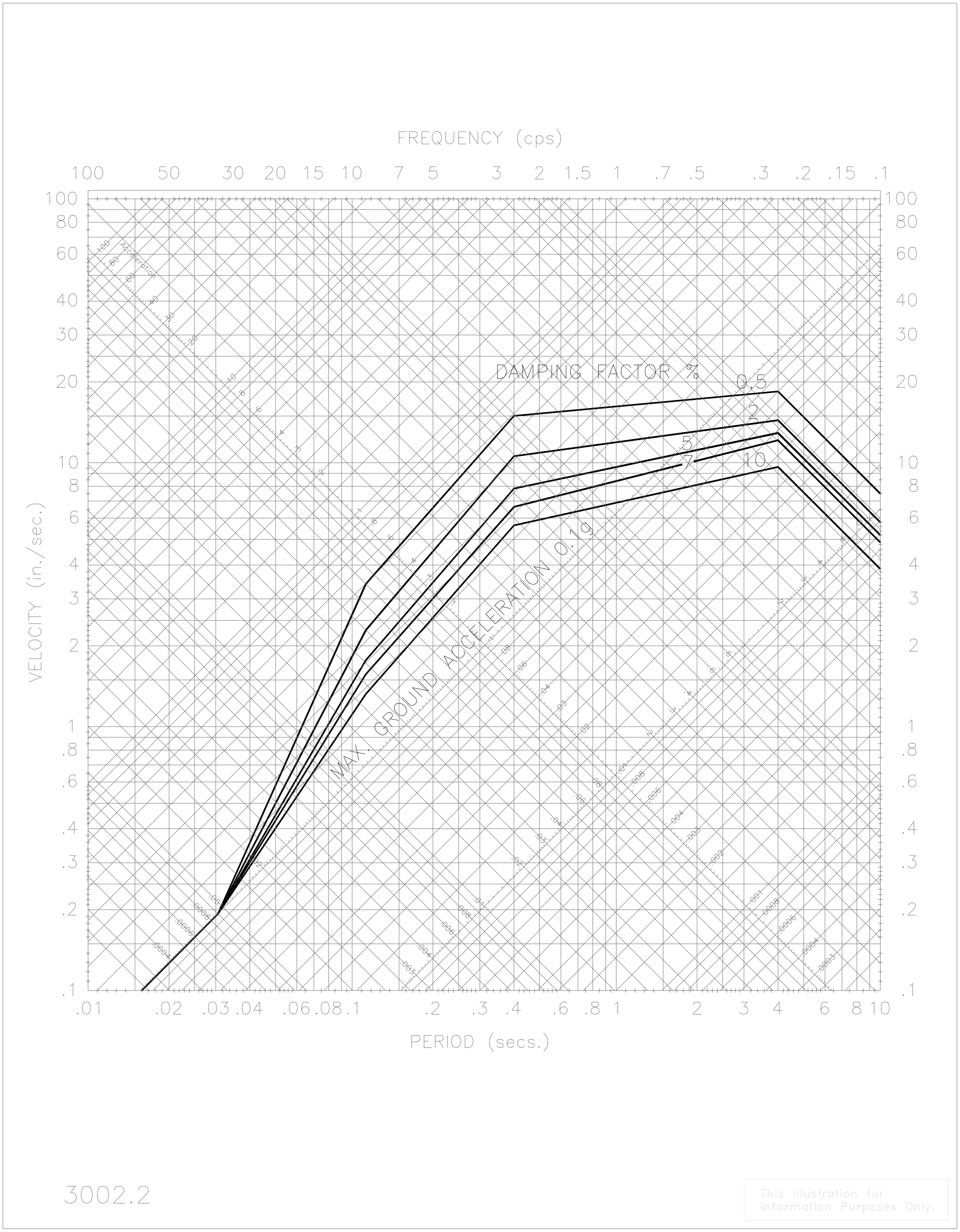


Figure 3.2-2, Horizontal Design Response Spectra

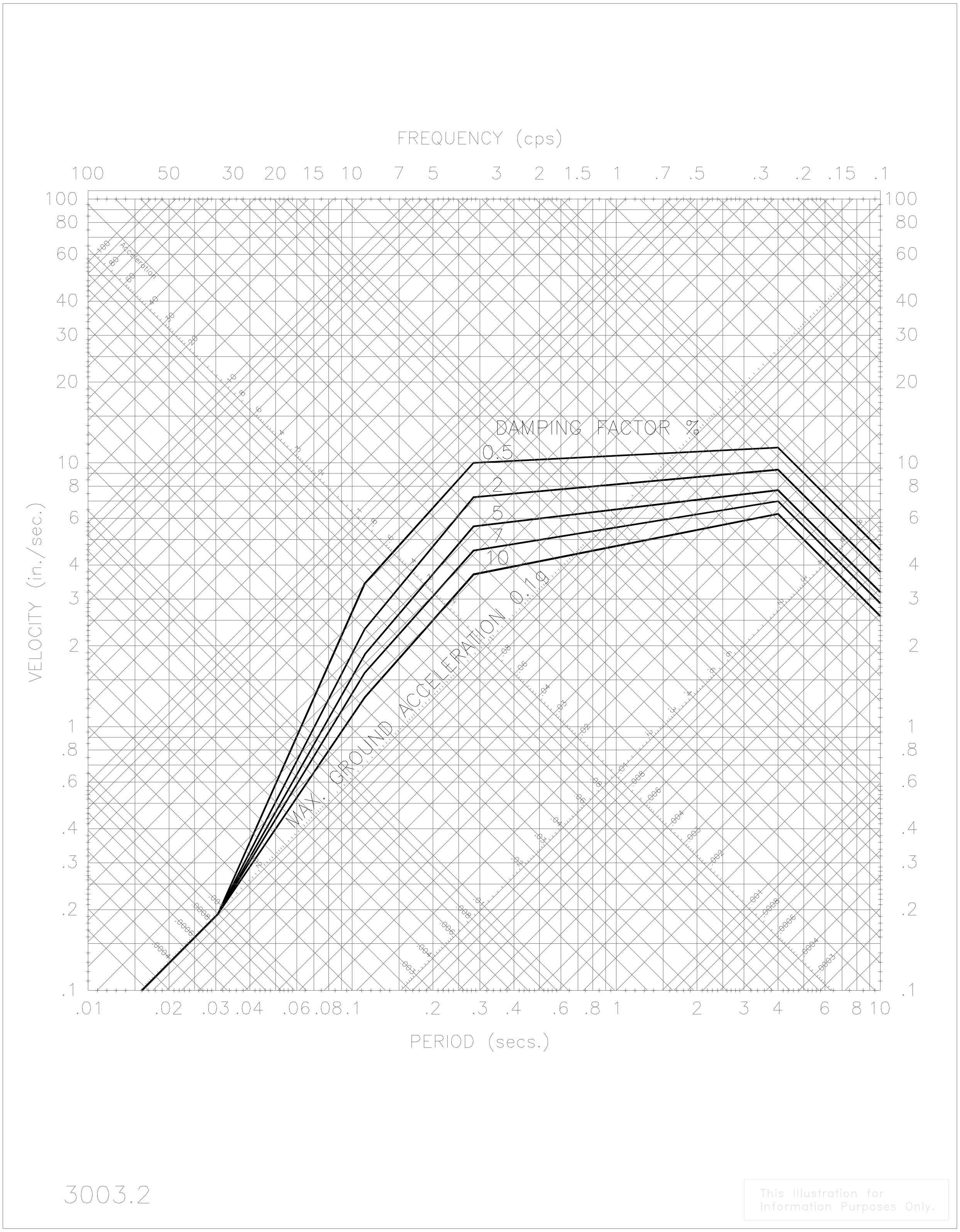


Figure 3.2-3, Vertical Design Response Spectra

Table 3.2-1, Design Wind Load (Enclosed Structures Subjected to 110 mi/h Wind)

	Height, ft (m)	Windward, lb/ft^2 (kg/m^2)	Leeward, lb/ft^2 (kg/m^2)	Roof, lb/ft^2 (kg/m^2)	Sides, lb/ft^2 (kg/m^2)	Limitations
External	0-29 (0-8.8)	+26(+127)	-19 (-93)	-22 (-107)	-22 (-107)	Height/Width <2.5
	30-49 (9.1-14.9)	+35(+171)	-26 (-127)	-25 (-122)	-25 (-122)	Height/Length <2.5
	50-99 (15.2-30.2)	+40(+195)	-30 (-146)	-35 (-171)	-35 (-171)	
	100-149 (30.5-45.4)	+45(+220)	-34 (-166)	-39 (-190)	-39 (-190)	
Internal Pressure	0-29 (0-8.8)	-9 (-44)	-9 (-44)	-9 (-44)	-9 (-44)	No Openings
	30-49 (9.1-14.9)	-10 (-49)	-10 (-49)	-10 (-49)	-10 (-49)	
	50-99 (15.2-30.2)	-12 (-59)	-12 (-59)	-12 (-59)	-12 (-59)	
	100-149 (30.5-45.4)	-14 (-68)	-14 (-68)	-14 (-68)	-14 (-68)	
Internal Vacuum	0-30 (0-9.1)	+9 (+44)	+9 (+44)	+9 (+44)	+9 (+44)	No Openings
	30-50 (9.1-15.2)	+10	+10 (+49)	+10 (+49)	+10 (+49)	
	50-100 (15.2-30.5)	+12(+59)	+12(+59)	+12(+59)	+12(+59)	
	100-150 (30.5-45.7)	+14(+68)	+14(+68)	+14(+68)	+14(+68)	

Sign convention:
+ Inward force
- Outward force

Table 3.2-2, Damping Values of SSCs for Design Basis Earthquake

Structure or Component	Damping Value % of Critical Damping
Welded steel structures	4
Bolted steel structures	7
Reinforced concrete structures	7
Equipment and large diameter piping systems, pipe diameter greater than 12 in (30.5 cm)	3
Small diameter piping systems, diameter equal to or less than 12 in (30.5 cm)	2
Prestressed concrete structures	5

Table 3.2-3, Design Loads for Surface Structures[1]

DESIGN CLASS	STRUCTURE	SEISMIC		TORNADO	SNOW	WIND
		DBE	UBC	DBT	lb/ft²	mi/h
Class II	Waste Handling Building	X[2]		X	27	110
Class II	Station A	X		X	27	110
Class IIIA	Support Building	(3)	X	(3)	10	99
Class IIIA	Exhaust Filter Building		X		10	99
Class IIIA	Building 412	(3) X		(3)	27	110
Class IIIB	Warehouse/Shops Building		X		10	91
Class IIIB	Water Pumphouse		X		10	91
Class IIIB	SH Shaft Hoist House & Electrical Room		X		10	91

Notes:

(1) For definition of various loads, see Section 3.2.9.1.
(2) "X" indicates applicable load.
(3) The main lateral force resisting members of the Support Building and Building 412 shall be designed for DBE and DBT to protect the Waste Handling Building from structural failure.

This page intentionally blank

3.3 Safety Protection Criteria

3.3.1 Confinement Requirements

The regulatory requirements for confinement applicable to the WIPP are defined in DOE Order O 420.1,[1] Facility Safety. Confinement systems for the WIPP shall be designed to the pertinent provisions of DOE O 420.1,[1] Facility Safety, and shall accomplish the following:

- Minimize the spread of radioactive and other hazardous materials within the unoccupied process areas
- Prevent, if possible, or minimize the spread of radioactive and other hazardous materials to occupied areas
- Minimize the release of radioactive and other hazardous materials in facility effluents during normal operation and anticipated operational occurrences
- Limit the release of radioactive and other hazardous materials resulting from Design Basis Accident (DBAs) including severe natural phenomena and man-made events, in compliance with the guidelines contained in DOE O 420.1,[1] Section 4.1.1.2, Design Requirements

The ventilation system of a confinement system shall maintain airflow into the containment rooms or areas of a building to ensure that the airflow is from non-contaminated areas to potentially contaminated areas, and then to areas potentially at higher levels of contamination.

Confinement systems for the WIPP shall be designed to specific provisions of DOE O 420.1,[1] Facility Safety, as follows:

- The primary confinement shall consist of the waste containers
- The secondary confinement system shall consist of the buildings/structures and associated ventilation systems that enclose the primary confinement, and which are identified in Section 4.4
- The tertiary confinement shall be the natural geologic setting

The secondary confinement shall be designed to ensure that it can withstand the effects of severe natural phenomena and man-made events, including DBAs, and remain functional to the extent that the guidelines in DOE O 420.1,[1] Section 4.1.1.2, Design Requirements, are not violated.

3.3.2 Fire Protection

The WIPP fire protection system shall be designed in conformance with the design criteria set forth in DOE Order O 420-.1,Facility Safety, and 30 CFR 57.[2] The fire protection system design shall conform to provisions of the following codes and standards, as applicable.

- National Fire Codes of the National Fire Protection Association (NFPA)
- Loss prevention data sheets of Factory Mutual Research Corporation
- Uniform Building Code (UBC)

- DOE/EP-0108, Standard for Fire Protection of DOE Electronic Computer/Data Processing Systems[3]

3.3.3 Radiological Protection

The WIPP facility shall use design considerations that assure and maintain radiation exposures as low as reasonably achievable (ALARA) to the general public and workers. These considerations shall be consistent with the intent of the Radiological Control Manual, DOE/EH-0256T,[4] 10 CFR 835,[5] and recommendations of Nuclear Regulatory Commission (NRC) Regulatory Guides 8.8[6] and 8.10.[7]

3.3.3.1 Controlled Areas

Entrance to and exit from controlled areas within the WIPP facility shall be implemented in accordance with the WIPP Radiation Safety Manual.[8]

3.3.3.2 High Radiation Areas

All high radiation areas shall be designed with access control and warning devices in accordance with the requirements set forth in DOE/EH-0256T[4] and 10 CFR 835.502.[5]

3.3.3.3 Shielding

The shielding design basis shall be to limit the maximum exposure to an individual worker to one-fifth of the annual occupational external exposure limits specified in 10 CFR 835.[5] Within the design basis, personnel exposures shall be maintained ALARA. Specifically, the shielding shall be designed to limit the occupational exposure during normal operation to the administratively selected limit of 1 rem/yr (10 mSv/yr) Total Effective Dose Equivalent (TEDE) for operating personnel.

The integrity, design, and performance of concrete shielding shall be assured by adherence to the requirements and practices recommended in ANSI N 101.6-1972, Concrete Radiation Shields.[9]

The hot cell shielding shall be designed for an internal gamma surface dose rate of 400,000 rem/hr (4,000 Sv/hr) and for an internal neutron surface dose rate of 45 rem/hr (0.45 Sv/hr).

3.3.3.4 Nuclear Criticality Safety

Criticality safety requirements shall be considered for the WIPP in accordance with DOE Order 5480.24.[10] The basic elements and control parameters of programs for nuclear criticality invoked by the DOE order are the American Nuclear Society's ANSI/ANS nuclear criticality safety standards listed below:

ANSI/ANS-8.1[11]	Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors
ANSI/ANS-8.3[12]	Criticality Accident Alarm System
ANSI/ANS-8.5[13]	Use of Borosilicate-Glass Raschig rings as a Neutron Absorber in Solutions of Fissile Material
ANSI/ANS-8.7[14]	Guide for Nuclear Criticality Safety in the Storage of Fissile Materials

ANSI/ANS-8.15[15] Nuclear Criticality Control of Special Actinide Elements

ANSI/ANS-8.19[16] Administrative Practices for Nuclear Criticality Safety

3.3.4 Industrial and Mining Safety

The WIPP surface SSCs shall be primarily designed to comply with the occupational safety and health program requirements of DOE Order 5483.1A,[17] and the Occupational Safety and Health Administration requirements of 29 CFR 1910[18] and 29 CFR 1926[19] to minimize the potential for industrial accidents.

The WIPP hoists and underground systems and equipment shall be primarily designed in conformance with the requirements of Mine Safety and Health Administration 30 CFR 57[2] and the New Mexico Mine Safety Code For All Mines.[20]

3.3.5 Off-site Radiological/Nonradiological Accident Risk Evaluation Guidelines

Radiological

Off-site radiological dose guidelines for accident analyses have been well established by national standards through the licensing process of nuclear facilities regulated by the Nuclear Regulatory Commission (NRC). These guidelines are based on the probabilities of occurrence of the accidents or events for the accident analysis. For nuclear power plants, the operational accidents or events are classified as Plant Conditions (PC), in accordance with the estimated probability of occurrence.[21,22] This established scheme (ANSI/ANS-51.1)[21] has also been adopted by the WIPP to compare accidental releases from postulated events to dose limits, based on estimated likelihood of occurrence. Table 3.3-1 summarizes the guidelines for the assessment of off-site radiological exposures.

Nonradiological

A unique set of approved nonradiological guidelines is not found in existing DOE orders. Proposed guidelines for application to WIPP (See Table 3.3-1) are based on Emergency Response Planning Guidelines (ERPG) published by the American Industrial Hygiene Association (AIHA).

Other commonly used guidelines that have been considered in the development of acceptance guidelines for the accident analysis include the following:

- Threshold limit value-Time-weighted average (TLV-TWA)
- Threshold limit value-Short-term exposure limit (TLV-STEL)
- Threshold limit value-Ceiling (TLV-C)
- Permissible exposure limits (PEL)
- Immediately dangerous to life or health (IDLH)
- Emergency response planning guidelines (ERPGs)
- Emergency exposure guidance level (EEGL)

- Short-term public exposure guidance level (SPEGL)

Currently, ERPGs do not exist for most of the nonradiological materials found in TRU mixed waste. Chemicals without established ERPG values will use the following alternate guidelines to derive a substitute ERPG assignment:[23]

ERPG-1 (designated TOX-1): Alternate guidelines:

- PEL-STEL
- TLV-STEL
- TLV-TWA x 3

ERPG-2 (designated TOX-2): Alternate guidelines:

- EEGL (60 minute) or
- PEL-C
- TLV-C
- TLV-TWA x 5

ERPG-3 (designated TOX-3): Alternate guidelines:

- EEGL (30 minute)
- IDLH

The derived toxicological limits from the ERPG and alternate guidelines are labeled as TOX-1, TOX-2, and TOX-3. The TOXs correspond to ERPG-1, ERPG-2, and ERPG-3, respectively. The compilation of the basis limits for derivation of alternate ERPG limits is provided in Table 3.3-3.[24,25,26]

3.3.6 On-site Radiological/Nonradiological Accident Risk Evaluation Guidelines

DOE-CAO adopts the same conceptual approach used for the on-site acceptance guidelines as for the off-site (public) dose. However, on-site guidelines are greater than those for the public, as DOE-CAO accepts the basic premise that entry onto the site implies acceptance of a higher degree of risk than that associated with the off-site public. This assumption is not considered remiss with regards to safety assurance, because the on-site acceptance guidelines do not result in any acute health effects noticeable to exposed individuals at frequencies greater than 1 E-4 event per year, and would not result in any acute life-threatening effects.

A three-tiered step function is again used. For accidents with an estimated frequency between 0.1 event per year and 0.01 event per year, the limit is 5 rem (50 mSv) based on the allowable yearly worker exposure limits cited in 10 CFR 835.[5] For the estimated frequency range of 1 E-2 to 1 E-4 event per year, the threshold is 25 rem (250 mSv) for the same reason the USNRC provided in 10 CFR 100[27] for using it for design basis reactor accident calculations (i.e., value at which no significant health effects result).

Potential guideline values for the final frequency range of 1 E-4 to 1 E-6 event per year were examined in detail. CAO specifies a value for this range consistent with the use of the Emergency Response Planning Guidelines-3 (ERPG-3), value for toxicological onsite hazards. This value accepts the possibility of some noticeable health effects, but precludes the possibility of lethal effects for nearly all individuals.

The DOE *Emergency Management Guide for Hazards Assessment*[28] uses 100 rem (1 Sv) whole body exposure as a threshold for early severe effects. It also acknowledges that early severe effects would not actually be experienced for a 50-year *dose* of 100 rem (1 Sv) due to alpha emitters. The guide also selects the ERPG-3 *dosage* as a threshold for early severe effects for non-radiological releases. The two values are roughly consistent in intent. Accordingly, a value of 100 rem (1 Sv) was assigned for the 1 E-4 to 1 E-6 event per year range. This information is summarized in Table 3.3-2. Nonradiological guideline definitions are consistent with the discussion in Section 3.3.5 and Table 3.3-3.

References for Section 3.3

1. DOE Order O 420.1, Chg. 2, Facility Safety, October 1996.
2. 30 CFR 57, Safety and Health Standards - Underground Metal and Nonmetal Mines, 1977.
3. DOE/EP-0108, Standard for Fire Protection of DOE Electronic Computer/Data Processing Systems, January 1984.
4. DOE/EH-0256T, Radiological Control Manual, June 1992.
5. 10 CFR 835, Occupational Radiation Protection, December 14, 1993.
6. Nuclear Regulatory Commission Regulatory Guide 8.8, Information Relevant to Ensuring Occupational Radiation Exposure As Low As Is Reasonably Achievable (Nuclear Power Reactors), March 1979.
7. Nuclear Regulatory Commission Regulatory Guide 8.10, Operating Philosophy for Maintaining Occupational Radiation Exposure As Low As Is Reasonably Achievable, September 1975.
8. WP 12-5, WIPP Radiation Safety Manual, Rev. 3, March 1997.
9. ANSI N101.6-1972, Concrete Radiation Shields, December 1972.
10. DOE Order 5480.24, Nuclear Criticality Safety, August 12, 1992.
11. ANSI/ANS-8.1, Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors, 1983.
12. ANSI/ANS-8.3, Criticality Accident Alarm System, 1986.
13. ANSI/ANS-8.5, Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material, 1986.
14. ANSI/ANS-8.7, Guide for Nuclear Criticality Safety in the Storage of Fissile Materials, 1975.
15. ANSI/ANS-8.15, Nuclear Criticality Control of Special Actinide Elements, 1981.
16. ANSI/ANS-8.19, Administrative Practices for Nuclear Criticality Safety, 1984.
17. DOE Order 5483.1A, Occupational Safety and Health Program for DOE Contractor Employees at Goverment Owned Contractor Operated Facilities, June 22, 1983.
18. 29 CFR 1910, Occupational Safety and Health Standards, 1970.
19. 29 CFR 1926, Safety and Health Regulations for Construction, 1979.
20. New Mexico Institute of Mining Technology, New Mexico Safety Code for All Mines, 1990.

21. ANSI/ANS-51.1-1983, American National Standards Institute, Standard Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants.

22. ANSI/ANS-52.1-1983, American National Standards Institute, Standard Nuclear Safety Criteria for the Design of Stationary Boiling Water Reactor Plants.

23. Craig, D.K., et al., Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for the use in DOE Facilities, May 1993.

24. American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances, ACGIH, Cincinnati, Ohio, ISBN:1-882417-06-2, 1994.

25. Federal Emergency Management Agency, Handbook of Chemical Hazards Analysis Procedures, 1989.

26. American Conference of Government Industrial Hygienists, Guide to Occupational Exposures Values-1993, ISBN:1-882417-07-0, 1994.

27. 10 CFR 100, Reactor Site Criteria.

28. DOE Emergency Management Guide for Hazards Assessment, June 2, 1996.

Table 3.3-1, Off-site Accident Risk Evaluation Guidelines

Description	Estimated Annual Likelihood of Occurrence	Description	Radiological Guidelines	Nonradiological Guidelines
Normal operations	$1 \geq p > 10^{-1}$			
Anticipated	$10^{-1} \geq p \geq 10^{-2}$	Incidents that may occur several times during the lifetime of the facility. (Incidents that commonly occur)	≤ 2.5 rem (25 mSv)	≤ PEL-TWA or TLV-TWA
Unlikely	$10^{-2} \geq p > 10^{-4}$	Accidents that are not anticipated to occur during the lifetime of the facility. Natural phenomena of this probability class include: Uniform Building Code-level earthquake, 100-year flood, maximum wind gust, etc.	≤ 6.5 rem (65 mSv)	≤ TOX-1(1)
Extremely Unlikely	$10^{-4} \geq p > 10^{-6}$	Accidents that will probably not occur during the life cycle of the facility.	≤ 25 rem (250 mSv)	≤ TOX-2(2)
Beyond Extremely Unlikely	$10^{-6} \geq p$	All other accidents.		

(1) TOX-1 Alternative Guidelines
ERPG1
PEL-STEL
TLV-STEL
TLV-TWA*3

(2) TOX-2 Alternative Guidelines
ERPG2
EEGL (60 min.)
PEL-C
TLV-C
TLV-TWA*5

Table 3.3-2, On-site Accident Risk Evaluation Guidelines

Description	Estimated Annual Likelihood of Occurrence	Description	Radiological Guidelines	Nonradiological Guidelines
Normal operations	$1 \geq p\ 10^{-1}$			
Anticipated	$10^{-1} \geq p \geq 10^{-2}$	Incidents that may occur several times during the lifetime of the facility. (Incidents that commonly occur)	≤ 5 rem (50 mSv)	TOX 1
Unlikely	$10^{-2} \geq p > 10^{-4}$	Accidents that are not anticipated to occur during the lifetime of the facility. Natural phenomena of this probability class include: Uniform Building Code-level earthquake, 100-year flood, maximum wind gust, etc.	≤ 25 rem (250 mSv)	TOX 2
Extremely Unlikely	$10^{-4} \geq p > 10^{-6}$	Accidents that will probably not occur during the life cycle of the facility.	≤ 100 rem (1.0 Sv)	TOX 3
Beyond Extremely Unlikely	$10^{-6} \geq p$	All other accidents.		

(1) TOX-1 Alternative Guidelines
ERPG1
PEL-STEL
TLV-STEL
TLV-TWA*3

(2) TOX-2 Alternative Guidelines
ERPG2
EEGL (60 min.)
PEL-C
TLV-C
TLV-TWA*5

(3) TOX-3 Alternative Guidelines
EEGL (30 minute)
IDLH

Table 3.3-3, Toxicological Guidelines for Derivation of TOXs Page 1 of 2

Substance	TLV - TWA (mg/m^3)	TLV - STEL/C (mg/m^3)	PEL - TWA (mg/m^3)	PEL - STEL/C (mg/m^3)	IDLH (mg/m^3)	EEGL (mg/m^3)	ERPG 1 - 2 - 3 (mg/m^3)
Asbestos	2 f/cc	n/a	.2 f/cc	1 f/cc (30min)	n/a	n/a	n/a
Beryllium	0.002	n/a	0.002	0.005	10	n/a	1 - 0.005 2 - 25 3 - 100
Cadmium	0.002	n/a	0.005	n/a	50	n/a	n/a
Lead	0.15	n/a	0.05	n/a	700	n/a	n/a
Butyl Alcohol	n/a	152	300	150	24,640	n/a	n/a
Carbon Tetrachloride	31	63	12.6	n/a	1,917	n/a	1 - 95 2 - 159 3 - 1917
Mercury	0.025	n/a	0.05	0.1	28	.2 (24 hour)	1 - 0.15 2 - 0.2 3 - 28
Methyl Alcohol	262	328	260	310	33,250	266	1 - 266 2 - 266 3 - 532
Methylene Chloride	174	n/a	500	1,000	21,000	n/a	n/a
Chloroform	10	n/a	2	50	5,000	500	1-100 2-1,000 3-5,000
1,1,2,2-Tetrachloroethane	6.9	n/a	35	n/a	1,505	n/a	n/a
Trichloroethylene	n/a	n/a	50	200	1,000	n/a	1-100 2-500 3-1,000
Polychlorinated Biphenyl (PCB)	0.5	n/a	0.5	n/a	10	n/a	n/a

Notes to Table:

EEGL is a concentration of a substance in air that has been judged by the Department of Defense to be acceptable for the performance of specific tasks by military personnel during emergency conditions lasting 1 to 24 hours. EEGL dosages may produce transient central nervous system effects and eye or respiratory irritation, but nothing serious enough to prevent response to emergency conditions.

Threshold limit values (TLVs) have been defined to include various levels of exposure to worker populations. TLVs are published by the American Conference of Governmental Industrial Hygienists (ACGIHs).

TLV-TWA: Threshold limit value-Time-weighted average for a specific substance defines the limit of acceptable concentration to which most workers can be exposed for up to a normal eight-hour day and a 40-hour week without adverse effect. As with other TLV values, the population that comprises the general public differs from the population defined for TLVs in that the general public includes additional groups such as children, elderly persons, and hospitalized patients.

TLV-STEL: Threshold limit value-Short-term exposure limit is a time weighted average concentration to which workers should not be exposed for longer than 15 minutes and which should not be repeated more than four times per day, with at least 60 minutes between successive exposures. Whereas the TLV-TWA is useful for chronic exposure effects, the TLV-STEL addresses effects of Short-term, high-level exposures. As with other TLV values, the population that comprises the general public differs from the population defined for TLVs in that the general population includes additional groups such as children, elderly persons, and hospitalized patients.

Table 3.3-3, Toxicological Guidelines for Derivation of TOXs Page 2 of 2

TLV-C: Threshold Limit Value-Ceiling is the concentration in air that should not be exceeded during any part of the working exposure, for the work population. Ceiling limits may be used with other TLVs or independently. As for other TLV values, the population that comprises the general public differs from the working population since it includes additional groups such as children, elderly persons, and hospitalized patients.

PELs have been developed by the Occupational Safety and Health Administration (OSHA) as a measure for safe and healthful working conditions for men and women employed in any business engaged in commerce in the United States. As with other exposure limits developed for industrial applications, limitations exist with respect to applicability to the general population. PEL is an exposure limit established by OSHA. PEL-C is the concentration that shall not be exceeded during any part of the workday exposure.

SPEGL-Short-term Public Emergency Guidance Level is an acceptable ceiling concentration for a single, unpredicted short-term exposure to the public. The exposure period is usually calculated to be one hour or less and never more than 24 hours. Five SPEGLs have been developed by the USNRC Committee on Toxicology and are generally set at between 0.1 and 0.5 of EEGL values.

IDLH levels have been developed to define concentrations of materials from which workers should evacuate within 30 minutes without escape-impairing symptoms or any irreversible health effect. As IDLH values were developed by the National Institute for Occupational Safety & Health (NIOSH) for industrial application, their usefulness for application to the general population is limited. IDLH is a NIOSH definition.

ERPGs are published by the AIHA These are intended to provide airborne concentration levels to which most individuals (in a community) could be exposed for periods up to one hour without experiencing adverse effects as defined by the ERPG level. These guidelines are intended for emergency response applications. ERPG designations are:

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

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

ERPG-1: The maximum airborne concentration to which nearly all individuals could be exposed for up to one hour without experiencing or developing health effects (i.e., more severe than sensory perception or mild irritation, if relevant).

a. There is no IDLH identified for asbestos. TLV for asbestos is set by the number of asbestos fibers. The TLV-TWA (per OSHA permissible exposure limits) is 0.2 fibers longer than 5 micrometers and with a length to diameter ratio of at least 3:1.

b. Conversion to fibers/cc and calculation of fraction of TLV: The asbestos release is assumed to be chrysotile, the most common form of asbestos. The density of chrysotileis 1.55 gm/cc (or 1.55E+09 mg/m^3). Fibers of respirable size would be approximately 10 microns long by 3.3 microns in diameter. Using the expression that volume equals (π/4)x(diameter squared) x (length), the volume of a fiber is then 8.5E-17 m^3. The volume multiplied by the density gives the mass as 1.3E-07 mg per fiber. Using the concentration in mg/m^3 at each receptor and converting to fibers/cc will allow a comparison of the asbestos released to the appropriate TLV.

   Fibers/cc = (Asbestos concentration mg/m^3)(1 fiber/1.3 x 10^{-7}mg)(1m^3/1.0 x 10^6cc)

c. C denotes ceiling value.

This page intentionally blank

FACILITY DESIGN AND OPERATION
TABLE OF CONTENTS

SECTION TITLE PAGE NO.

FACILITY DESIGN AND OPERATION
TABLE OF CONTENTS

SECTION TITLE PAGE NO.

FACILITY DESIGN AND OPERATION
TABLE OF CONTENTS

SECTION TITLE PAGE NO.

FACILITY DESIGN AND OPERATION
LIST OF FIGURES

FACILITY DESIGN AND OPERATION
LIST OF FIGURES

FACILITY DESIGN AND OPERATION
LIST OF TABLES

FACILITY DESIGN AND OPERATION

This Chapter provides an overview of (1) the design of the WIPP facility and associated principal structures, systems, and components (SSCs), and (2) the waste handling/emplacement process. Sufficient detail is provided to facilitate hazard identification and principal design and safety criteria selection.

As discussed in the General Plant Design Description[1] (GPDD), no Design Class I SSC exists at the WIPP. Design information is provided in this chapter only for those SSCs listed in Table 4.1-1 that have been designated as Design Class II, and IIIA in the GPDD. Design Class IIIB SSCs are briefly described only to the extent necessary to complete the overview of the facility design and operation. Detailed design information on each SSC may be found in the respective System Design Description (SDD).

4.1 Summary Description

The WIPP facility is located in Eddy County about 26 miles east of Carlsbad, New Mexico, encompassing 10,240 acres (16 sections) within the site boundary (Figure 4.1-1).

The controlled zones and associated fenced-in areas are described in Chapter 2. The facility is divided into three basic groups: surface structures, shafts, and subsurface structures, shown on Figures 4.1-2a, 4.1-2b, and 4.1-3.

The WIPP facility surface structures accommodate the personnel, equipment, and support services required for the receipt, preparation, and transfer of waste from the surface to the underground. The surface structures are located in an area (approximately 35 acres) within a perimeter security fence (Figure 4.1-2a). WIPP surface traffic flow is shown in Figure 4.1-2a.

The vertical shafts extending from the surface to the underground horizon are the waste shaft, the salt handling (SH) shaft, the exhaust shaft, and the air intake shaft (AIS). These shafts are lined from the shaft collar to the top of the salt formation (about 850 ft [259 m] below the surface), and are unlined through the salt formation. The shaft lining is designed to withstand the full piezometric water pressure associated with any water-bearing formation encountered.

The subsurface structures consist of the waste disposal area, the support area, and the experimental area (Figure 4.1-3). The experimental area was deactivated in September 1996.

References for Section 4.1

1. U.S. Department of Energy, Waste Isolation Pilot Plant, General Plant System Design Description (GPDD), Revision 2, April 1997.

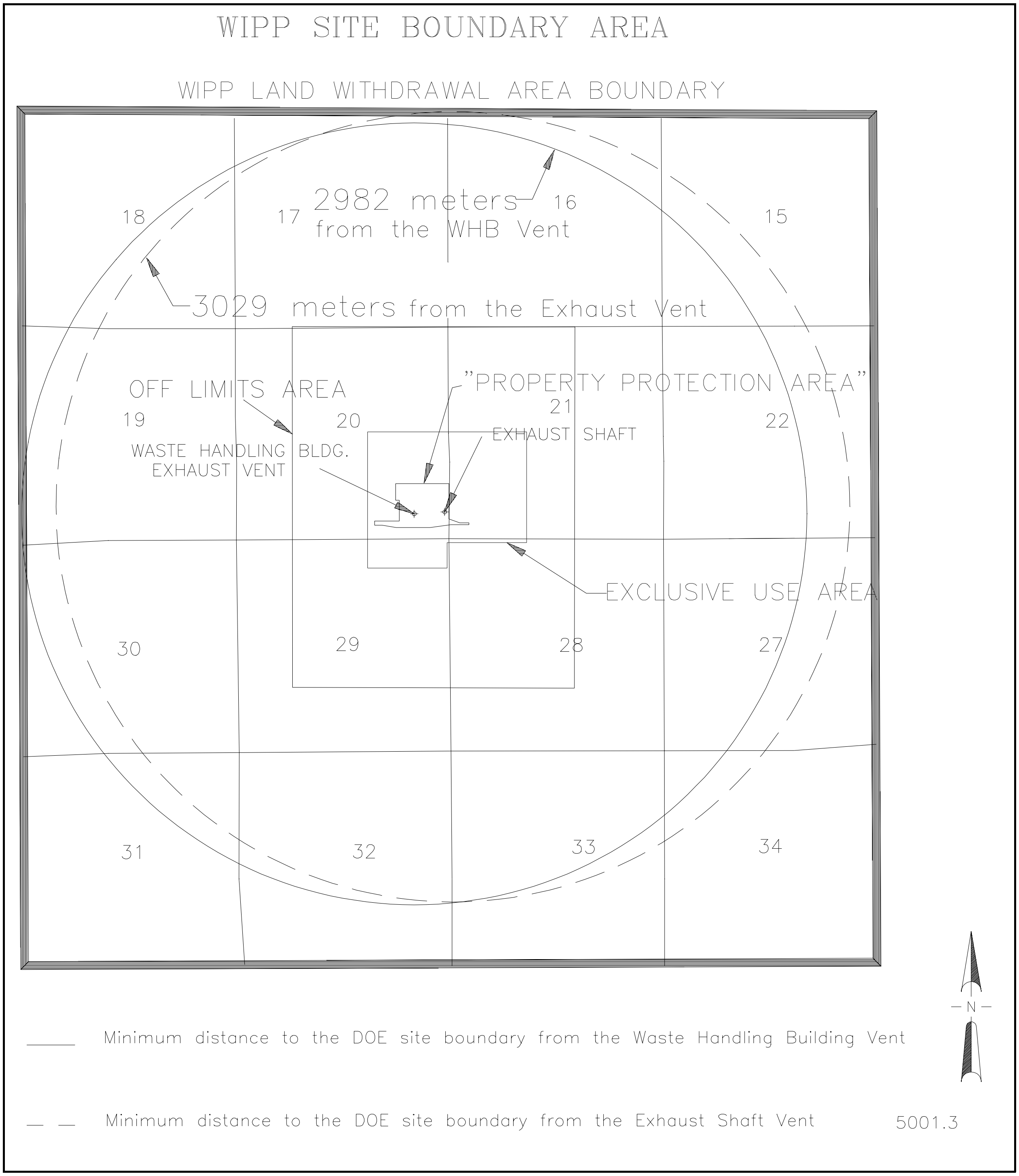


Figure 4.1-1, WIPP Site Boundary and Subdivisions

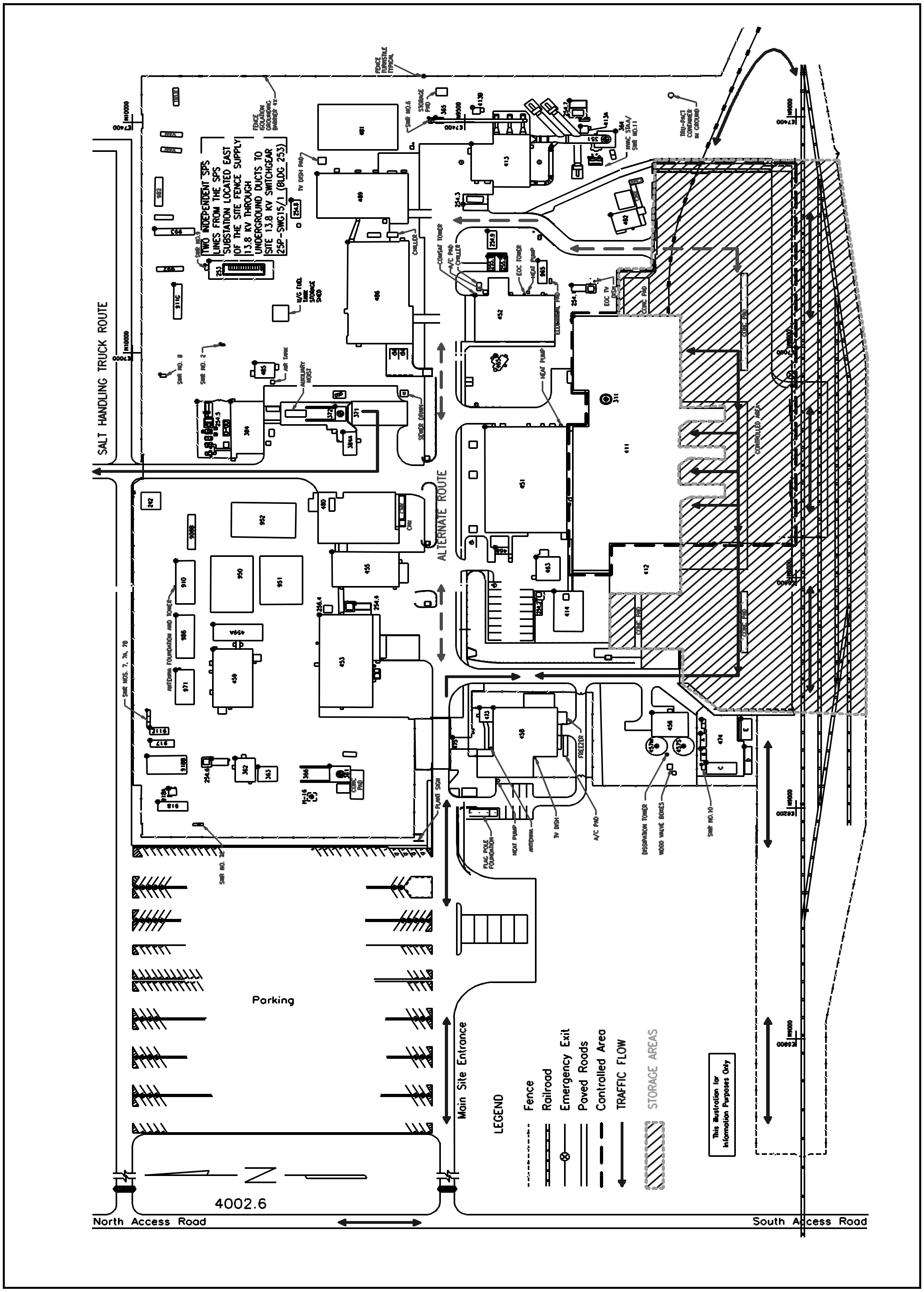


Figure 4.1-2a, WIPP Surface Structures

BLDG./ FAC. #	DESCRIPTION
242	NORTH GATEHOUSE
253	13.8 KV SWITCHGEAR 25P-SWG15/1
254.1	AREA SUBSTATION NO.1 25P-SW15.1
254.2	AREA SUBSTATION NO.2 25P-SW15.2
254.3	AREA SUBSTATION NO.3 25P-SW15.3
254.4	AREA SUBSTATION NO.4 25P-SW15.4
254.5	AREA SUBSTATION NO.5 25P-SW15.5
254.6	AREA SUBSTATION NO.6 25P-SW15.6
254.7	AREA SUBSTATION NO.7 25P-SW15.7
254.8	AREA SUBSTATION NO.8 25P-SW15.8
254.9	AREA SUBSTATION NO.9 25P-SW15.9
255.1	BACKUP GENERATOR #1 25-PE 503
255.2	BACKUP GENERATOR #2 25-PE 504
311	WASTE SHAFT
351	EXHAUST SHAFT
361	AIR INTAKE SHAFT
362	AIR INTAKE SHAFT/HOIST HOUSE
363	AIR INTAKE SHAFT/WINCH HOUSE
364	EFFLUENT MONITORING INSTRUMENT SHED A
365	EFFLUENT MONITORING INSTRUMENT SHED B
366	AIR INTAKE SHAFT HEADFRAME
371	SALT HANDLING SHAFT
372	SALT HANDLING SHAFT HEADFRAME
384	SALT HANDLING SHAFT HOISTHOUSE
384A	SALT HOIST OPERATIONS
411	WASTE HANDLING BUILDING
412	TRUPACT MAINTENANCE FACILITY
413	EXHAUST FILTER BUILDING
413A	EFFLUENT MONITORING ROOM A
413B	EFFLUENT MONITORING ROOM B
414	WATER CHILLER FACILITY & BLDG
451	SUPPORT BUILDING
452	SAFETY & EMERGENCY SERVICES FACILITY
453	WAREHOUSE/SHOPS BUILDING
455	AUXILLIARY WAREHOUSE BUILDING
456	WATER PUMPHOUSE

BLDG./ FAC. #	DESCRIPTION
457N	WATER TANK 25-D-001A
457S	WATER TANK 25-D-001B
458	GUARD AND SECURITY BUILDING
459	CORE STORAGE BUILDING
459A	SANDIA ANNEX
463	COMPRESSOR BUILDING
465	AUXILIARY AIR INTAKE
468	TELEPHONE HUT
473	ARMORY BUILDING
474	HAZARDOUS WASTE STORAGE FACILITY
474A	HAZARDOUS WASTE STORAGE BUILDING
474B	HAZARDOUS WASTE STORAGE BUILDING
474C	OIL & GREASE STORAGE BUILDING
474D	GAS BOTTLE STORAGE BUILDING
474E	HAZARD MATERIAL STORAGE BUILDING
474F	WASTE OIL RETAINER
475	GATEHOUSE
480	VEHICLE FUEL STATION
481	AUXILIARY WAREHOUSE
482	EXHAUST SHAFT HOIST EQUIP. WAREHOUSE
485	COMPRESSOR BUILDING
486	ENGINEERING BUILDING
489	TRAINING BUILDING
H-16	SANDIA TEST WELL (NOT IDENTIFIED)
908B	HBS TRAILER
910	ENVIRONMENTAL MONITORING TRAILER
911G	SANDIA OFFICES TRAILER

BLDG./ FAC. #	DESCRIPTION
917	AIS MONITORING
918	VOC TRAILER
918A	VOC AIR MONITORING STATION
918B	VOC LAB TRAILER
950	WORK CONTROL TRAILER
951	PROCUREMENT / PURCHASING
952	TRAILER (7-PLEX)
965	SAMPLE PREPARATION LAB
971	HUMAN RESOURCES TRAILER
982	TRAILER
986	PUBLICATIONS & PROCEDURES TRAILER
992	SANDIA CALIBRATION LAB TRAILER
993	SANDIA OFFICES TRAILER
SWR NO.1	SWITCHRACK NO. 1
SWR NO.2	SWITCHRACK NO. 2
SWR NO.3	SWITCHRACK NO. 3
SWR NO.6	SWITCHRACK NO. 6
SWR NO.7,7A,7B	SWITCHRACK NO. 7, 7A, 7B
SWR NO.7C	SWITCHRACK NO. 7C
SWR NO.8	SWITCHRACK NO. 8
SWR NO.9	SWITCHRACK NO. 9
SWR NO.10	SWITCHRACK NO. 10
SWR NO.11	SWITCHRACK NO. 11

4003.8

This illustration for Information Purposes Only

Figure 4.1-2b, Legend for Figure 4.1-2a

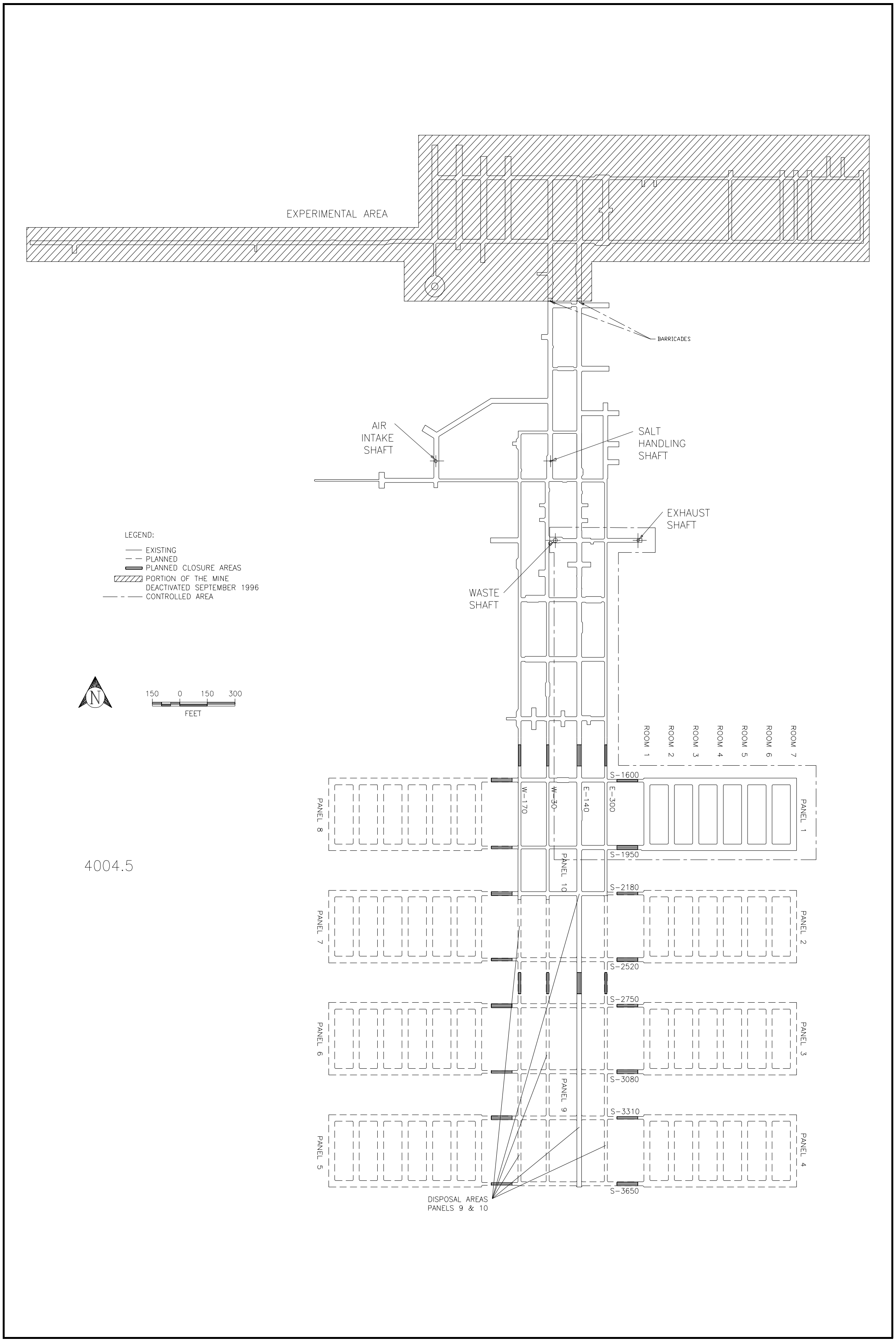


Figure 4.1-3, Planned Disposal Horizon

Table 4.1-1, Design Classes of Structures, Systems, and Components at the WIPP Facility **Page 1 of 5**

System/Component	Design Class (Note 1)	Seismic/Tornado Design Requirements	Design Class Function
COMPRESSED AIR SYSTEM (SDD-CAOO)			
High Efficiency Particulate Air (HEPA) filters for Support Building compressors	II		Control of radioactive effluent from entering the compressed air system
PLANT BUILDINGS, FACILITIES, AND MISCELLANEOUS EQUIPMENT (SDD-CFOO)			
Waste Handling Building structure and structural components including tornado doors (Bldg. 411)	II	Design Basis Earthquake (DBE), Design Basis Tornado (DBT)	Provide physical confinement
Auxiliary Air Intake Shaft and Tunnel (Bldg 465)	II	DBE, DBT	Failure could prevent mitigation
Station A Effluent Monitoring Instrument Shed (Bldg 364)	II	DBE, DBT	Design Class Interface. (Houses Station A)
Effluent Monitoring Rooms A and B (Building 413A and 413B)	II	DBE, DBT	Design Class Interface. (Houses Local Processing Units (LPU)s collecting data from Stations A and B)
Station B Effluent Monitoring Instrument Shed (Bldg 365)	IIIA	Uniform Building Code (UBC)	Design Class Interface. (Houses monitoring equipment for Exhaust Filter Building duct)
Support Building (Bldg 451)	IIIA	UBC (Note 2)	Design Class Interface. (Houses Central Monitoring Room (CMR)
Exhaust Filter Building (Bldg 413)	IIIA	UBC	Design Class Interface. (Houses Exhaust Filtration System)
EFB HEPA Filter Units & Isolation Dampers	II		Failure could prevent mitigation
EFB Exhaust System	IIIA		Failure could prevent mitigation
Building 412 (Originally TRUPACT Maintenance Facility)	IIIA	UBC (Note 2)	Design Class Interface. (Structural interface with WHB)

Table 4.1-1, Design Classes of Structures, Systems, and Components at the WIPP Facility Page 2 of 5

System/Component	Design Class (Note 1)	Seismic/Tornado Design Requirements	Design Class Function
PLANT MONITORING AND COMMUNICATION SYSTEM (SDD-CMOO)			
Central Monitoring System	IIIA		Monitors important facility parameters
ELECTRICAL SYSTEM (SDD-EDOO {Surface and Underground})			
Diesel Generator and associated equipment	IIIA		Provides backup power to Design Class II and IIIA items
ENVIRONMENTAL MONITORING SYSTEM (SDD-EM00)			
Volatile Organic Compound (VOC) Monitoring Equipment and sub-systems	IIIA		Monitors release of VOCs
HEATING, VENTILATION, AND AIR CONDITIONING (HVAC) SYSTEM (SDD-HV00)			
Exhaust Filtration System	II		Design Class Interface. (Control of radioactive effluent)
HEPA Filters	II		Control of radioactive effluent
Tornado Dampers	II	DBE, DBT	Control of radioactive effluent
Exhaust Systems HV01 (Bldg 411, CH HVAC), HV02, (Bldg 411, RH HVAC), and HV04 (Station A and Bldg 413, Exhaust Filter Building HVAC)	IIIA		Design Class Interface. (Provide filtration and maintain differential pressure)
HVAC for the CMR	IIIA		Design Class Interface. (Maintains acceptable CMR environment)

Table 4.1-1, Design Classes of Structures, Systems, and Components at the WIPP Facility **Page 3 of 5**

System/Component	Design Class (Note 1)	Seismic/Tornado Design Requirements	Design Class Function
RADIATION MONITORING SYSTEM (SDD-RM00)			
Stations A3, B2 and C (including the UPSs)	II	DBE, DBT	Monitors radioactive effluents
The remainder of the RMS SSCs (except PV00 equipment which is IIIB) are Design Class IIIA	IIIA		Monitors radioactive effluents
UNDERGROUND HOIST SYSTEM (SDD-UH00)			
Waste Hoist and Equipment	IIIA	(Note 3)	Failure could cause radioactive material release
UNDERGROUND VENTILATION SYSTEM (SDD-VU00)			
Exhaust duct elbow at the top of the Exhaust Shaft	II	DBE, DBT	Design Class Interface. (Channels exhaust air to the EFB)
HEPA Filters and Isolation Dampers	II		Control of radioactive effluent
Exhaust Fans for the filtration mode	II		Design Class Interface. (Channels exhaust air through the EFB)
Exhaust System Instruments and Hardware	IIIA		Design Class Interface. (Supports Exhaust Filtration System)
(6) High Pressure Fans for Bulkhead 309 (Pressure Chamber)	IIIA		Maintain buffer zone between RMA and non-RMA
WASTE HANDLING EQUIPMENT (SDD-WH00)			
6-ton TRUDOCK cranes	IIIA	DBE	Failure could cause radioactive materials release
Adjustable Center-of-Gravity Lift Fixtures (ACGLF's)	IIIA		Failure could cause radioactive materials release
TRUPACT-II tools	IIIA	(Note 6)	Failure could cause radioactive materials release
Leak check tools for TRUPACT-II	IIIA	(Note 6)	Failure could cause radioactive materials release
TRUPACT-II Lift Fixture (Non ACGLF)	IIIA		Failure could cause radioactive materials release

Table 4.1-1, Design Classes of Structures, Systems, and Components at the WIPP Facility **Page 4 of 5**

System/Component	Design Class (Note 1)	Seismic/Tornado Design Requirements	Design Class Function
Strongback Lifting Fixture (CH)	IIIA		Failure could cause radioactive materials release
SWB Lift Fixture Adapter	IIIA		Failure could cause radioactive materials release
TDOP Lift Fixture Adaptor	IIIA		Failure could cause radioactive materials release
SWB forklift Lift Fixture	IIIA		Failure could cause radioactive materials release
TRUDOCK Vent Hood System	IIIA		Failure could prevent mitigation
Facility Cask	II	(Note 4)	Provides permanent shielding
Telescoping Port Shield	II	UBC (Note 5)	Provides permanent shielding
Shield Bell	II	(Note 5)	Provides permanent shielding
Shield Valve	II	(Note 5)	Provides permanent shielding
Hot Cell Viewing Windows	II	(Note 5)	Provides permanent shielding
Transfer Drawer	II	UBC (Note 5)	Design Class Interface. (Provides permanent shielding)
140/25 ton crane	IIIA	UBC (Note 7)	Failure could cause radioactive materials release
Cask Lifting Yoke	IIIA		Failure could cause radioactive materials release
Facility Cask Loading Room Hoist	IIIA		Failure could cause radioactive materials release
Facility Grapples	IIIA		Failure could cause radioactive materials release
The Horizontal Emplacement and Retrieval Equipment (HERE)	IIIA		Failure could cause radioactive materials release
Hot Cell 15-ton Bridge Crane Bridge Mounted Manipulator PAR 6000	IIIA IIIA	(Note 7) (Note 8)	Failure could cause radioactive materials release Failure could cause radioactive materials release
Master-Slave Manipulator	IIIA		Failure could cause radioactive materials release

Table 4.1-1, Design Classes of Structures, Systems, and Components at the WIPP Facility **Page 5 of 5**

System/Component	Design Class (Note 1)	Seismic/Tornado Design Requirements	Design Class Function
Overpack Welder Equipment	IIIA		Failure could cause radioactive materials release
Grapple Rotating Block	IIIA		Failure could cause radioactive materials release
Canister Shuttle Car	IIIA		Failure could cause radioactive materials release

Notes

Note 1 See Table 3.1-2 for Basic Design Requirement and Table 3.2-3 for the Design Loads.
Note 2 The main lateral force resisting members of the Support Building and Building 412 are designed for DBE and DBT to protect the Waste Handling Building from their structural failure.
Note 3 Design loads and requirements dictated by Mine Safety and Health Administration (MSHA).
Note 4 Cask certification requirements exceed DBT/DBE.
Note 5 System completely within a Class II confinement - DBE/DBT not required.
Note 6 TRUPACT-II Design included in Safety Analysis Report for Packaging (SARP).
Note 7 Designed to hold load in place in the event of a DBE.
Note 8 Supports designed to prevent manipulator from falling during DBE.

This page intentionally blank

4.2 Facility Design

4.2.1 Surface Structures

WIPP's structures provide for the handling and subsequent underground emplacement of Transuranic (TRU) waste. Surface waste handling operations are conducted within a controlled area (CA). The normal extent of the CA for simultaneous contact handled (CH) and remote handled (RH) waste handling activities is depicted in Figure 4.1-2a. Operational Health Physics (OHP) will determine specific boundary locations and posting requirements for CAs, as required by scheduled waste handling activities and radiological conditions inside the Waste Handling Building (WHB). The CA external to the WHB provides for the receipt, storage, and dispatch of rail- or truck-transported radioactive waste shipping containers. OHP will determine specific boundary locations and posting requirements for the external CA consistent with scheduled activities.

The TRUPACT-II CH TRU shipping containers are removed from their transporters outside of the WHB prior to transfer into the WHB. RH TRU waste shipments, including the transporter trailer and shielded road cask shipping containers, are transferred into the WHB for subsequent operations.

The land areas around the surface buildings are designed to minimize erosion. Runoff water is diverted as necessary from the buildings, tracks, or roads and returned to the natural drainage path.

The WIPP facility does not lie within a 100-year floodplain. There are no major surface-water bodies within 5 mi (8 km) of the site, and the nearest river, the Pecos River, is approximately 12 mi (19.3 km) away. The general ground elevation in the vicinity of the surface facilities (approximately 3,400 ft [1,036 m] above mean sea level) is about 500 ft (152 m) above the riverbed, and 400 ft (122 m) above the 100-year floodplain. Protection from flooding or ponding caused by probable maximum precipitation (PMP) events is provided by the diversion of water away from the WIPP facility by a system of peripheral interceptor diversions. Additionally, grade elevations of roads and surface facilities are designed so that storm water will not collect on the site under the most severe conditions. Repository shafts are elevated at least 6 inches (15.2 cm) to prevent surface water from entering the shafts. The floor levels of all surface facilities are above the levels for local flooding due to PMP events.

The WIPP site is regulated by a National Pollutant Discharge Elimination System (NPDES) Storm Water General Permit. Facilities at the WIPP site have been constructed to contain or control storm water discharges; these include retention basins and storm water diversion berms. The site water tanks (two 180,000 gal [681354 L]) are located at the southwest corner of the property protection area, the topography of the site includes a sloping terrain to this corner of the site. There is a catch basin to the west of the water tanks, which is designed with adequate capacity (approximately 4.5 acres; approximately .25 acre/ft depth for failure of both tanks) to hold runoff from a failure of the water tanks.

4.2.1.1 Waste Handling Building

The WHB and its associated systems provide a facility to unload TRU waste from the incoming shipping containers and to transfer the TRU waste to the underground disposal area via the waste shaft. The WHB is divided into the following functional areas: the CH TRU waste handling area, the RH waste handling area, the WHB support area, Building 412, and the WHB mechanical equipment room. The general layout of the building is shown in Figure 4.2-1a and Figure 4.2-1b, with sectional views shown in Figure 4.2-3. Details of the hot cell area are given in Figure 4.2-4a, Figure 4.2-4b, and Figure 4.2-4c.

The WHB is a steel frame structure with insulated steel siding, and includes portions of the building, such as the hot cell complex, that are constructed of concrete for shielding and structural purposes. The WHB acts as a confinement barrier to control the potential for release of radioactive material and is classified as Design Class II. The WHB is designed for Design Class II loads, including the Design Basis Earthquake (DBE) and Design Basis Tornado (DBT). Waste handling areas subject to potential for contamination are provided with impermeable protective coatings. The WHB Confinement/Ventilation System is discussed in detail in Section 4.4, the Safety Support Systems in Section 4.5, and the Utility/Auxiliary Systems in Section 4.6.

4.2.1.1.1 CH TRU Waste Handling Area

The CH TRU side of the WHB has space and equipment for the unloading of TRUPACT-II shipping containers and enables the transfer of facility pallets and waste containers to the waste hoist for transfer underground. Waste transport routes to the WHB are shown in Figure 4.2-2. This area has air locks, CH Bay, and an unassigned area.

Entrance Air Locks

TRUPACT-II shipping containers are unloaded from the transport trailers in the CA external to the WHB and are transferred into the CH Bay area through the three air locks that provide access to the CH TRU side of the WHB. The WHB ventilation system maintains the interior of the WHB at a pressure lower than the ambient atmosphere to ensure air flows into the WHB, preventing the inadvertent release of airborne hazardous or radioactive materials. To assist the HVAC in maintaining the building at a negative pressure, the doors at each end of the air lock are interlocked to prevent inadvertent opening of both doors at the same time and thereby increasing CH Bay pressure.

CH Bay

The CH Bay on the CH TRU side of the WHB is used for surface CH TRU waste handling operations. To accommodate the TRUPACT-II shipping containers, the WHB is equipped with two TRUDOCKS (Design Class IIIB) and two overhead cranes for opening and unloading the TRUPACT-II shipping containers (Figure 4.2-5). Each TRUDOCK is designed to accommodate up to two TRUPACT-IIs. The TRUDOCK functions as a work platform, providing easy access to the TRUPACT for unloading.

The CH Bay also provides space for transferring loaded facility pallets to the waste hoist via forklifts, a shielded holding area, a waste handling equipment battery recharge area, and temporary storage areas for waste containers.

Storage locations are provided within the CH Bay for equipment, facility pallets, and TRUPACT-II drum pallets. Temporary waste storage within the WHB is discussed in Section 4.3. The shielded holding area may provide for surface holding of CH TRU waste containers during operational interruptions. The shielded holding area can accommodate one facility pallet load (i.e., 4 SWBs, 2 TDOPs, 28 drums, or combinations of all three).

TRUDOCK 6 TON CRANE

Each TRUDOCK is serviced by a 6 ton overhead crane that is used to transfer the TRUPACT-II outer containment vessel (OCV) and inner containment vessel (ICV) lids to their individual support stands, and the payload waste containers to the facility pallet. The cranes are Design Class IIIA and are identical having a single girder, underhung bridge, trolley, and wire rope hoist (Figure 4.2-6).

Each crane is controlled by its individual pendant control. The TRUDOCK crane is designed to hold its load in place in the event of a DBE or loss of power. Overhead cranes used in waste handling operations are certified to lift their rated capacity, and load tested to 125 percent of maximum rated lift. The crane control system allows the operator to lift and transfer the load by manual control or by use of an automatic, programmed control system which first lifts the waste assemblies vertically off the TRUDOCK via the shortest route horizontally to the location of the pallet. The cranes use specially designed lifting and load balancing fixtures, adjustable center-of-gravity lift fixture (ACGLF), SWB lifting assembly, TDOP lifting assembly and short and long lifting leg sets. The ACGLF also includes three electrical actuator motors and arms to rotate the lifting legs into their locking lift positions. The control system has limit switches with lights to indicate that each lifting leg has rotated to attach to the lifting pins. The following are the crane's motor ratings:

Drive	Horse Power	RPM	Operating Speed (FPM)	Travel
Hoist	7	1800	20	20 ft (6.1 m)
Trolley	½	1800	50	26 ft (7.9 m)
Bridge	1	1800	50	47 ft 4 in (14.4 m)

TRUDOCK Exhaust System

Each TRUDOCK has an exhaust system with two working stations, and each station consists of two sub-systems: (1) the TRUDOCK Vent Hood System (TVHS) (Design Class IIIA), and (2) the TRUDOCK Vacuum System . Both sub-systems are routed through industrial grade HEPA filters before entering the CH Bay exhaust system (which is also HEPA filtered before discharging to the atmosphere). (See Figures 4.2-7 and 4.2-8).

The TVHS consists of an enclosure which is installed over the TRUPACT-II ICV lid and the TRUPACT-II body before the lid is removed. The enclosure is connected to the exhaust system before the lid is removed, thus ensuring that any potential radioactive contamination will be passed through a system industrial grade HEPA filter.

The TRUDOCK Vacuum System is used to evacuate the TRUPACT-II OCV or ICV to pull the outer or inner lid down to assist in lid removal. The vacuum system inlet is connected by flexible tubing, using quick disconnect fittings, to the appropriate TRUPACT-II ICV or OCV vent port tool. A radiation assessment filter in the inlet line is used when evacuating the TRUPACT-II ICV. This process also discharges into the WHB controlled exhaust system.

Adjustable Center-of-Gravity Lift Fixture

The ACGLF (Design Class IIIA) is used with a TRUDOCK crane to lift the OCV and ICV lids, an empty ICV, or the payload waste containers out of the TRUPACT-II. The ACGLF has a lift capacity of 10,000 lb (4,542 kg) and weighs approximately 2,500 lb (1134 kg) (Figure 4.2-9). The ACGLF is designed as follows:

- The lower strongback assembly (carbon steel lifting beam structure) has three revolving joints, 120 degrees apart, to which the lifting legs are attached.

- Three linear actuators mounted on the underside of the lower strongback, provide the linear motion for each of the lifting leg revolving mechanisms which connect the lifting legs to the load.

- Two rotating weights to balance the load to be lifted are mounted on a circular upper plate assembly. The rotating weights are attached to two counter-rotating ring gears which are independently driven by gear motors.

- Two 1/4 HP, 115 Vac, single phase gear motors drive the counter-rotating ring gears that position the rotating weights around the circumference of the upper plate assembly.

- Three short lifting legs lift the OCV and ICV lids, empty ICV, or SWBs (when lifted with an SWB lift fixture adapter), and three long lifting legs lift a 14 drum pay load pallet. The bottom of the lifting legs are designed to engage a horizontal lifting bar in the lifting pockets of the OCV and ICV lids, SWB lift fixture adapter, and drum shipping pallet when the lifting leg is rotated into position.

- Two tilt sensors provide X and Y axis tilt indication of the ACGLF.

- Two balance weight position sensors continuously provide the position of each of the two rotating weights.

- A single point lifting shackle is mounted in the center of the ACGLF for attachment to the crane.

- One control console (portable with 4 wheels) provides operator controls and indicators to monitor the balance condition of the load, and to compensate, if necessary, for load imbalance by repositioning the two counter weights.

Non-adjustable Center of Gravity Lift Fixture

This fixture (Design Class IIIA) is similar to the ACGLF in function except it has no capability for balancing the load. It can be used as a backup for the ACGLF, if no ACGLF is available, to lift the TRUPACT-II OCV and ICV lids, entire ICV, and payload waste containers (pallet with 14 drums, or 2 SWBs strapped together). The fixture has a lift capacity of 10,000 lb (4,536 kg), and a weight of 600 lb (272 kg).

SWB Lift Fixture Adapter

The SWB lift fixture adapter (Design Class IIIA) frame is made from 6 in (15.24 cm) square steel tubing with a 3/16 in (0.48 cm) wall thickness. The center base is 56.44 in (143.4 cm) long, with a lift pocket for the ACGLF at one end, and a latch assembly at the other end. Two arms extend from the center bar near the lift pocket end to support two additional latch assemblies, each located 18 in (45.72 cm) from the center line of the center bar. Two slightly longer arms extend from the center base, near the opposite end, and provide two additional lift pockets. The three lift pockets are located on a circle of 56 in (142.24 cm) diameter to match the positioning of the three legs of the ACGLF. The SWB lift fixture adapter has a rated lifting capacity of 7,500 lb (3,402 kg) and weighs 334 lb (151.5 kg) (Figure 4.2-10).

TDOP Lift Fixture Adaptor

The TDOP lift fixture adaptor (Design Class IIIA) is made from 6 in (15.24 cm) square steel tubing with a 3/13 in (0.48 cm) wall thickness and is reinforced with a 7 gauge steel plate. It consists of three legs spaced 120 degrees apart with a latch assembly on the end of each leg. The latch hinge center lines are located on a 35 in (88.9 cm) radius from the center of the assembly. In-board from the latches are sections of schedule 80 pipe welded vertically to the assembly tubing in which holes are drilled horizontally and cold rolled steel pins are welded in place. These lift pockets are located on a circle of 56 in (142.2 cm) in diameter to match the positioning of the three legs of the ACGLF. The latch assemblies, which mate with the three lifting clips on the TDOP, are engaged with the latch handles, and are locked in place with ball lock pins. The TDOP lift fixture adaptor has a rated lifting capacity of 7,000 lb (3175 kg) and weighs 300 lb (136 kg) (Figure 4.2-28).

TDOP Upender

An upender is provided to support the recovery of a damaged SWB. The overpack container for an SWB is a TDOP. The TDOP must be laid horizontally to allow a forklift to insert the SWB. The TDOP must then be returned to the vertical position to allow installation of the TDOP lid. The TDOP upender provides a rotation of 90 degrees through the use of a mechanical chain and double reduction gear driven by an electrical motor.

The upender has a rated maximum capacity of 8,000 lbs (3628 kg) and a gross weight of 5920 lbs (2685 kg). Based on commercial industrial equipment commonly used to rotate large rolls of sheet metal or paper, the upender has been modified with a table sized to accommodate the TDOP. The table has a urethane coated Vee block and tie down straps to prevent a TDOP from rolling while being transported on the upender. The upender is bolted to a CH Facility Pallet prior to use to provide for stability and to allow transporting with a 13 ton forklift on the surface, an Underground Transporter, or the 20 ton forklift underground.

An amber warning beacon and horn mounted on the control enclosure activates 5 to 10 seconds prior to movement of the cradle. End of travel limit switches automatically stop the cradle in either the full up or down positions. Overtravel limit switches and hard mechanical stops prevent the cradle from rotating significantly beyond the full up or full down positions.

WHB Forklifts

There are two heavy-duty industrial 13 ton forklift trucks (Design Class IIIB). These forklift trucks are used to unload the TRUPACT-IIs from their transportation trailers (or rail cars), and move them through the WHB airlocks to support stands located in the pockets of the TRUDOCKS in the CH bay of the WHB. They are also used to move and transfer facility pallets, with or without a load of waste containers, between the CH bay and the conveyance loading car. Each of the 13 ton forklift trucks have a maximum lift height of 96 in (2.5 m). The forklift trucks' drive units use dc motors which are battery powered. The forklift trucks can operate for eight hours before the batteries have to be recharged. Each forklift truck has a high volume pump unit that supplies the fluid power for lift, tilt, and sideshift of the forks. A separate hydraulic power unit supplies fluid power for braking and steering.

Battery powered 6 ton capacity forklifts are available for use in both the WHB and underground. Diesel powered 6 ton capacity forklifts are available for use underground. The electric forklifts are equipped with push/pull attachments to handle waste containers. The diesel forklifts have push/pull attachments which can handle both waste containers and backfill super sacks. A 4 ton capacity diesel powered forklift with push/pull attachment is available and is capable of emplacing backfill super sacks on top of the waste stacks.

There is one 6 ton forklift truck (Design Class IIIB) in the CH bay of the WHB. It has a hydraulically operated side-shift positioner for shifting the load to the right or left. Either standard type forks or specially designed fixtures can be attached to the positioner for lifting different loads. The forklift truck is a standard battery powered forklift truck with a maximum lift height of 118 in (3 m).

The 6 ton forklift truck can operate for 8 hours before requiring a recharge of the batteries. It can be operated with different attachments as listed below:

- A BRUDI push/pull rack fixture with a drum handler to lift and move seven-packs of waste containers (drums).
- A single or double drum handling device.
- An SWB forklift fixture to lift and move individual SWBs.
- Two forks for lifting loads

Brudi Attachment

The Brudi attachment (Design Class IIIB) replaces the forks on the front carriage of a 6 ton forklift, and is used to handle waste containers on slipsheets (Figure 4.2-11). In normal operation, the Brudi attachment grips the edge of the slip sheet and draws the slipsheet and waste containers onto the platen for transport. When the destination is reached, the platen is positioned at the proper height, the gripper releases the slipsheet, and the linkage pushes the slip sheet and the waste containers into position.

SWB Forklift Fixture (forklifts)

One SWB forklift fixture (Design Class IIIA) is provided in the CH bay area of the WHB to lift and move SWBs with a 6 ton battery powered forklift truck. The SWB forklift fixture is basically a welded steel frame designed to be mounted and supported on the front side of a 6 ton forklift truck carriage from which the lifting forks have been removed. The fixture is a lifting accessory with a rated load lifting capacity of 4,000 lb (1,815 kg) designed specifically for lifting SWBs, and weighs 360 lb (163 kg) (Figure 4.2-12).

Facility Pallets

Facility pallets (Figure 4.2-13), (Design Class IIIB) are fabricated steel units designed to support drums, 85-gallon (321 L) overpacks, Ten-Drum Overpacks (TDOPs), or Standard Waste Boxes (SWBs), and have a rated load of 25,000 lb (11,340 kg). The facility pallets are designed with approximately 3 in (76 mm) deep pockets in the top plate of the pallet to accommodate two sets of two-high 7-packs, two stacks of two-high SWBs, two sets of two-high 4-packs of 85-gal (321 L) drums, or two TDOPs. Stacks of waste containers are secured to the facility pallet prior to transfer. Waste containers are separated by a slipsheet and a reinforcement plate, as required. Operations involving facility pallets are discussed in Section 4.3. Fork pockets in the side of the pallet allow the facility pallet to be lifted and transferred by forklift to prevent direct contact between TRU mixed waste containers and forklift tines. This arrangement reduces the potential for puncture accidents. A WIPP facility pallet can accommodate the contents of two TRUPACT-IIs. Since the maximum TRUPACT-II load is 7,265 lb (3,295 kg), the maximum weight of a loaded facility pallet is less than 19,000 lb (8,618 kg), including the pallet weight.

The Conveyance Loading Room

When a loaded facility pallet is ready to be transferred to the underground, a 13 ton forklift will transport the pallet to the conveyance loading room adjacent to the waste hoist. There the facility pallet will be loaded on the conveyance loading car in preparation for transfer to the waste hoist (Figure 4.2-1a). The conveyance loading room serves as an air lock between the CH Bay and the waste hoist shaft, preventing excessive airflow between these two areas. With the waste hoist materials platform properly positioned and prepared, the conveyance loading car will move onto the waste hoist conveyance on rails. There the facility pallet will be transferred to the waste hoist, and the conveyance loading car will be returned to the conveyance loading room.

The Conveyance Loading Car

The conveyance loading car (Design Class IIIB) is an electric vehicle that operates on rails. It is designed with a flat bed that has adjustable height capability, and will be used to transfer the facility pallets on or off the pallet support stands in the waste hoist conveyance by raising and lowering the bed (Figure 4.2.14).

<u>Waste Containers</u>

CH TRU waste containers will be equipped with filter vents. The filter vents allow aspiration, preventing internal pressurization of the container and minimizing the buildup of flammable gas concentrations, and preventing the escape of any radioactive particulates. Each container is equipped with carbon-composite filters.

Standard 55-Gallon Drums

The standard 55-gallon metal drum (Figure 4.2-15) is a Department of Transportation (DOT) Type 7A (Authorized Type A package) or equivalent, steel fabricated drum with a maximum gross weight of 1,000 lb (453.5 kg), and is constructed with a lap welded bottom and numerous lid configurations. A standard 55-gallon drum has a gross internal volume of 208 L. 55-gallon drums may be used to collect site derived waste.

Standard Waste Box (SWB)

The SWB (see Figure 4.2-16) is a DOT Type 7A (Authorized Type A package) or equivalent, steel fabricated box with a lap welded bottom, and an internally flanged bolted closure lid. The weight of an empty SWB is approximately 680 lb (308.4 kg), and the maximum gross weight of a loaded SWB is 4,000 lb (1814 kg). Four threaded couplings (two on each side of the SWB with the lifting clips) are installed in the flange for inserting a filter to provide protection from particulate leakage during shipment or build-up of internal pressure. A minimum of two filters are required on each SWB. A SWB has an internal volume of 489 gallons (1880 L).SWBs may be used to collect site derived waste.

Eighty-Five Gallon Drum Overpack

The 85-gallon (321L) drum is a DOT Type 7A (Authorized Type A package) or equivalent, steel fabricated drum. The 85-gallon (321 L) drum overpack, which is shown in Figure 4.2-17, will be used primarily for overpacking contaminated 55-gal (208 L) drums at the WIPP facility. 85-gallon (321 L) drums may be used to collect site derived waste.

Ten-Drum Overpack (TDOP)

The TDOP is a metal container, similar to a SWB, that meets DOT Type 7A (Authorized Type A package) or equivalent, and is certified to be noncombustible. The TDOP is a welded-steel, right circular cylinder, approximately 74 in (1.9 m) high and 71 in (1.8 m) in diameter (Figure 4.2-18). An unloaded TDOP weighs approximately 1,600 lbs (725.8 kg) The maximum loaded weight of a TDOP is 6,700 lb (3,039.1 kg). The TDOP has an internal volume of 1162-gal (4400 L). A bolted lid on one end is removable, sealing is accomplished by clamping a neoprene gasket between the lid and the body. Filter ports are located near the top of the TDOP. A TDOP may contain up to ten standard 55-gal (208 L) drums or one SWB. TDOPs may be used to overpack drums or SWBs containing CH TRU mixed waste.

Pipe Overpack

The pipe overpack consists of a stainless steel pipe component surrounded by cane fiberboard and plywood dunnage within a standard 55-gallon (208 L) drum with a rigid polyethylene liner and lid. The pipe container provides three significant control functions with regard to waste materials: (1) criticality control, (2) shielding, and (3) containment of waste material.

The pipe component is a stainless steel, cylindrical pipe of 1/4-inch (0.64 cm) nominal thickness, with a closed bottom cap and a bolted stainless steel lid sealed with a butyl rubber O-ring (Figure 4.2-27a and 4.2-27b). The pipe component is approximately 2 ft (61 cm) long, and is available with either a 6-inch (15.24 cm) or a 12-inch (30.48 cm) diameter. The pipe component shall be vented through a filter. The pipe component is centered in the standard 55-gallon (208 L) vented steel drum with cane fiberboard and plywood packing material.

The pipe component and pipe overpack weights are as follows:

Size	Pipe Component Maximum Content Weight lbs. (kg)	Pipe Component Maximum Gross Weight lbs. (Kg)	Pipe Overpack Maximum Gross Weight lbs. (Kg)
6-inch (15.24 cm) diameter pipe component	66 lbs. (29.9 kg)	153 lbs. (69.4 kg)	328 lbs. (148.8 kg)
12-inch (30.48 cm) diameter pipe component	225 lbs. (102 kg)	407 lbs. (184.6 kg)	547 lbs. (248.1 kg)

Material content forms authorized for transport in the pipe component are as follows:

Form No.	Description
1	Direct load: Solids, any particle size; e.g., fine powder or organic particulate
2	Direct load: Solids, large particle size; e.g., sand, concrete, or debris
3	Direct load: Large, solid objects; e.g., metal cans containing waste

4.2.1.1.2 RH TRU Waste Handling Area

The RH side of the WHB includes structures and equipment for the unloading of shielded road cask shipping containers containing RH TRU waste canisters, and transferring the canisters of RH TRU waste from the shielded road cask to a shielded facility cask via the hot cell. The major areas within the RH waste handling area are shown in Figure 4.2-1a and Figure 4.2-1b.

RH Bay

The RH Bay on the RH side of the WHB provides a cask receiving area, preparation area, maintenance station and handling equipment for RH TRU waste shielded road cask shipping containers. A 140-ton bridge crane with a 25-ton auxiliary hoist is also provided in this area for lifting the shielded road cask, and is designed to stay on its rails retaining control of the load during a DBE.

Shielded Road Cask Receiving Area

The shielded road cask receiving area provides space to unload RH shielded road casks from incoming truck or rail transporters, and to load empty shielded road casks on outgoing transporters. The overhead bridge crane is designed to lift a shielded road cask from the transporter, and to position the shielded road cask on the road cask transfer car located at the road cask preparation station. The road cask receiving area also provides lay down space for shielded road cask tie-downs, impact limiters, and other components that must be removed as part of the shielded road cask unloading operation.

Road Cask Preparation Area

The road cask preparation area provides a tracked transfer car that travels between the road cask preparation area and the road cask unloading room portion of the hot cell complex. The transfer car supports the shielded road cask, and incorporates an integral work platform, providing personnel access to the head area of the shielded road cask. Shielded road cask preparatory operations in this area include: radiological surveys, controlled venting of the shielded road cask cavities, removing the outer closure, unbolting of the inner closure, and installing a shielded road cask seal collar for mating with the seal ring in the road cask unloading room. The road cask transfer car is designed for a shielded road cask weight of up to 50,000 lbs (22,676 kg).

Road Cask Maintenance Station

The road cask maintenance station, located adjacent to the road cask preparation area, provides space and equipment for periodic shielded road cask maintenance; this area lies within the operating envelope of the overhead bridge crane. If required, this area could be used for shielded road cask decontamination activities.

Hot Cell Complex

The hot cell complex provides the required facilities and equipment necessary to transfer canisters of RH TRU waste from the shielded road cask to the shielded facility cask. Facilities included within the hot cell complex are: the road cask unloading room, the hot cell, the canister transfer cell, and the facility cask loading room. The hot cell complex is designed for a 45 rem/h (0.45 Sv/h) neutron surface dose rate and a gamma surface dose rate of 400,000 rem/h (4,000 Sv/h). Viewing windows, equivalent to hot cell wall shielding, provide nearly 100 percent visual observation of all areas within the hot cell. Supporting facilities include an operating gallery, a hot cell HEPA filter gallery, a crane maintenance room, and a manipulator repair room. Details of the hot cell complex are shown in Figure 4.2-4a, Figure 4.2-4b and Figure 4.2-4c.

Road Cask Unloading Room

The road cask unloading room is a floor-level, concrete-shielded room where the shielded road cask is transferred by the road cask transfer car. A 140-ton concrete-filled shield door at the entrance to the road cask unloading room provides radiation protection for personnel outside the room during shielded road cask unloading operations. The shield door is supported by air bearings for ease of movement and interfaces with an inflatable seal.

Access to the hot cell above the road cask unloading room is through shielded floor plugs in the hot cell. These plugs must be in place when the shielded road cask enters the cask unloading room. An interlock is provided between the road cask unloading room shield door and the hot cell grapple, and requires that the door be closed in order to operate the grapple or to handle a waste canister. The unloading room ceiling incorporates a seal ring and road cask seal collar, with an inflatable seal, that mates with the upper surface of the road cask. When the shield door is closed and sealed, and the shielded road casks are mated with the seal collar, the road cask unloading room functions as an air lock between the hot cell (including the road cavity) and the RH Bay. The hot cell is maintained at the lowest negative pressure and air leakage, if any, would be from the RH Bay through the road cask unloading room to the hot cell itself.

Hot Cell

The hot cell is a concrete-shielded room where RH waste canisters are handled following removal from the shielded road cask. The hot cell is a shielded cell, and has provisions for maintenance of installed equipment. Air locks are provided for personnel access to the hot cell, and access is permitted only when RH canisters are not present.

Two ports are located in the floor of the hot cell: (1) an 8 ft 8 in (2.64 m) diameter port which also contains a concentric 2 ft 8¼ in (0.82 m) diameter port, and which connects with the road cask unloading room; and, (2) a 5 ft (1.52 m) square port which connects with the canister transfer cell. When closed, these ports provide shielding corresponding to the level of radiation protection required by the road cask unloading room and the facility cask loading room. Position switches are used to ensure the proper closure of the canister transfer cell port. The port connecting to the road cask unloading room also allows the transfer of shielded road cask heads into the hot cell.

The hot cell contains two primary workstations: an inspection station and a welding station. Inspection of the RH canisters, including visual inspection, verification of canister identification, and contamination checks are accomplished at the inspection station. If the results of this inspection show that overpacking of the canister is required, this will be accomplished at the welding station. At the welding station, the canister is inserted into an overpack body, and the closure is welded using remotely operated welding equipment.

The hot cell is equipped with a remotely operated 15-ton bridge crane, master/slave manipulators, a bridge mounted power manipulator, a portable overpack welder, a closed-circuit television system, a shielded pass through drawer, and various storage locations supporting hot cell operations.

The overhead bridge crane, equipped with a rotating block and grapple, is used for all heavy lifting operations within the hot cell, including handling of the hot cell shield plug(s), road cask inner closures, RH canisters, and canister overpack components. This crane is designed to stay on its tracks, and to maintain control of its load in the event of a DBE or electrical failure.

The master/slave manipulators are used to conduct detailed handling operations, including contamination checks at the inspection station and support functions at the welding station. A shielded transfer drawer is used to introduce small items into the hot cell, and to allow swipe materials to be checked. The bridge-mounted manipulator is provided to accomplish those specific operations that lie between the capability of the bridge crane and the master/slave manipulators. Various storage locations are provided within the hot cell, from change-out stations for the bridge mounted power manipulator tools, to overpack canister components.

Canister Transfer Cell

The canister transfer cell is located beneath the hot cell, and transfers canisters from the hot cell to the facility cask loading room via a seven position shuttle car. The cell includes provisions for a manual override tool to be used in the event of a grapple failure or to release the grapple from an RH canister, and is operated from an area shielded from the canister transfer cell. Canisters are lowered into the shuttle car by the hot cell bridge crane through a shielded valve in the floor of the hot cell. A ceiling-mounted hoist, located in the facility cask loading room, is used to remove canisters from the shuttle car through a shield valve in the floor of the facility cask loading room.

The shuttle car has chain drives, is equipped with retainers to ensure that the car stays on its tracks, and is designed to resist a DBE. Drive components are located outside of the canister transfer cell providing easy access for maintenance.

Facility Cask Loading Room

The facility cask loading room is the final element of the RH hot cell complex, and provides for transfer of the RH canister to the facility cask, which is subsequently transferred to the waste hoist and to the underground. This is accomplished by lifting the canister from the shuttle car through a shield valve, and into a vertically oriented facility cask positioned in the facility cask loading room. The shield bell, located above the facility cask, and the telescoping port shield valve mating with the underside of the facility cask, ensure shielding integrity. In addition, when the operating console is used during this operational sequence, it is located behind a shield. When loaded, the facility cask is rotated to the horizontal position, supported by the tracked facility cask transfer car, and is ready for transfer on the waste hoist. To control potential for contamination spread, the facility cask loading room functions as an air lock between the shaft and the hot cell.

RH Support Facilities

Facilities supporting RH operations are the hot cell operating gallery, the crane maintenance room, the manipulator repair room, and the hot cell filter gallery. The operating gallery provides the space for hot cell operating personnel to monitor and control all operations within the hot cell (Figures 4.2-4a, Figure 4.2-4b and Figure 4.2-4c). The master/slave manipulators are operated from this area, and are moved from this area to the manipulator repair room for maintenance and repair.

The manipulator repair room is adjacent to the operating gallery, and provides space for repairing the hot cell master/slave manipulators.

The hot cell filter gallery provides space for hot cell HEPA filters and personnel access for maintenance. The filters are normally changed manually, and in the event it becomes necessary, space is provided for remote filter removal (i.e., provision of oversized filter housings). Bag out provisions are incorporated in the design of the HEPA filter system.

The crane maintenance room provides space and facilities for maintenance of the hot cell bridge crane. With the hot cell bridge crane moved into the crane maintenance room and the shield door closed, maintenance personnel may safely enter the room even with a RH canister in the hot cell.

4.2.1.1.3 Building 412

Building 412 (designed as the TRUPACT maintenance facility) is Design Class IIIA; however, the structural portions of the building are Design Class II because of its interface with the WHB. Building 412 provides space and equipment for minor scheduled and unscheduled maintenance activities and includes a 25-ton overhead crane.

4.2.1.1.4 WHB Support Areas

WHB support areas, common to both the CH TRU and RH TRU areas of the WHB, include the waste hoist support areas and the main mechanical equipment room containing the HVAC equipment.

Air locks are located on both the CH TRU and RH TRU sides of the waste hoist, including the conveyance loading room on the CH TRU side of the waste hoist and the facility cask loading room on the RH TRU side of the waste hoist. Access doors to the hoist are interlocked to control air flow; and, air flow is towards the hoist from the CH TRU loading room, or from the RH TRU facility cask loading room.

The hoist control room provides space and equipment for operation of the waste hoist and controls available for operation in manual or automatic.

The main mechanical equipment room of the WHB houses the exhaust fans, HEPA filters (except for the hot cell HEPA filters, which are located adjacent to the hot cell), and the associated ducting that controls ventilation flow within the WHB.

4.2.1.1.5 Waste Handling Building Effluent Monitoring System

The WHB exhaust system is Design Class IIIA, the supply system is Design Class IIIB, and the HEPA filters and isolation dampers are Design Class II. The WHB ventilation system has a single discharge point, with most of the air coming from the WHB being processed through a prefilter and two stages of HEPA filters prior to its release to the environment. Some of the air may go down the waste shaft (Section 4.4.2.1). Station C is located downstream of the HEPA filters and continuously monitors for both alpha and beta-gamma airborne contamination. In addition to air monitoring, fixed air sampling is used to quantify the total amount, if any, of radioactivity released to the environment.

4.2.1.2 Exhaust Filter Building

The Exhaust Filter Building, containing the filtration equipment associated with the underground ventilation system, is adjacent to the exhaust shaft. During normal operations, air is pulled from underground areas, up the exhaust shaft, and discharged to the environment without the HEPA filtration units in service. In the event of an underground radiological event, airflow from the underground is diverted through the HEPA filtration units located in this building to remove airborne radioactive particulates from the air stream. The underground ventilation system is discussed in Section 4.4.2.3, and the Exhaust Filter Building layout is shown in Figure 4.2- 19.

The Exhaust Filter Building structure is classified as Design Class IIIA, and the HEPA filters and isolation dampers are Design Class II. The major areas within the Exhaust Filter Building are the filter room and support area. The filter room houses the HEPA filtration units. The support area includes two mechanical equipment rooms housing the building filtration units, the exhaust fans, the supply-air handling units, the motor control centers, and the air lock.

The effluent monitoring system at the Exhaust Filter Building is composed of two separate stations. Station A is located within the exhaust shaft, and will obtain its sample 21 ft (6.4 m) below ground level in this shaft. Station B is positioned downstream from the HEPA filtration system that is located in the Exhaust Filter Building. Station A contains radiation effluent monitors (REMS) for the detection of airborne alpha or beta-gamma contamination that will be used only for research. Each station contains fixed air samplers operated by the WIPP, one each for WID, the state of New Mexico Environmental Department, and the Environmental Evaluation Group, quantifying the total amount of radioactivity released to the environment.

4.2.1.3 Water Pumphouse

The Water Pumphouse, adjacent to the two water storage tanks (Figure 4.1-2a and 4.1-2b), contains two fire water pumps (one electric and one diesel), three electric domestic water pumps, and space for water chlorination equipment and chemical storage. The Water Pumphouse is an above ground steel frame and siding building classified as Design Class IIIB.

4.2.1.4 Support Building

The Support Building, adjacent to the WHB, houses general support services for activities at the WIPP facility. The Support Building is constructed of steel framing and sandwich panel siding, and is classified as Design Class IIIA. The main lateral force-resisting members of the Support Building are designed for DBE and DBT to protect the WHB from their structural failure.

4.2.1.5 Support Structures

The following support structures are designed to the Uniform Building Code (UBC), and are classified as Design Class IIIB support structures.

- Salt Handling Shaft Headframe and Hoist House
- Air Intake Shaft Headframe and Hoist House
- Main Warehouse Building
- Guard and Security Building
- Main Gatehouse
- Safety and Emergency Services Building
- Compressor Building
- Engineering Building
- Training Building

4.2.2 Shaft and Hoist Facilities

4.2.2.1 Shaft and Hoist General Descriptions

The WIPP facility utilizes four shafts:

- Waste Shaft
- Salt Handling (SH) Shaft
- Exhaust Shaft
- Air Intake Shaft (AIS)

These shafts are vertical openings extending from the surface to the underground disposal level as shown on Figure 4.1-2a, which shows the location of the shafts relative to surface features. All shaft construction and mining operations are in accordance with 30 CFR 57.[2]

The waste hoist system is designated as a Design Class IIIA; and, the SH shaft, the exhaust shaft, and the AIS hoist system are designated as Design Class IIIB. The waste shaft, SH shaft and AIS shaft are designed to resist the dynamic forces of the hoisting system. Shaft linings are designed based on expected hydrostatic heads in the Rustler Formation.

4.2.2.2 Shaft and Hoist General Features

The principal components of each shaft are the shaft collar (extending from above the ground surface to the top of the bedrock), the shaft lining (extending from the bottom of the collar to the top of the salt formation at about 850 ft (259 m) below the surface), and the key section that terminates the lining in the salt formation, with the remainder of each shaft being unlined.

The shaft collars are situated about 400 ft (122 m) above the historic flood plain of the Pecos River and the collar slab around the shaft, where used, is at a higher elevation than the surrounding ground.

The waste shaft, the SH shaft, and the AIS are equipped with conveyances, and all hoist towers are made of structural steel. The conveyances in the waste shaft and AIS are guided by steel cables (guide ropes), and the conveyance in the SH shaft is guided by fixed wooden guides, and is equipped with safety dogs. The waste shaft is equipped with catch sprags in the hoist tower to prevent the conveyance or counterweight from falling into the shaft if the conveyance overtraveled against the upper crash beam and the hoist ropes failed.

The waste hoist and SH hoist redundantly installed brake systems are designed for either set of brakes to stop the fully-loaded conveyance under all conditions. In the event of a power failure, the brakes will set automatically. The AIS hoist is also equipped with two sets of brakes.

The control system for each hoist detects malfunctions or abnormal operations (such as overtravel, overspeed, power loss, circuitry failure, or starting in a wrong location) and triggers an alarm which automatically shuts down the hoist.

4.2.2.3 Shaft and Hoist Specific Features

The Waste Hoist system exists for the main purpose of moving radioactive waste from the surface to the underground. The system can be used to remove radioactive waste from the disposal area if required. It is also used to transport personnel, material and equipment. The system supports maintenance in the Waste shaft. The equipment that is part of this system is the Waste Hoist equipment installed in the Waste Handling building, the headframe, shaft switches, and the conveyance. The hoist systems in the shafts and all shaft furnishings are designed to resist the dynamic forces of the hoisting operations (these forces are greater than the seismic forces on the underground facilities). In addition, the Waste Hoist headframe is designed to withstand a DBE (the DBE is defined in Section 3.2.7). The waste hoist is equipped with a control system that will detect malfunctions or abnormal operations of the hoist system (such as overtravel, overspeed, power loss, circuitry failure, or starting in a wrong direction), and will trigger an alarm that automatically shuts down the hoist. The waste shaft and hoist arrangement is shown on Figure 4.2- 20.

The inside diameter of the unreinforced concrete-lined upper portion of this shaft is 19 ft (5.8 m). The waste hoist conveyance (outside dimensions) is approximately 30 ft (9.15 m) high by 11 ft (3.35 m) wide by 15 ft (4.6 m) deep, and carries a maximum payload of 45 tons. The conveyance contains an upper and lower deck. During loading and unloading operations, the conveyance is steadied by fixed guides. At the station underground, rope stretch is removed by a chairing device that supports the weight of the conveyance and payload.

The Waste Hoist itself is an electrically driven friction hoist. The Hoist Motor is a 600 HP DC machine, designed for a maximum operating speed of 13.5 RPM. The hoists maximum rope speed is approximately 500 ft/min (2.54 m/s). The field is formed by wound poles, and is supplied with a constant DC current obtained from rectifying a 480 volt three-phase supply. The DC voltage magnitude and direction controls the speed and direction of the hoist. There is one silicon controlled rectifier (SCR) power supply to power the hoist. The brake system can safely stop and hold the conveyance without the drive motor. Automatic control circuitry will sense electrical problems with the drive motor and stop the hoist.

There are two brakes, mounted approximately 180 degrees apart, on each braking flange of the Hoist Wheel. These disc brakes (four total) are spring set, and are released by hydraulic pressure. Brake switches indicate brake set, release, and wear. A redundant hydraulic power supply exists to supply hydraulic pressure to release the brakes. Each pressure unit has its own motor, pump, and oil reservoir. There is an automatic switch over from the primary system to the standby system if the hydraulic pressure decreases below the set point. There is no automatic switchover from the standby system to the primary system. A timed back up pressure relief path exists to set the brakes if for any reason the brake pressure is not released within a few seconds after the application of the brake set signal.

Hoisting, Tail, and Guide Ropes are provided for the safe operation of the conveyance and the counterweight. The hoisting ropes are 1-3/8" (3.5 cm) diameter, fully locked coil bright steel ropes suitable for use with a friction hoist. The tail ropes are 2-1/4" (5.7 cm) diameter, nonrotating bright steel, with a synthetic fiber core. The three tail ropes approximately balance the weight of the six hoisting ropes. The guide ropes are 1-3/4" (4.45 cm) diameter, half-lock bright steel with internal and external lubrication and are designed to operate with minimal field lubrication only. There are four guide ropes for the conveyance and two guide ropes for the counter weight. Tension in these ropes is maintained by weights on the bottom of the ropes. The size of the weights are different to prevent harmonic vibrations during operation of the hoist.

A conveyance and counterweight overtravel arrestor system exists to stop them if the normal control system has failed. Four timbers are provided at the tower and the sump regions for both the conveyance and the counterweight to assist in absorbing energy to stop an over traveling conveyance or counterweight. Retarding frames rest in notches either at the top of the wood arresters (Sump Area), or at the bottom of the wood arresters (Tower area). The retarding frames have knives that cut into the timbers if driven by the conveyance or the counterweight.

If the conveyance over travels against the upper crash beams and the hoist ropes fail, safety lugs on the conveyance mate with pivoting dogs on the catchgear mounted in the headframe to prevent the conveyance from falling if the ropes break. The counterweight catchgear system functions in a similar fashion to stop the counterweight from falling. Each catchgear frame is mounted on a hydraulic shock absorber which absorbs energy from a descending conveyance or counterweight. Lever arms exist to raise the pivoting dogs if they are not supporting any weight.

Emergency stop buttons are provided at the Master Control Station (MCS) and all the control stations to effect an emergency stop of the hoist. These buttons are operable in all modes of hoist operation. These buttons will open the control power loop and set the hoist brakes. These buttons provide the most rapid means of bringing the hoist to a stop. A controlled stop button that will decelerate the conveyance before setting the brakes is located on the control panel, to the left of the MCS. This is a slower and softer stopping action than the emergency stop.

Twelve signals, two analog and ten contact, from the Waste Hoist Operation are transmitted to the CMR for remote monitoring. The analog signals are the hoist motor volts and amps. The contact signals are "Hoist Operation, Manual", "Hoist Operation, Semi-Auto", "Hoist, Abnormal Condition", "Emergency Stop", "Men Working in Shaft", "Waste on Hoist", "Personnel on Hoist", "Hoist, Up", and "Hoist, Down".

The Waste Hoist Signaling System consists of bells and lights activated by the operators at the MCS and the operating stations.

The SH shaft is used to transport mined salt to the surface, and to provide personnel transportation between the surface and the underground horizon. It also acts as a duct for supplying air to the underground mining and disposal areas, and is one route for the power, control, and communications cables. The hoist's maximum rope speed is approximately 1,800 ft/min (9.15 m/s). The shaft inside diameter is 10 ft (3.05 m) for the steel lined portion, and 11 ft 10 in (3.6 m) for the unlined portion.

The exhaust shaft is used as the opening to exhaust air from the underground disposal areas to the surface. The inside diameter of the lined portion of this shaft is 14 ft (4.3 m). The shaft lining is unreinforced concrete. The shaft key incorporates polymeric chemical water seal rings. The exhaust shaft collar does not utilize a building or headframe, and is sealed at the top by a 14 ft (4.3 m) diameter elbow that diverts exhaust air into the exhaust ventilation system.

The AIS is used primarily to supply the fresh air to the underground areas, and is also used for backup egress of personnel between the surface and the underground horizon. The hoist's maximum rope speed is approximately 830 ft/min (4.2 m/s). The inside diameter of the unreinforced concrete lined upper portion of this shaft is 16 ft (4.9 m).

4.2.3 Subsurface Facilities

4.2.3.1 General Design

The subsurface structures in the underground are located at 2,150 ft (655 m) below the surface and include the waste disposal, north, and support areas. The underground support areas provide the facilities to service and maintain all underground equipment for mining and disposal operations, monitor for radioactive contamination, and allow limited decontamination of personnel and equipment. The mining, north, and waste disposal areas are isolated from each other by air locks and bulkheads (Some mining construction activities may be required within an active disposal panel, however, these activities can be separated from the disposal processes and areas by time, ventilation controls, and temporary bulkheads). Transportation of waste containers from the waste hoist to the disposal panel(s) (Figure 4.2-21b) takes place within the CA (Figure 4.1-3).

The underground support facilities and their ventilation flows in the shaft pillar area are shown on Figure 4.2- 21a.

The support facilities on the disposal side provide a maintenance area, a vehicle parking area with plug-in battery charging, and a waste transfer station.

The support facilities on the mining side consist of a vehicle parking area, an electrical substation, a welding shop, a warehouse, offices, materials storage area, emergency vehicle parking alcoves, and a fueling station for diesel equipment. A mechanical shop is located in the north area.

An experimental area, separate from the other areas of the underground repository contained separate areas for evaluating the interaction of simulated waste and thermal sources on bedded salt under closely monitored, controlled conditions. The experimental area was deactivated in September 1996. The deactivation was accomplished by the construction of two light weight cementitious block walls. The walls are located just north of the N780 drift in the E300 and E140 entries. The light weight cementitious walls not only serve as a barricade preventing access but also isolate and prevent any measurable ventilation from entering or exiting the deactivated area.

Underground mining procedures and cavity dimensions incorporate the results of the salt creep analysis in DOE/WIPP 86-010, Waste Isolation Pilot Plant Design Validation Final Report.[1]

The mining area fuel dispensing room is in an alcove off the mining exhaust entry. This fuel dispensing room provides a location and pumping facilities for a portable fuel tank. The portable diesel tank hoisting and lowering is done through the waste shaft, or the SH shaft as required. An automatic dry chemical fire suppression system, with main and reserve tanks, is provided in the fueling area. Fire-generated smoke and fumes would be exhausted directly to the exhaust ventilation system.

The underground transporters are equipped with fire resistant fuel tanks. The transporter is a diesel-powered tractor trailer with an articulating frame steering system. The transporter has two sections; (1) a front section consisting of the tractor cab and diesel engine, and (2) the rear section consisting of a flat bed trailer with a ball screw driven pallet transfer system mounted in the middle of the bed. The pallet transfer system is designed to handle a load of 28,000 lb (12,698 kg). The tractor has a fully hydraulic power type of steering system with a direct drive hydraulic pump, an orbital valve operated by the steering wheel, and two steering cylinders located at the articulated joint. The axle brakes are air over hydraulic disc brakes with a dual master cylinder and separate circuits for the front and rear brakes. There is also a drive line disc brake which is used as a parking brake. This brake is automatically applied when air pressure falls from the normal 100 psi (7 kg/cm^2) level to below 45 psi (3.2 kg/cm^2). The brake can also be set manually from the tractor cab. The roller guided pallet mover with hook is screw driven by a full-length ball drive. After the hook is engaged to the facility pallet pin, operation of the ball screw is controlled from a switch in the tractor cab, which rotates the ball screw. This advances the ball nut and hook to the front of the trailer, sliding the facility pallet from the waste shaft conveyance on to the transporter trailer. The underground transporter is then ready to move the facility pallet to an underground disposal room or the facility pallet platform.

There are two 6 ton and one 4 ton diesel powered forklift trucks in the underground, which are equipped with push/pull attachments mounted on the forks. The 4 ton diesel powered forklift truck is normally used to emplace backfill super sacks with the Loron push/pull attachment mounted on the forks. The 6 ton capacity diesel powered forklift trucks equipped with push/pull attachments capable of handling 8,500 lb (3,855 kg) are provided to lift and transport waste containers and backfill super sacks. The forklift-attachment combination will handle the following combinations on slipsheets: a single 7-pack of 55 gallon (208 L) drums, a single SWB, a single TDOP, a stack of two 7-packs of 55 gallon (208 L) drums, a stack of two SWBs, or a single backfill super sack. The attachments can be removed if required for other tasks.

Standard battery powered 6 ton forklift trucks in the underground are as described in section 4.2.1.1.1.

The BRUDI attachment is used with a 6 ton forklift truck with the forks removed to handle waste containers on slip sheets. The BRUDI attachment is connected to the forklift truck front carriage. The BRUDI has a gripper which grips the edge of the slip sheet on which the waste containers sit, and a linkage assembly to pull or push the waste containers onto or off the platen. After the 6 ton forklift truck moves the waste containers to the emplacement location, the BRUDI pushes the waste containers into position after the forklift truck has raised or lowered the BRUDI platen to the proper height. The use of the BRUDI attachment prevents direct contact between waste containers and forklift tines.

Loron attachments with 4,200 lb (1,905 kg) and 8,500 lb (3,855 kg) capacity are available. The Loron attachments use the same push/pull technique as the BRUDI units described previously. The 4,200 lb (1,905 kg) capacity Loron is installed on the forks of a 4 ton capacity forklift and is used to emplace backfill super sacks of MgO backfill on top of the waste stacks. The 8,500 lb (3,855 kg) capacity Loron is installed on the forks of a 6 ton forklift, and is used to emplace either waste container packages or the backfill super sacks on top of waste sacks.

The SWB forklift fixture in the underground are identical to the SWB forklift fixture described in section 4.2.1.1.1, and is used to perform the same function.

4.2.3.2 TRU Waste Disposal Area

The disposal area (see Figures 4.1-3) provides space for 6.2×10^6 ft^3 (1.76×10^5 m^3) of TRU waste material in TRU waste containers of which up to 2.5×10^5 ft^3 (7.08×10^3 m^3) can be RH TRU waste. This area also includes the four main entries and the cross-cuts that provide access and ventilation. Figure 4.2-22 shows a typical waste container disposal configuration.

CH TRU waste may be received at the WIPP facility in seven-pack configuration, SWBs or TDOPs. The seven-pack of drums and SWBs will be stacked three high, and may be intermixed within rows and columns. TDOPs will be placed on the bottom row. 85-gallon overpacks will be placed on the top row only.

The ribs (pillars or walls) of the disposal rooms and entries are used for storing RH TRU waste canisters. RH TRU waste may be disposed in the same rooms as CH TRU waste.

The amount of TRU waste in each panel/room is limited by thermal, structural, and physical considerations, and emplacement is designed not to exceed 10 kW/acre. Based on current design and thermal constraints, a spacing of approximately 8 ft (2.4 m) between centers for RH TRU waste canisters has been specified, and a shield plug provides shielding between the canister and the room.

Typically main entries and cross cuts in the repository provide access and ventilation to the disposal area. The main entries link the shaft pillar/service area with the disposal area and are separated by pillars. Typical entries are 13 ft (4.0 m) high and 14 ft (4.3 m) wide. Each of the panels labeled Panels 1 through 8 will have seven rooms. The locations of these panels are shown in Figure 4.1-3. The rooms will have nominal dimensions of 13 ft (4.0 m) high by 33 ft (10 m) wide by 300 ft (91 m) long and are separated by 100 ft- (30 m) wide pillars.

If waste volumes disposed of in the eight panels fail to reach the stated design capacity, the DOE may choose to use the four main entries and crosscuts adjacent to the waste panels (referred to as the disposal area access drifts) for disposal, as follows:

E-300 will be mined to be 14 ft (4.3 m) wide and 12 ft (3.7 m) high
E-140 is mined to 25 ft (7.6 m) wide by 13 ft (4 m) high
W-030 and W-170 will be similar to E-300.

Presently, only the construction of these areas is planned. The above drifts extend from S-1600 to S-3650 (i.e., 2,050 ft long [625 m]). Crosscuts (east-west entries) will be 20 ft (6.1 m) wide by 13 ft (4 m) high by 470 ft (143 m) long. The layout of these excavations is shown on Figure 4.1-3.

Panel 1 is the first panel to be used for waste disposal, and was excavated from 1986 through 1988. Its rooms and access drifts have been rock-bolted to assure stability. Panel 1 has been rebolted with threaded bar rising resin anchors. In addition, Room 1 has been supplied with a supplementary roof-support system consisting of rock bolts, steel channel sets, and a wire-mesh and lacing system. The DOE intends to mine panels in the following order:

Final ½ Panel 10 (access drifts for Panels 1,2,7, and 8)
Panel 2
First ½ Panel 9 (access drifts for Panels 3,4,5 and 6)
Panel 3
Final ½ Panel 9
Panel 4
Panels 5 through 8

At normal operating (waste throughput) rates, rock bolting in Panels 2 through 8 may only be required locally (i.e. spot bolting). Rock fixtures used at WIPP comply with 30 CFR 57,[2] Subpart B. Each ground control support system installation is individually assessed and evaluated. As a result they vary from time to time and place to place.

A discussion of the design life of underground disposal rooms is included in Section 4.3.5. An evaluation of the effective life of the underground rooms in Panel 1 was performed during April 1991, by a panel of geotechnical experts. The panel members concluded that if no additional remedial measures were taken, the rooms in the panel would likely have a total life of seven to eleven years from the time of excavation using the installed roof support system, consisting of patterned mechanically anchored rockbolts. Experience in Panel 1 confirmed the conclusion of the expert panel.

Plans call for bolt systems installed in the future to equal or exceed the bearing characteristics of the bolts used in the primary pattern in Panel 1. The configuration of Panel 2 through 8 will be similar to Panel 1, therefore; the performance of these rooms should be similar to those in Panel 1. Supplementary support systems will further extend the effective life of the rooms, should they be required. A detailed discussion of initial and supplementary support systems is included in Section 4.3.5.

The support system will be subjected to longitudinal and lateral loading due to the rock deformation. The anchorage components may undergo lateral deformation due to offsetting along clay seams or fractures and increasing tensile loading. Rigid, non-yielding support systems are not designed to accommodate salt creep; however, they do respond to creep and continue to provide support during ductile behavior. Yielding support systems are currently being evaluated in the WIPP underground. These systems are designed to yield at predetermined loads, and provide support over their prescribed yield interval without maintenance. Preliminary data indicate that the design and performance of some of these systems are clearly superior to rigid systems in their ability to respond to salt creep while maintaining adequate ground support.

Because the disposal area access drifts must remain open and operational for a much longer period than any panel, they will require additional consideration from time to time. They are subject to regular and systematic inspection and evaluation, and appropriate ground control measures will be implemented whenever necessary.

The DOE will ensure that any room in which waste will be placed will be sufficiently supported to assure compliance with all laws and regulations. Creep and rock failure in WIPP excavations progress slowly. As a result, many years pass before any operationally significant instability could occur. This long period allows more than sufficient time for whatever actions are appropriate, such as additional monitoring, installing supplementary support, or taking other managerial and operational actions. Support is installed to the requirements of 30 CFR 57, Subpart B. Random checks are conducted by Quality Assurance/Quality Control personnel as each system is installed. Geotechnical monitoring, design, analysis, and planning are performed in addition to regulatory inspections, maintenance, and construction, as discussed in detail in Section 4.3.5.

The underground facilities ventilation system will provide a safe and suitable environment for underground operations during normal WIPP facility operations. The underground system is designed to provide control of potential airborne contaminants in the event of an accidental release or an underground fire.

The main underground ventilation system is divided into four separate flows (Figure 4.2-21a): one flow serving the mining areas, one serving the northern areas, one serving the disposal areas, and one serving the Waste Shaft and station area. The four main airflows are recombined near the bottom of the Exhaust Shaft, which serves as a common exhaust route from the underground level to the surface. The underground confinement/ventilation system is discussed in detail in Section 4.4.

4.2.3.3 Backfill

Magnesium oxide (MgO) will be used as a backfill in order to provide chemical control over the solubility of radionuclides. The MgO backfill will be purchased prepackaged in the proper containers for emplacement in the underground. Purchasing prepackaged backfill eliminates handling and placement problems associated with bulk materials, such as dust creation. In addition, prepackaged materials will be easier to emplace, thus reducing potential worker exposure to radiation. Should a backfill container be breached, MgO is benign and cleanup is simple. No hazardous waste would result from a spill of backfill.

The MgO backfill will be purchased and received typically in two different containers: 1) a super sack typically holding 4,100 $\pm$ 50 lb (1859 $\pm$ 22.7 kg), and 2) a mini sack holding 26 $\pm$ 1 lb (11.8 $\pm$ 0.45 kg). Quality assurance requirements, such as material quality and quantity, will be addressed by using current quality assurance procedures in the procurement process and receipt inspection. The filled containers will be shipped by road or rail, and will be delivered underground using current shaft and material handling procedures and processes.

The mini sack will be a conical container with a nominal base diameter of 5.75 in. (14.6 cm), a nominal overall length of 33 in. (83.8 cm), and a nominal top diameter of 3 in. (7.6 cm). The mini sack shall be constructed of woven polypropylene material, coated or uncoated (alternate materials are acceptable subject to approval by WID Engineering prior to shipment). Poly Vinyl Chloride (PVC) material is not acceptable. It will have an integral handle/hook attached into the sack closure. Six sacks will be manually placed in the external voids of each seven-pack unit just before the seven-pack is positioned on the waste stack. The mini sack will be lifted up behind the shrink wrap around the top of the seven-pack, slid into place, and held there by the four inch (10.2 cm) hole in the lower slip sheet. See Figure 4.2-23. Once the sacks are in place, the seven-pack will be positioned on the waste stack in the normal manner.

A similar process will be used for standard waste boxes (SWB), except that the sacks will be hung from the lift clips on these units. See Figure 4.2-23.

Super sacks will be handled and placed using the slip sheet/BRUDI technique used for normal waste handling operations. Hence, no new procedures or training are required. Once each row of waste units is in place, a layer of super sacks will be placed on top of them. See Figure 4.2-24. The assembled (empty) dimensions of the super sack shall be a hexagon which is nominally 61 in. (155 cm) across the flats by 24.5 in. (62.2 cm) high. The super sack shall be constructed such that it retains its shape well enough to not deform beyond a 65 in. (165 cm) hexagon with 12 in. (30.5 cm) radius corners after filling and shipping. The super sack shall be constructed of woven polypropylene material, with a minimum weight of 8.0 ounces per square yard, coated or uncoated (alternate materials are acceptable subject to approval by WID Engineering prior to shipment). Poly Vinyl Chloride (PVC) material is not acceptable. The filled super sack must be able to retain it's contents for a period of two years after emplacement without rupturing from it's own weight. The super sack will have an integral slip sheet or base attachment so that it can be handled and placed in a manner that is identical to emplacement of waste units, using a BRUDI-like attachment (a low-headroom push-pull device from Loron, Inc.) on a lift truck.

Finally, mini sacks will be manually stacked on the floor in the space between the waste stack and rib side. These sacks can be placed horizontally or vertically as may be convenient, and loading rates up to 100 lb per linear ft (148.8 kg per linear m) can be achieved.

Quality control will be provided within waste handling operating procedures to record that the correct number of sacks (six) are placed.

Backfill placed in this manner is protected until exposed when sacks are broken during creep closure of the room and compaction of the backfill and waste. Backfill in sacks utilizes existing techniques and equipment and eliminates operational problems such as dust creation and introducing additional equipment and operations into waste handling areas. There are no mine operational considerations (e.g. ventilation flow and control) when backfill is placed in this manner.

4.2.3.4 Panel Closure System

Chapter 10 discusses the Closure Plan that describes the activities necessary to close the Waste Isolation Pilot Plant (WIPP) facility. The Closure Plan describes several types of closure. The first type is panel closure, which occurs as underground panels are filled. Secondly, final closure at the end of the Disposal Phase is described.

Following completion of waste emplacement in each underground panel, disposal-side ventilation will be established in the next panel to be used, and the panel[3] containing the waste will be closed. A panel closure system will be emplaced in the panel access drifts, as shown in Figure 4.1-3. The panel closure system is designed to meet the following requirements that were established by the DOE for the design[3]:

- The panel closure system shall consider potential flow of VOCs through the disturbed rock zone (DRZ) in addition to flow through closure components.

- The panel closure system shall perform its intended functions under loads generated by creep closure of the tunnels.

- The panel closure system shall perform its intended function under the conditions of a postulated methane explosion.

- The nominal operational life of the closure system is 35 years.

- The panel closure system for each individual panel shall not require routine maintenance during its operational life.

- The panel closure system shall address the most severe ground conditions expected in the waste disposal area.

- The design class of the panel closure system shall be IIIB (which means that it is to be built to generally accepted national design and construction standards).

- The design and construction shall follow conventional mining practices.

- Structural analysis shall use data acquired from the WIPP underground.

- Materials shall be compatible with their emplacement environment and function.

- Treatment of surfaces in the closure areas shall be considered in the design.

- Thermal cracking of concrete shall be addressed.

- During construction, a QA/QC program shall be established to verify material properties and construction practices.

- Construction of the panel closure system shall consider shaft and underground access and services for materials handling.

The final panel closure design[3] was prepared with the assumption that there would be no backfill in the disposal rooms. With the inclusion of backfill, the design has been re-examined, and it has been determined that the changes are insignificant for several reasons. First, the backfill has no effect on the gas generation rate so that the values used in the design for gas generation and methane buildup remain the same. Second, the quantity of backfill is sufficient to fill one-tenth of the void volume in the room. This results in more rapid pressurization of the room; however, the effect is small and will only be important after the facility is sealed. Third, the reduced volume will result in a faster concentration buildup of methane. This would not result in a revision of the design. Instead, it would change the criteria for installing explosion walls.

The design for the panel closure system calls for a composite panel barrier system consisting of a rigid concrete plug with or without removal of the DRZ, and either an explosion-isolation wall or a construction-isolation wall. The design basis for this closure is such that the migration of hazardous waste constituents from closed panels during the operational and closure period would result in concentrations at the WIPP facility well below health-based standards. The source term used as the design basis included the average concentrations of VOCs from CH waste containers, as measured in headspace gases through January 1995. The VOCs are assumed to have been released by diffusion through the container vents, and are assumed to be in equilibrium with the air in the panel. Emissions from the closed panel occur at a rate determined by gas generation within the waste and creep closure of the panel. Due to the relatively small amount of RH waste (approximately five percent of the total waste volume), VOC emissions from RH waste are assumed to contribute insignificantly to total VOC emissions. This design meets the environmental performance standard.

Figures 4.2-25 and 4.2.26 show diagrams of the panel closure design and installation envelopes. Reference 3 provides the detailed design, and the design analysis for the panel closure system. The panel closure design is such that components can be added or removed, or their shapes adjusted depending on the particular ground conditions at the time of installation. For example, in Reference 3, Option A represents the likely closure of panels less than 20 years old at the time of final facility closure, and whose entries are sufficiently intact such that DRZ removal is not needed. These would likely include Panels 6 through 8. Option B represents the preferred option for panels that will be closed for more than 20 years prior to final facility closure, and whose entries are reasonably intact at time of closure. These will likely be Panels 2 through 5. Option C may be desirable for panels whose entries require DRZ removal, and whose closure precedes final facility closure by less than 20 years. This is the likely configuration of the closure for Panels 9 and 10. Finally, Option D may be appropriate for panels whose entries require significant removal of the DRZ, and whose closure will precede final facility closure by more than 20 years. Panel 1 is the most likely candidate for this type of closure.

The 20-year limit in the design selection process is based on what the DOE believes to be conservative analytical results that indicate methane, being generated by waste degradation at the rate of 0.1 mole per drum per year, will not reach flammable concentrations for at least 20 years. As part of the decision making process on design selection, an investigation of the DRZ would precede the selection of the concrete component and the specification of the amount of excavation that is needed. These investigations could be done using geophysical methods (such as ground penetrating radar) or drill holes. Drill holes can be investigated using video cameras or "scratchers." The DOE considers the 20-year criterion is still appropriate, since the design report shows that it takes 25 years to reach explosive limits. A ten percent reduction in this time is still beyond 20 years. Furthermore, the chances that methane will be generated initially are minimized by the fact that the closed panels will be initially oxic and may remain so for a long time after facility closure.

The DOE believes that design Options A through D will function adequately as panel closures, given the current state of knowledge about gas generation, the understanding of the DRZ, the expected characteristics of the waste, and the inability of monitoring techniques to accurately detect extremely small concentrations of VOCs. However, in the event sufficient information is collected that allows the DOE to make less conservative assumptions regarding these items, the designs A through D may prove to provide significantly more protection than is actually needed. Consequently, the DOE has retained as a design concept, Option E, which is simply the explosion wall portion of Options B and D. Option E represents a significantly simpler panel closure system that the DOE would use if either of the following criteria are met as indicated:

- Gas generation rates are smaller. Current (unreported) work being performed by Sandia National Laboratories indicates that microbial gas generation rates under humid conditions are close to zero, and/or

- Average headspace concentrations are less than the averages used in the calculations. As new wastes are generated, the use of organic solvents is expected to drastically be reduced.

As stated previously, the DOE will evaluate these criteria at the time a panel closure is needed and will select the proper closure design.

References for Section 4.2

1. DOE/WIPP 86-010, Waste Isolation Pilot Plant Design Validation Final Report.

2. Safety and Health Standards - Underground Metal and Nonmetal Mines, 8th edition, 1994. Title 30, Code of Federal Regulations, Part 57.

3. Detailed Design Report for an Operational Phase Panel-Closure System, DOE/WIPP-96-2150, U.S. Department of Energy, Carlsbad Area Office, Carlsbad, New Mexico.

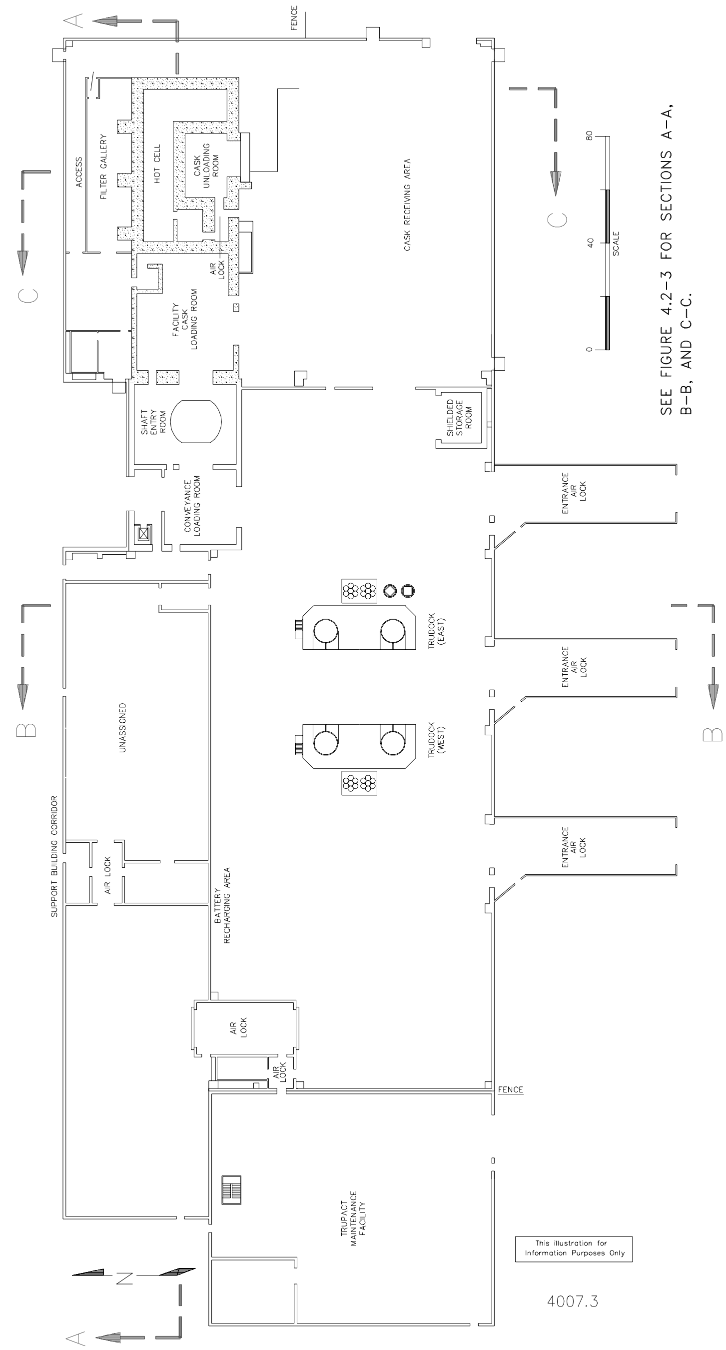


Figure 4.2-1a, WHB Plan (Ground Floor)

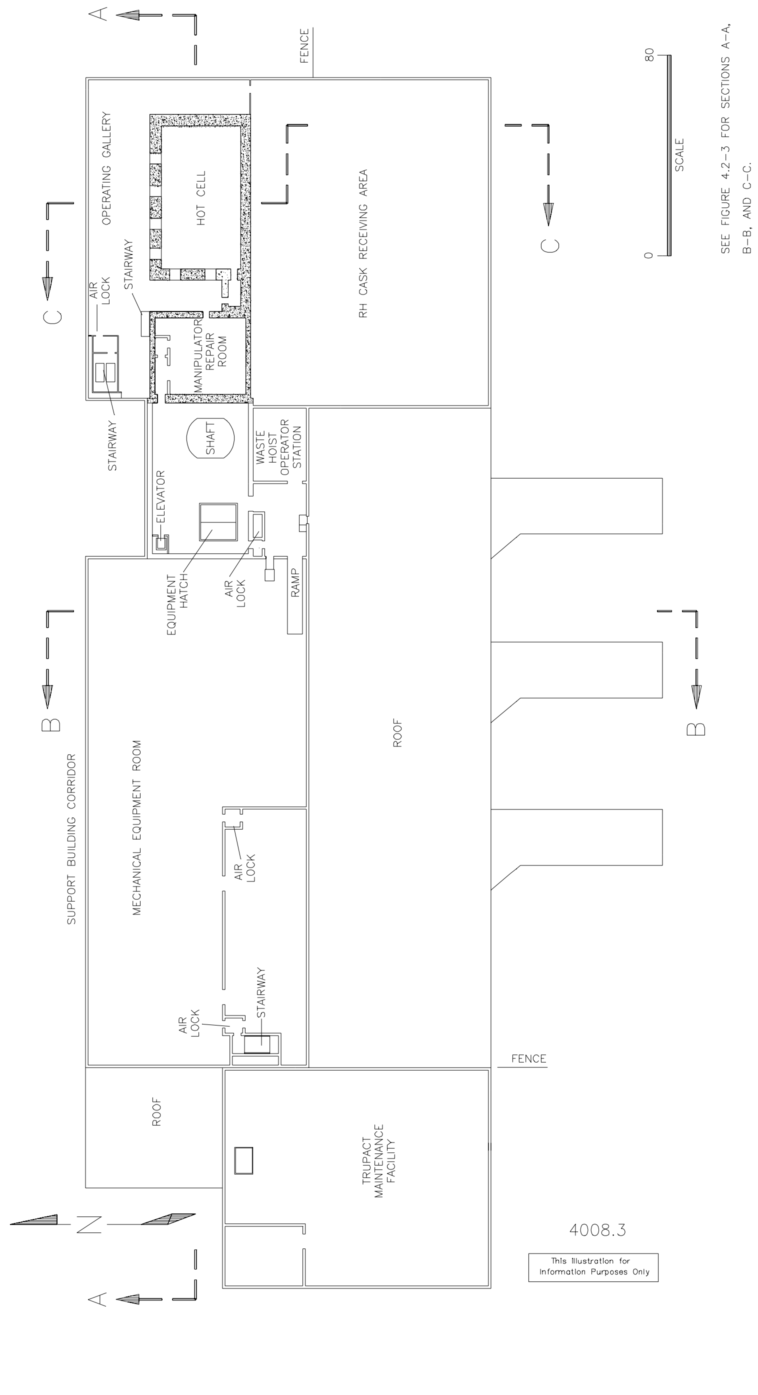


Figure 4.2-1b, Waste Handling Building Plan (Upper Floor)

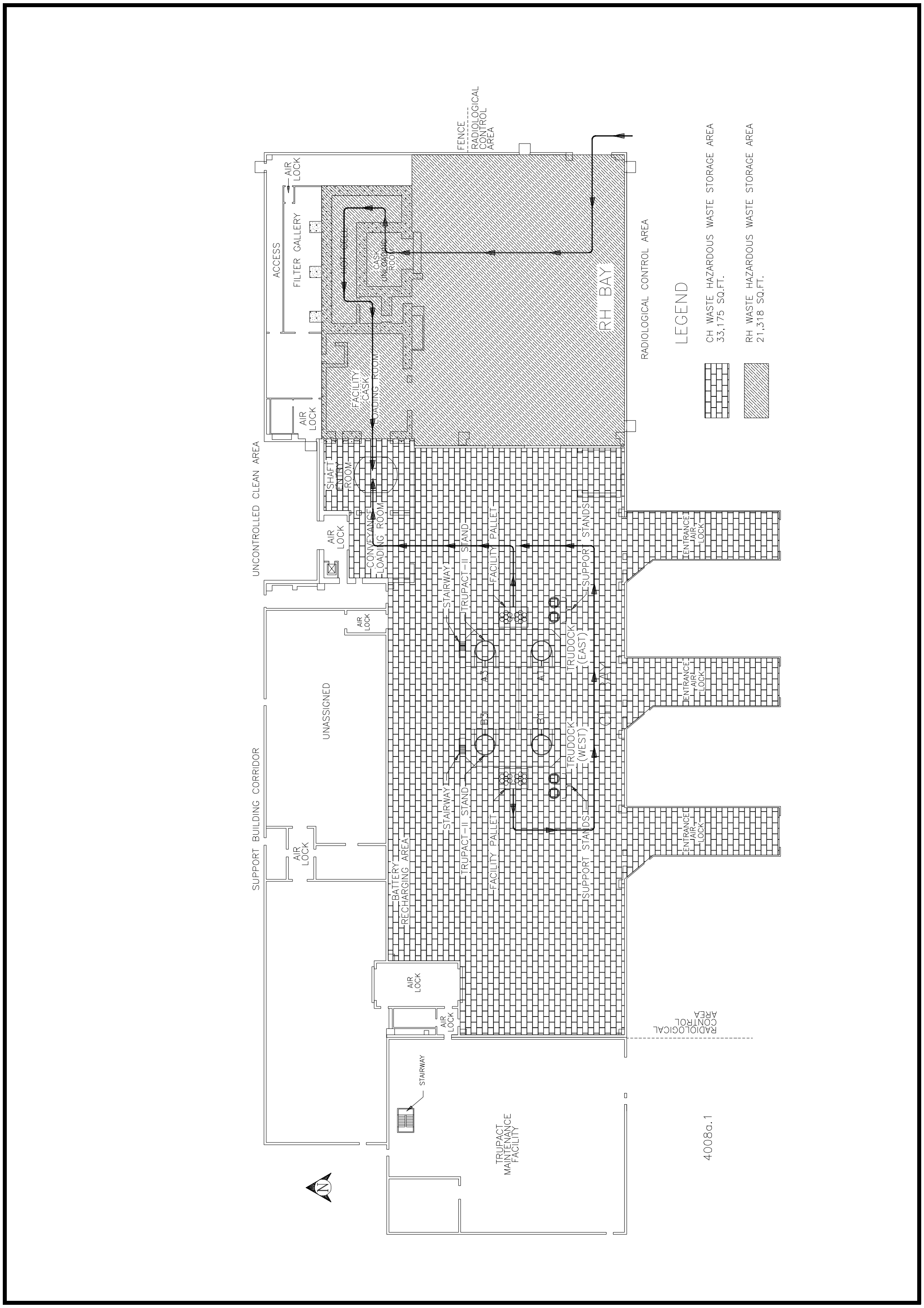


Figure 4.2-2, Waste Transport Routes in the Waste Handling Building

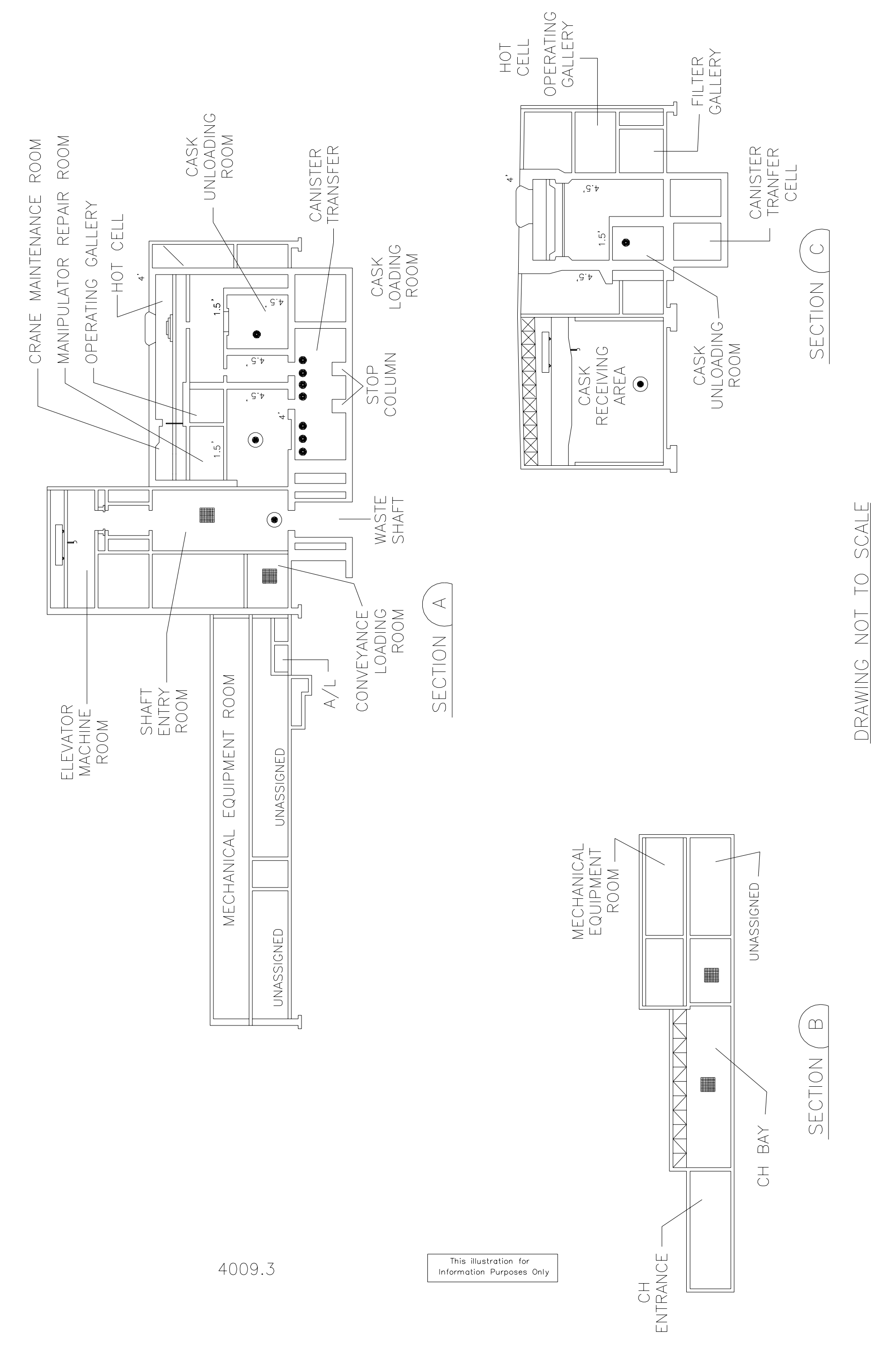


Figure 4.2-3, Waste Handling Building (Sections)

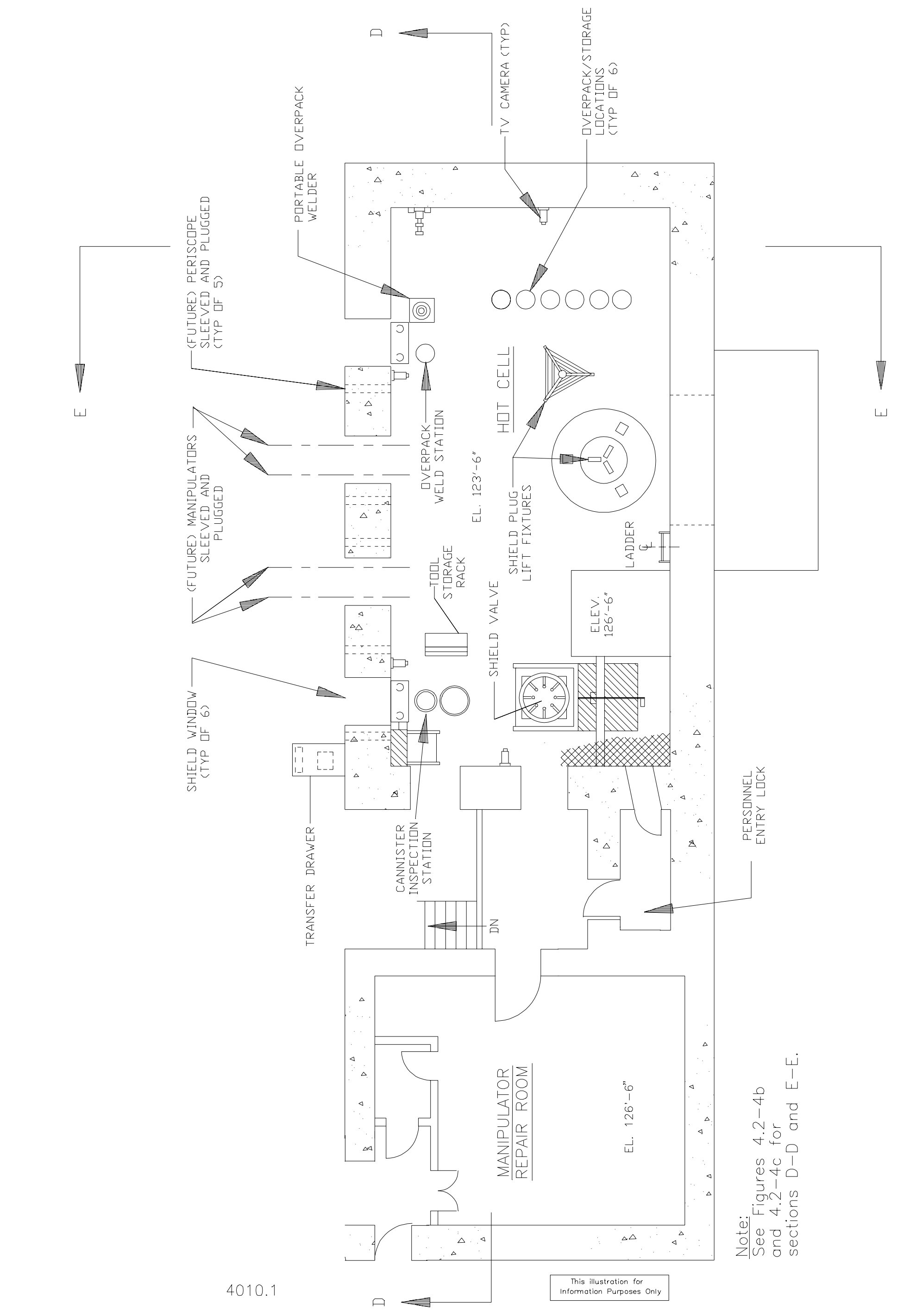


Figure 4.2-4a, Details of Hot Cell

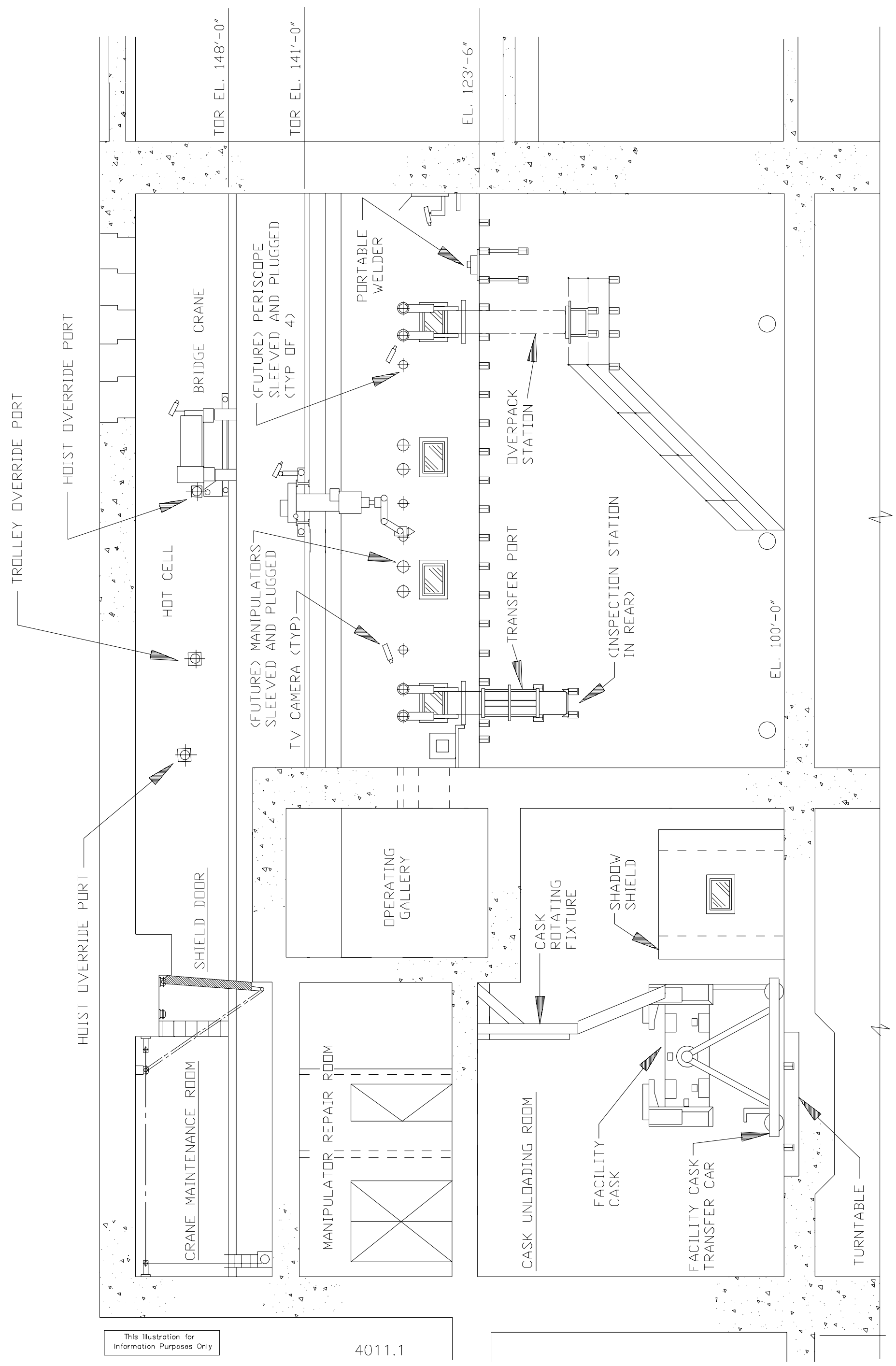


Figure 4.2-4b, Details of Hot Cell Cross Section at D-D

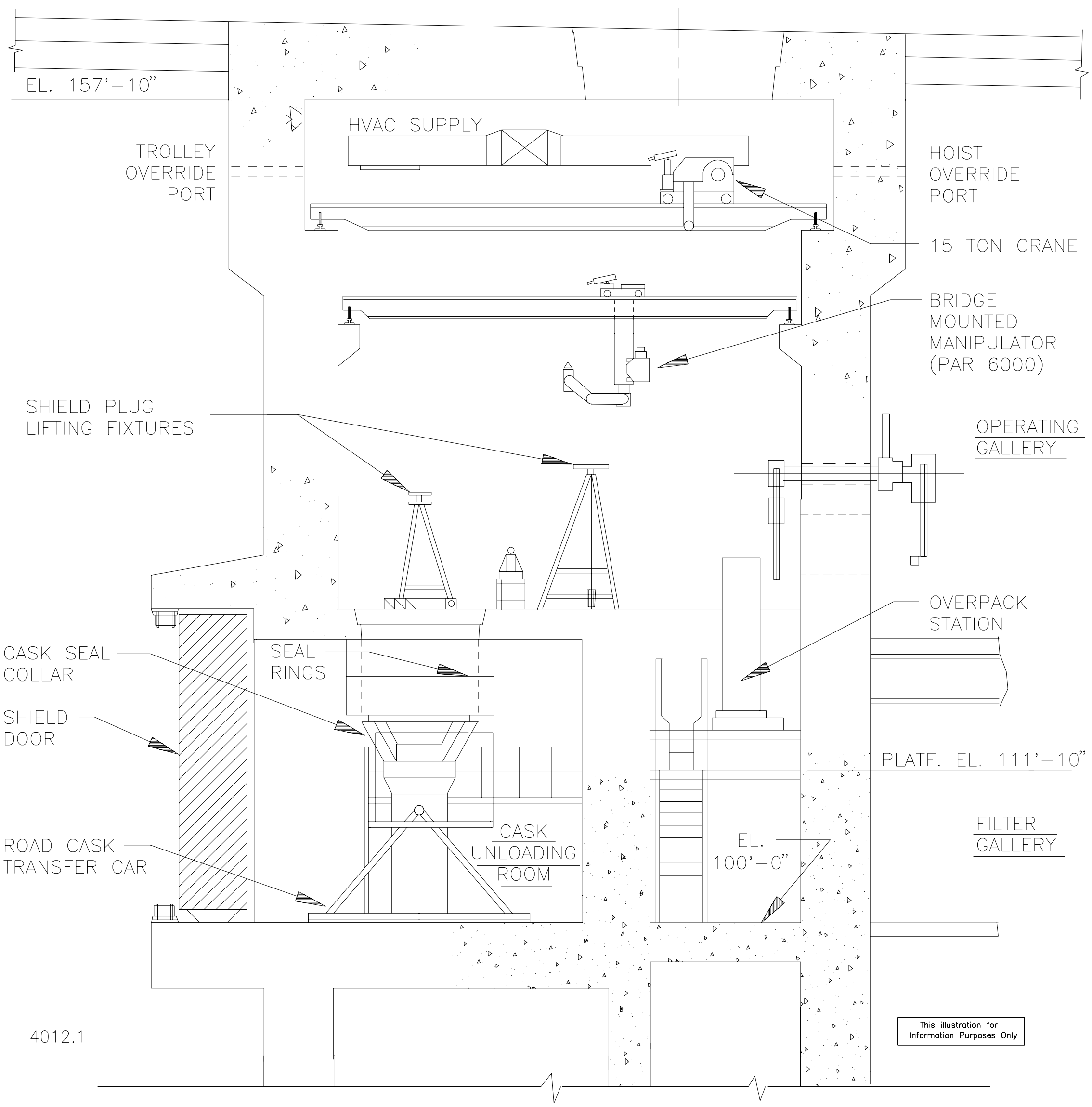


Figure 4.2-4c, Details of Hot Cell Cross Section at E-E

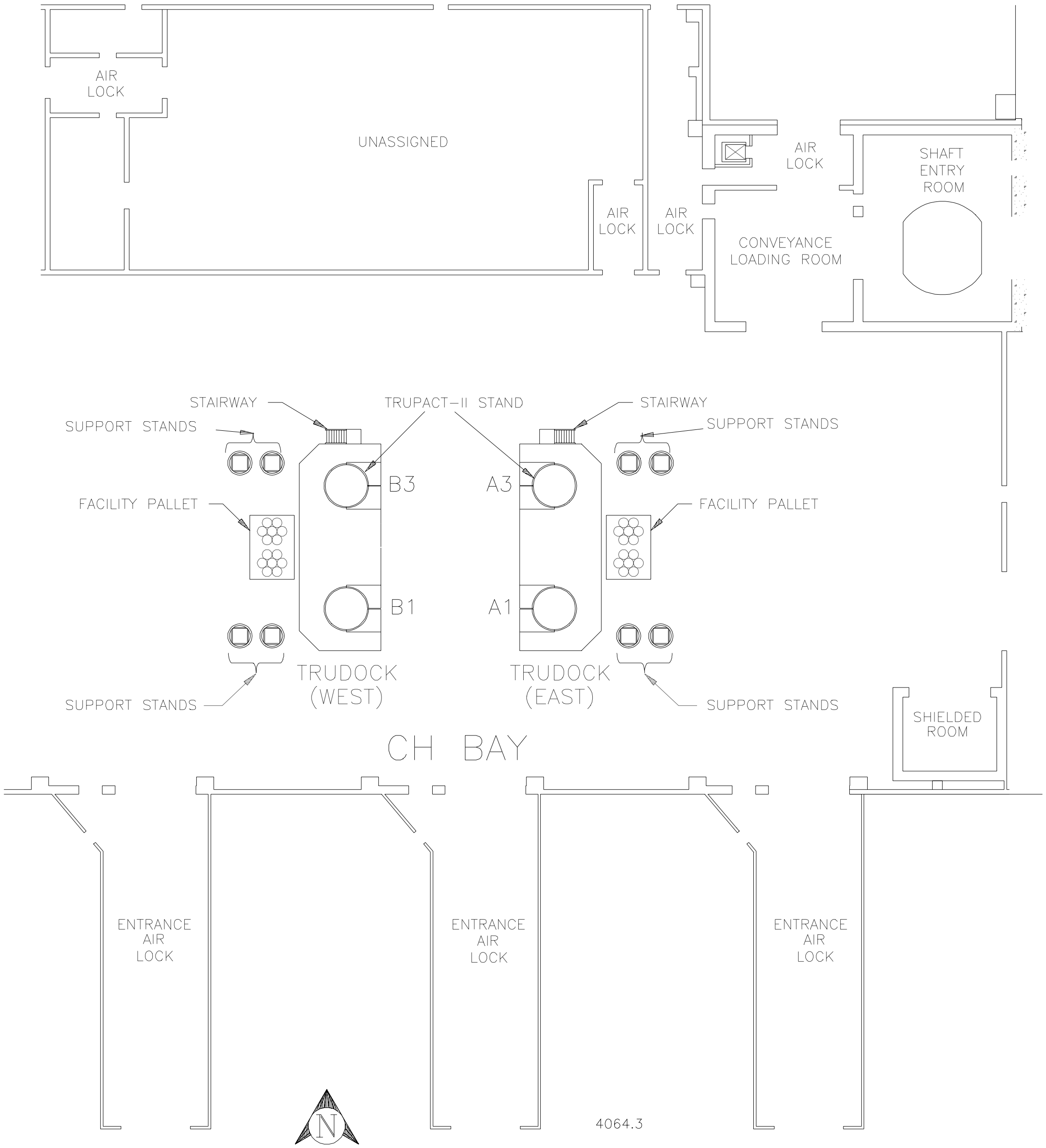


Figure 4.2-5, Configuration of CH TRU Waste Unloading TRUDOCKS in the WHB

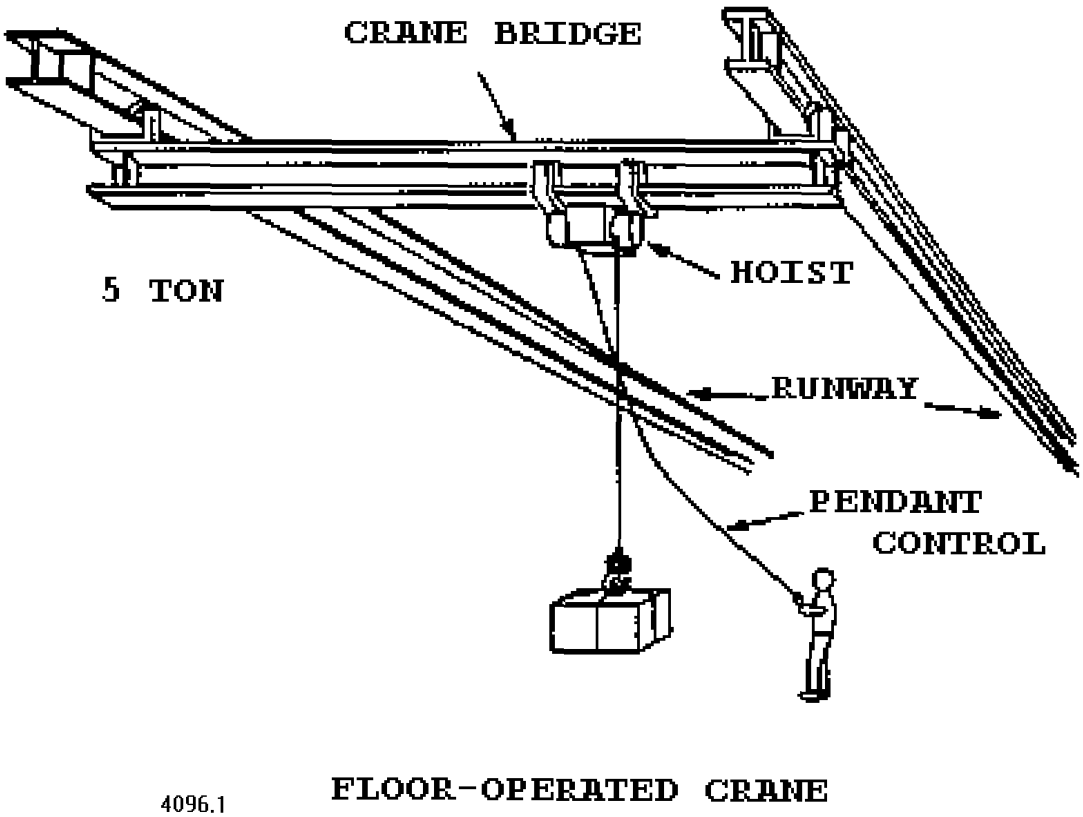


Figure 4.2-6, Typical Overhead Crane

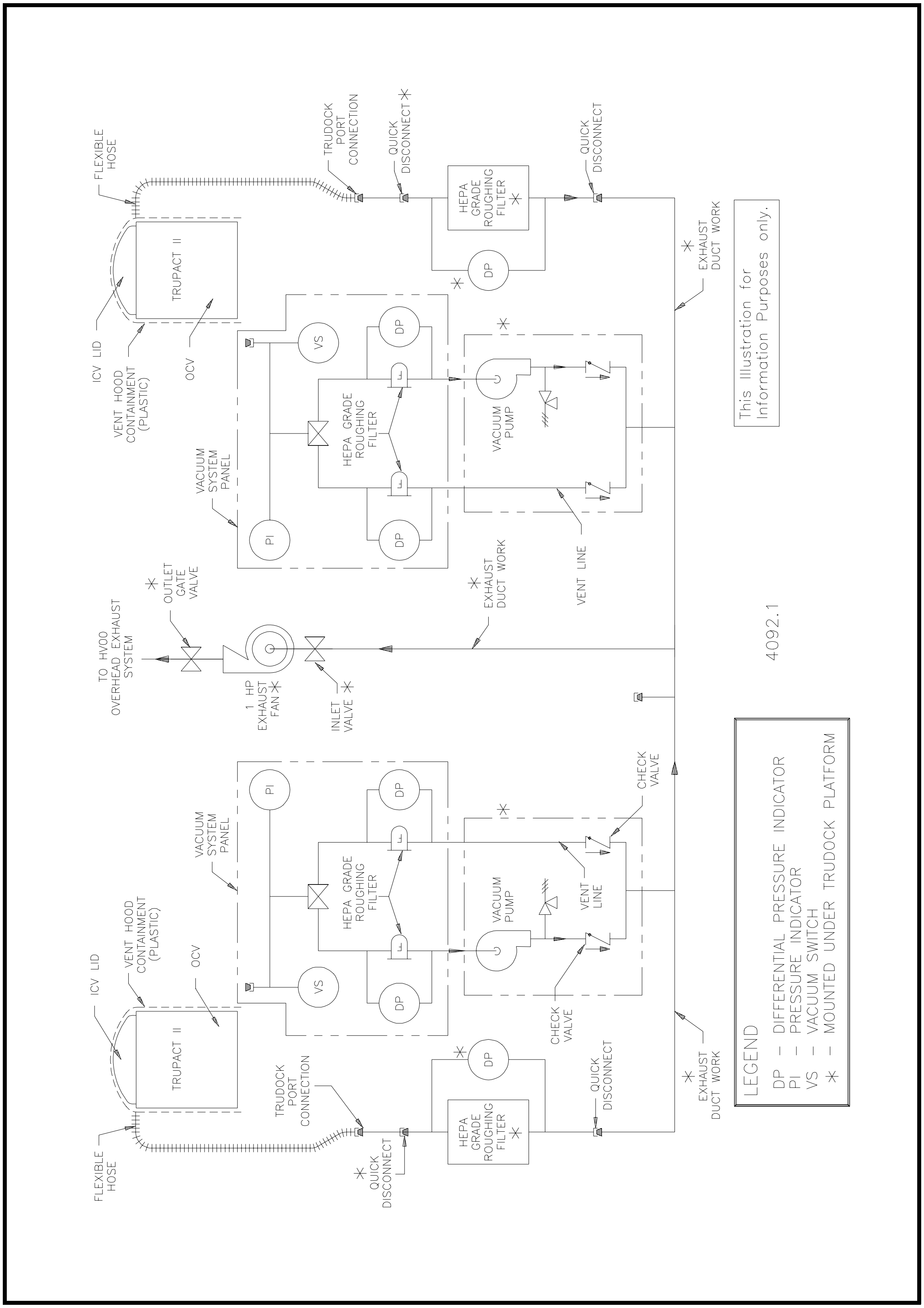


Figure 4.2-7, TRUDOCK Exhaust System

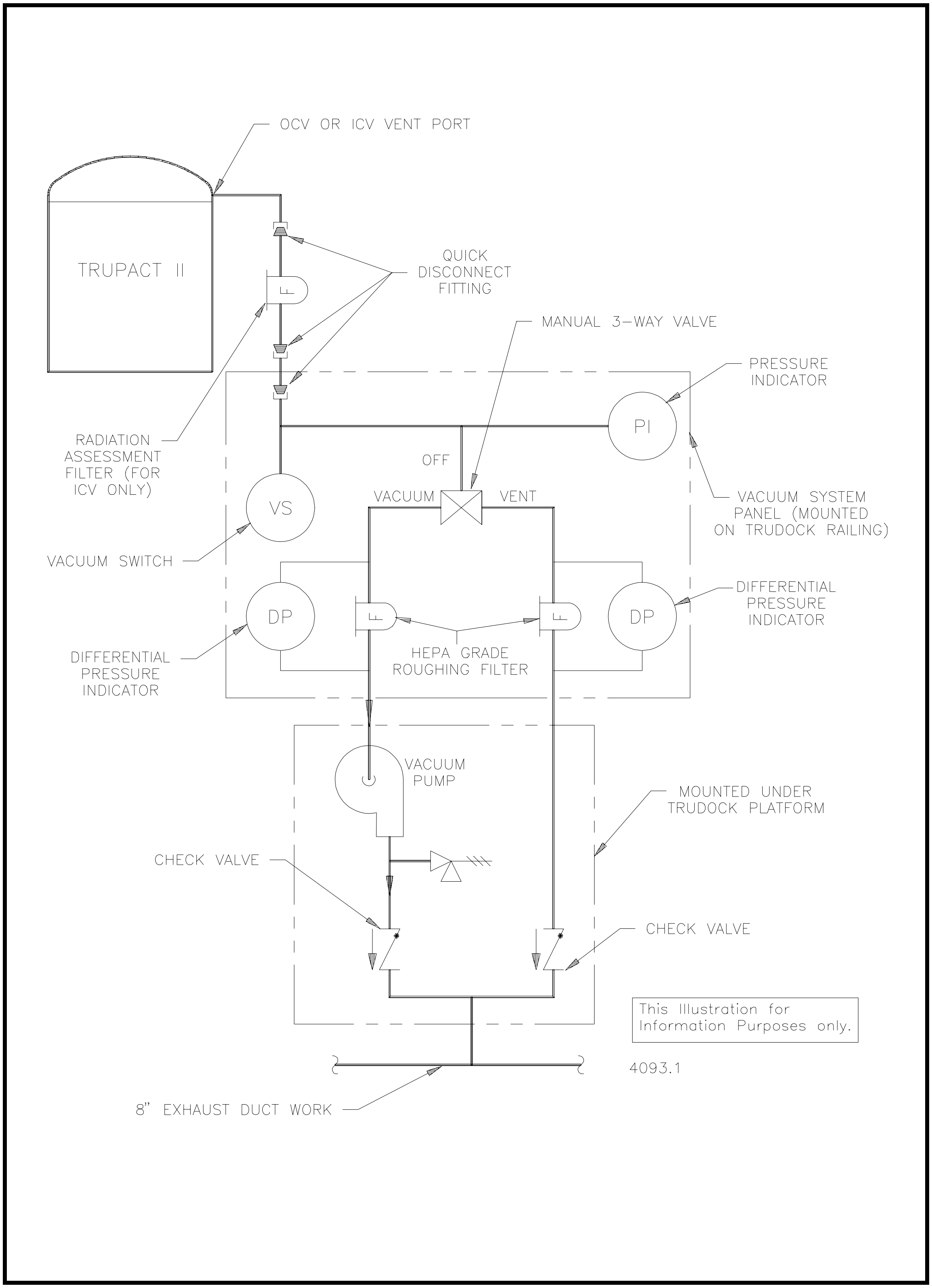


Figure 4.2-8, TRUDOCK Vacuum System Schematic

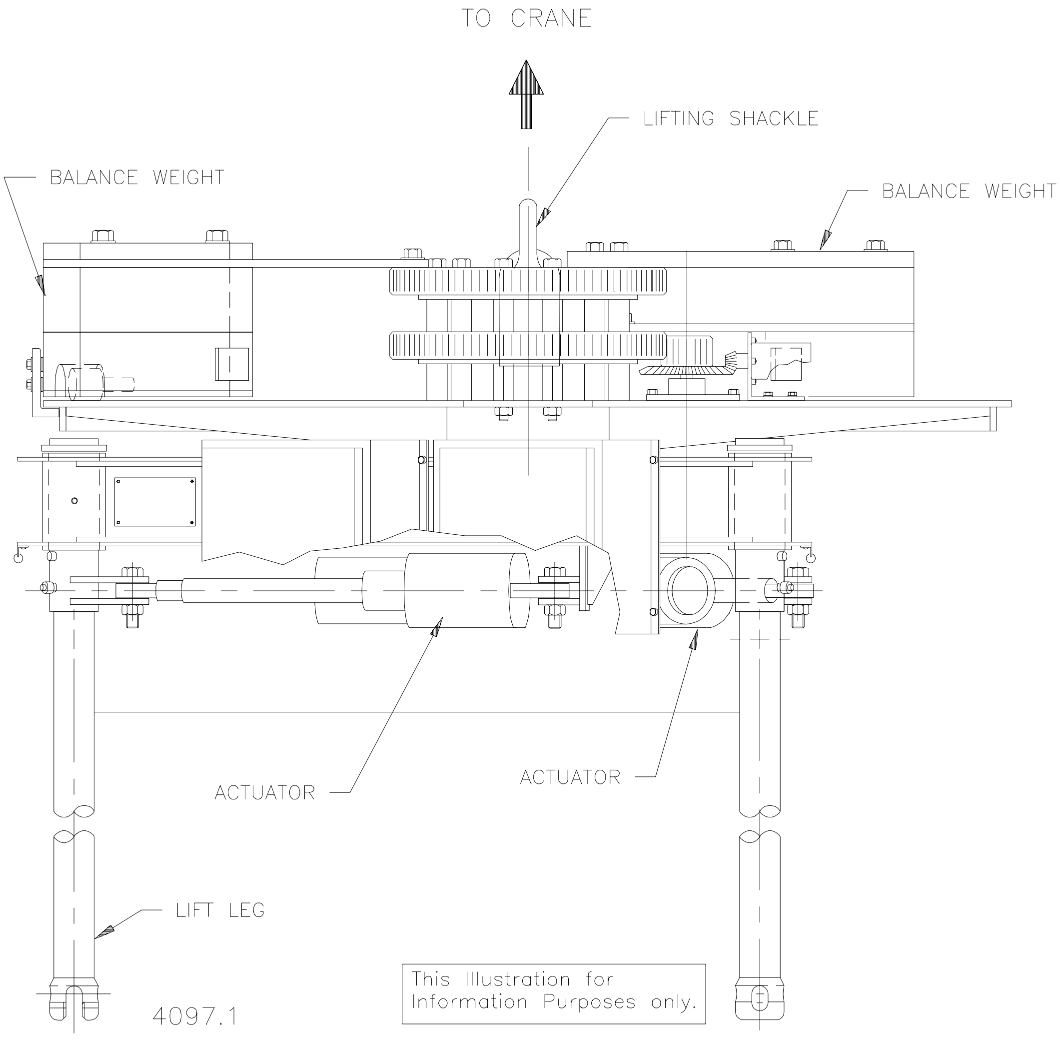


Figure 4.2-9, Adjustable Center of Gravity Lift Fixture

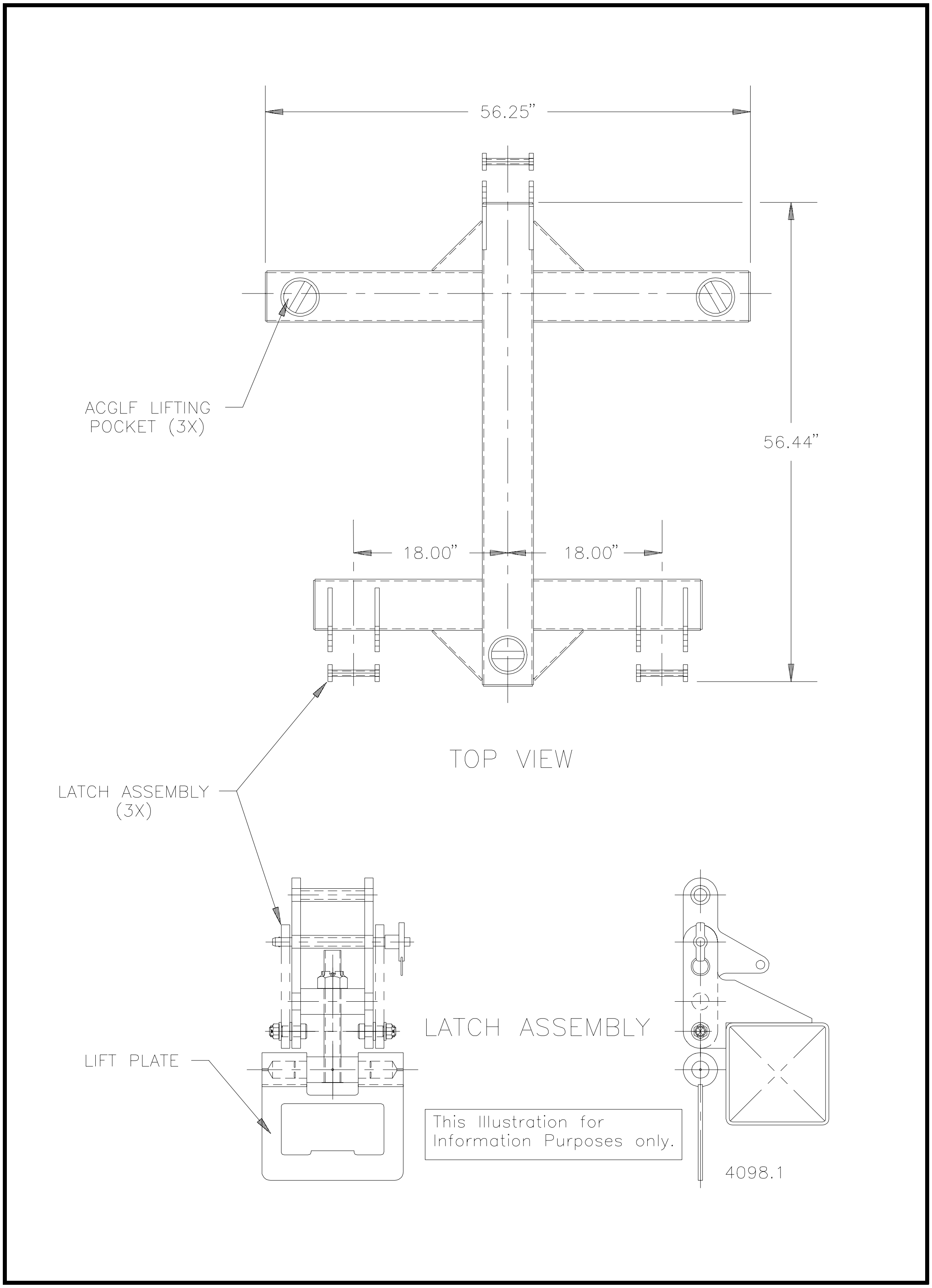


Figure 4.2-10, SWB Lift Fixture Adapter

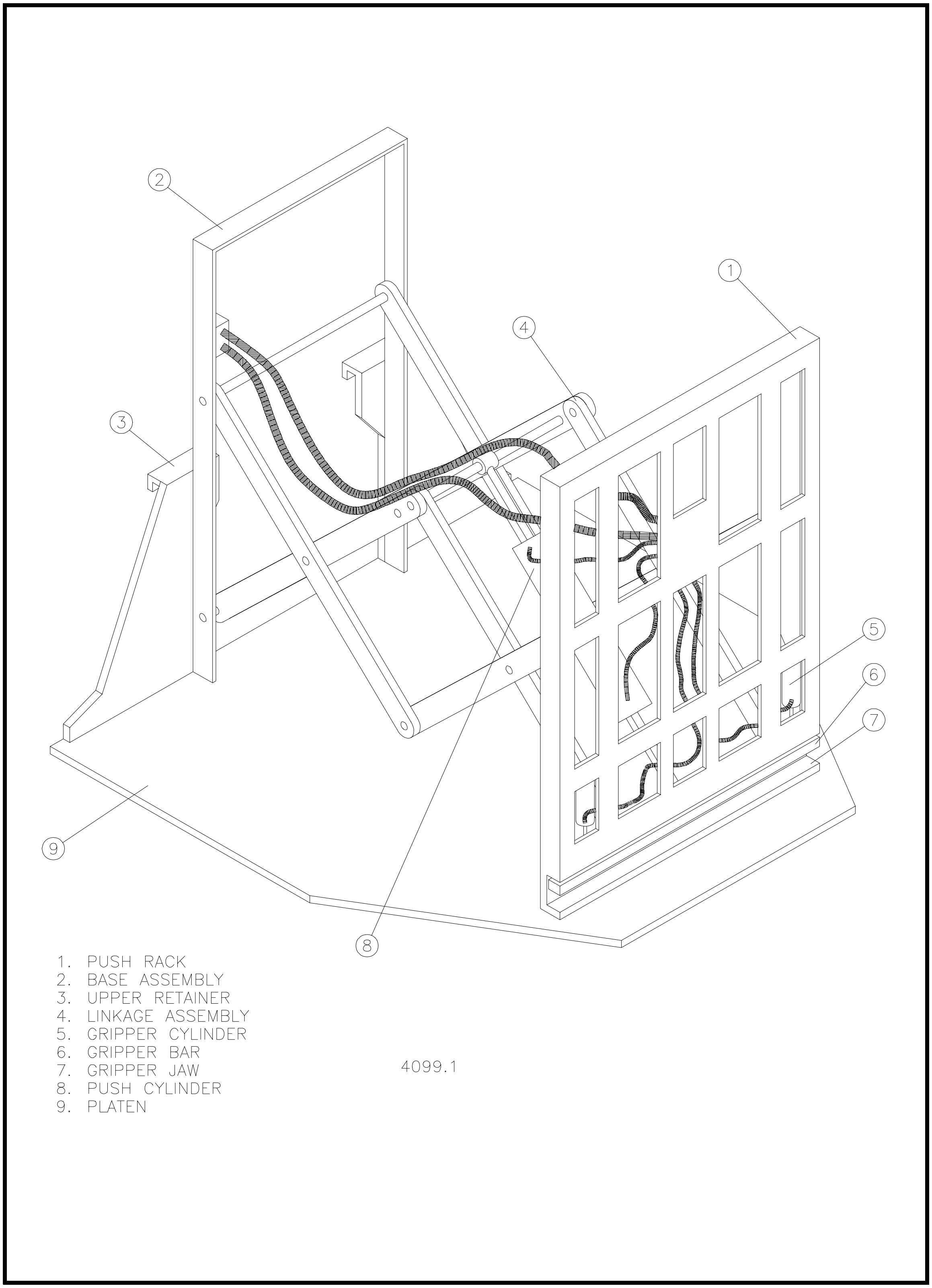


Figure 4.2-11, Brudi Attachment to allow Handling of Waste Containers

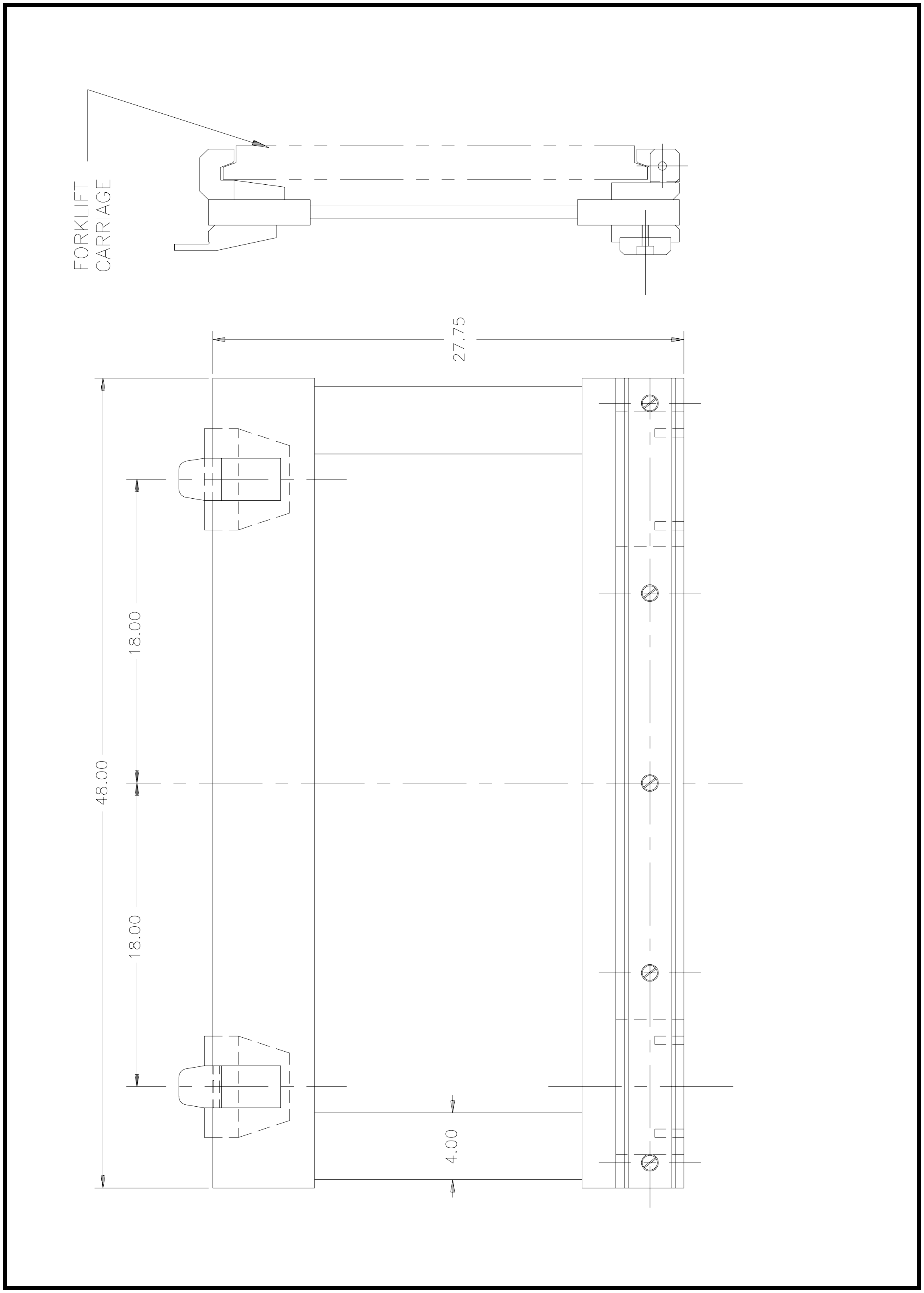


Figure 4.2-12, SWB Forklift Fixture

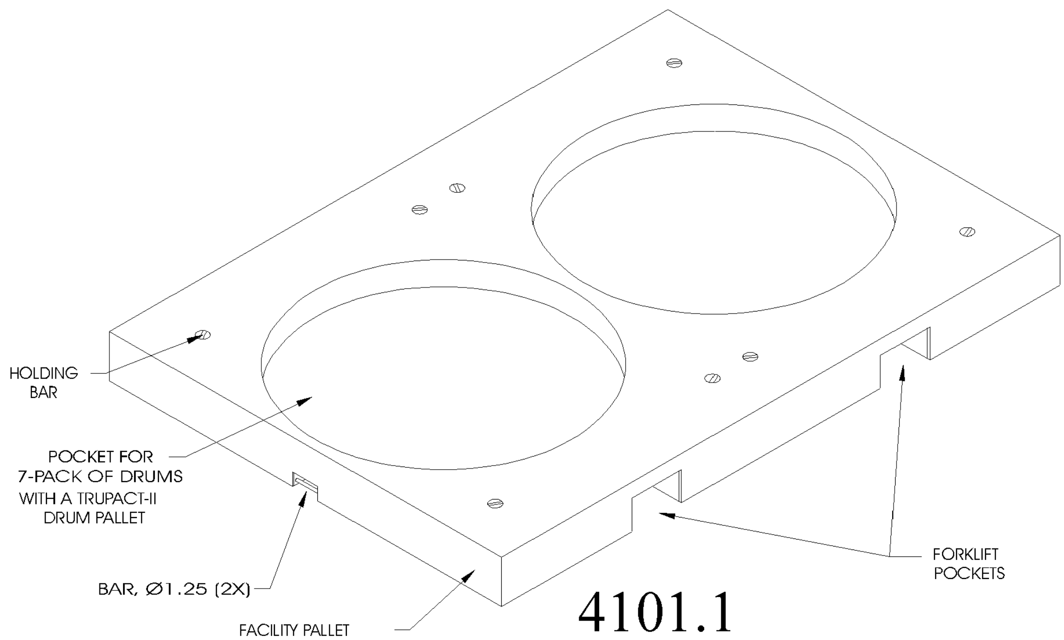


Figure 4.2-13, Facility Pallet

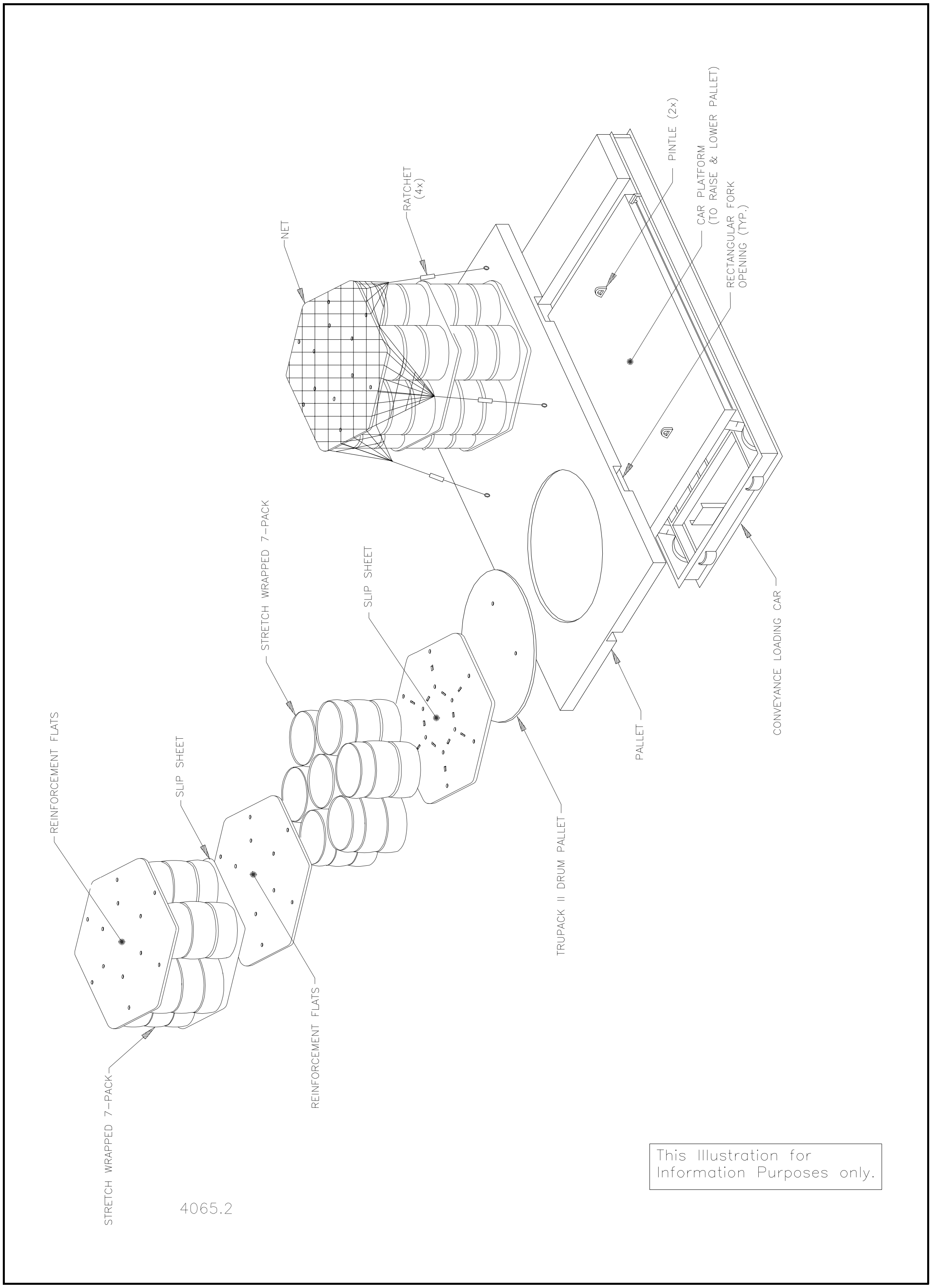


Figure 4.2-14, CH TRU Waste Pallet on Conveyance Loading Car

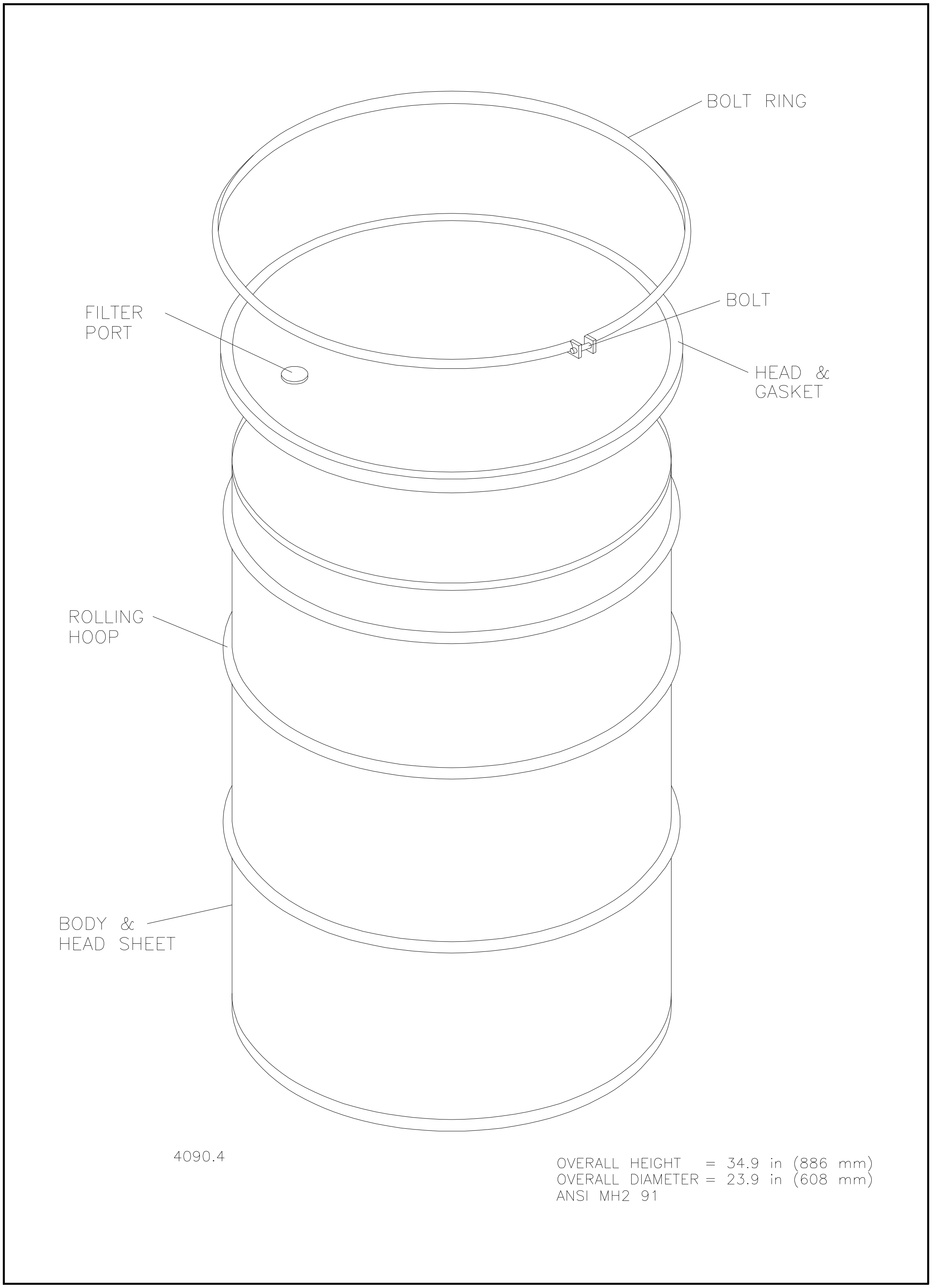


Figure 4.2-15, Standard 55-Gallon Metal Drum

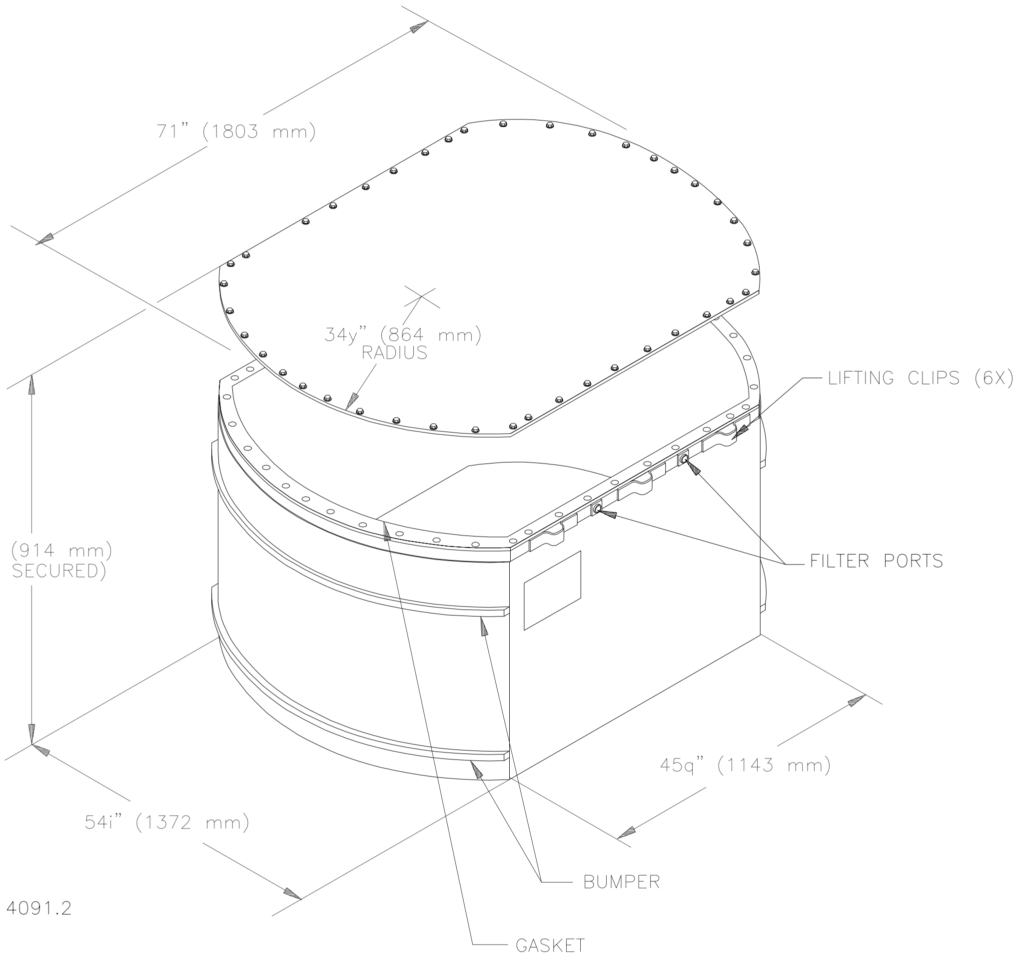


Figure 4.2-16, Standard Waste Box

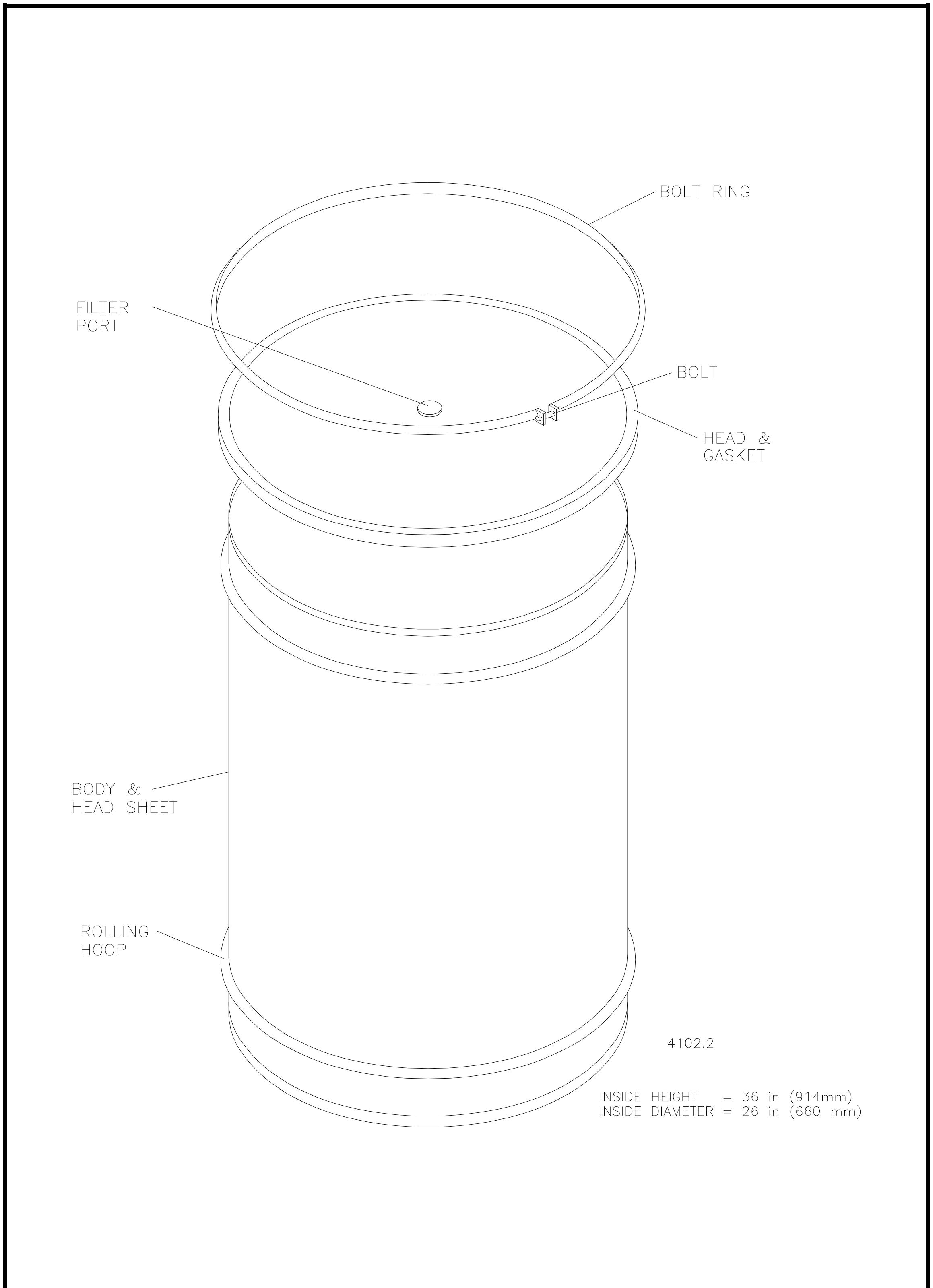


Figure 4.2-17, 85-Gallon Overpack

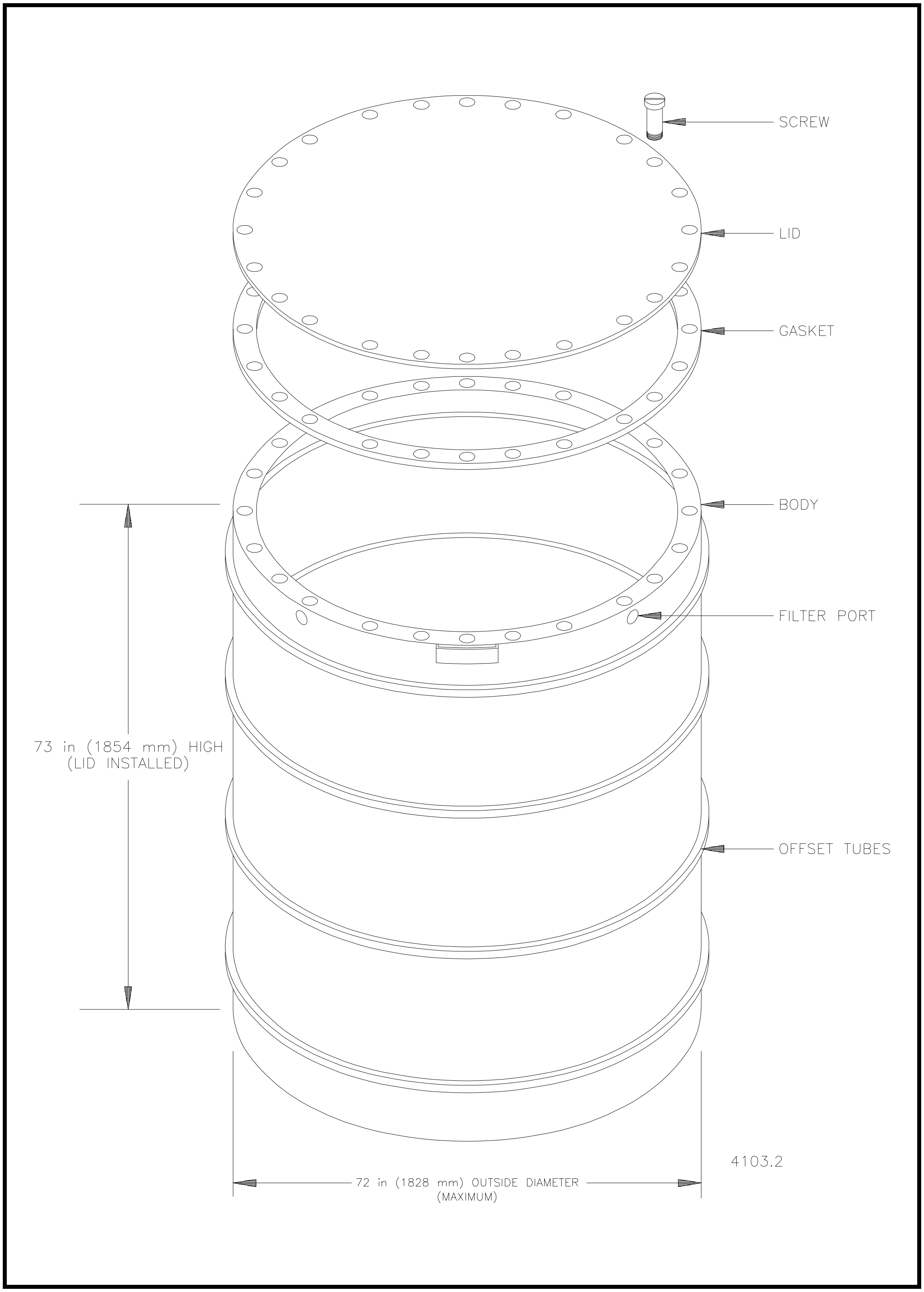


Figure 4.2-18, Ten-Drum Overpack

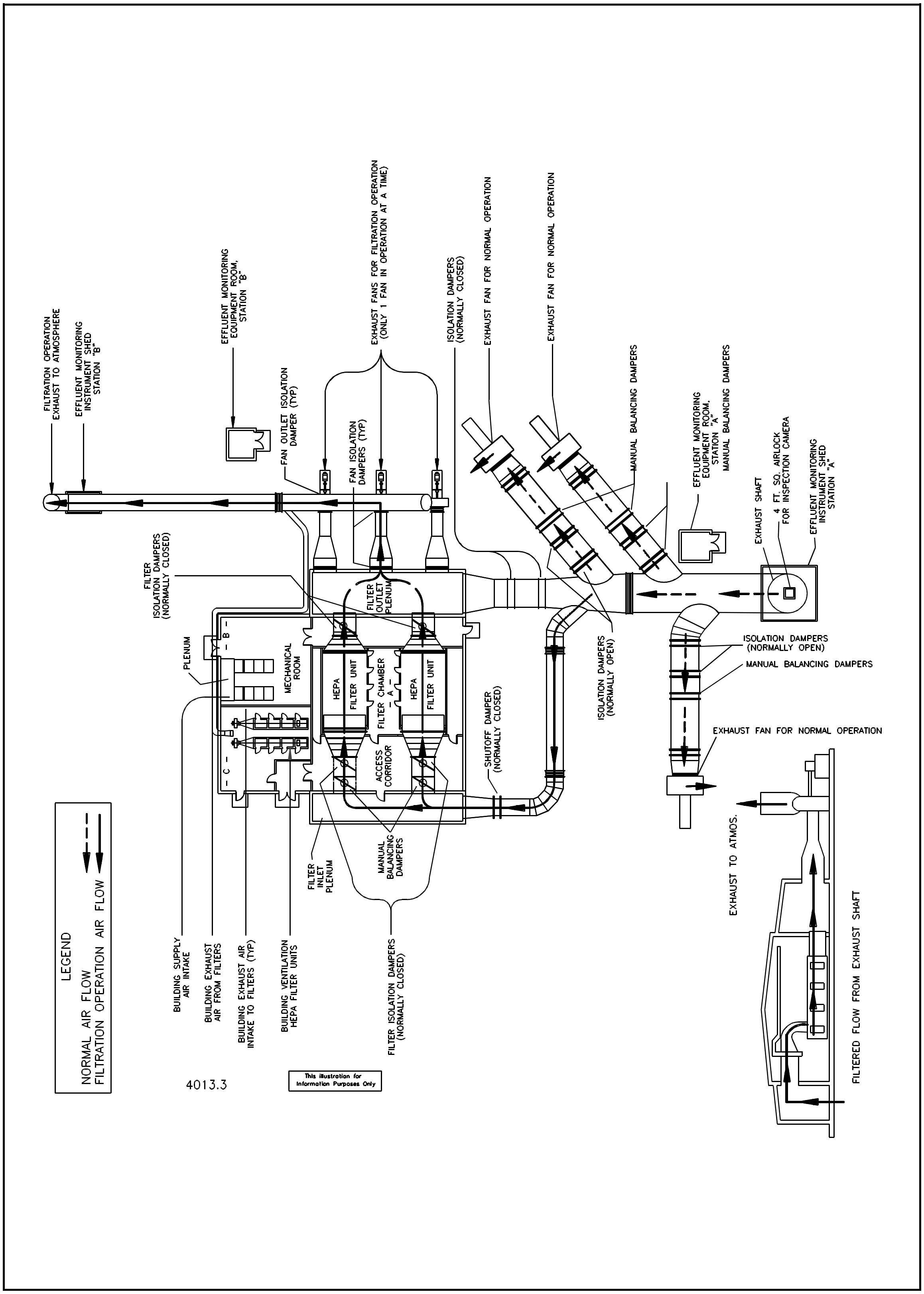


Figure 4.2-19, Exhaust Filter Building

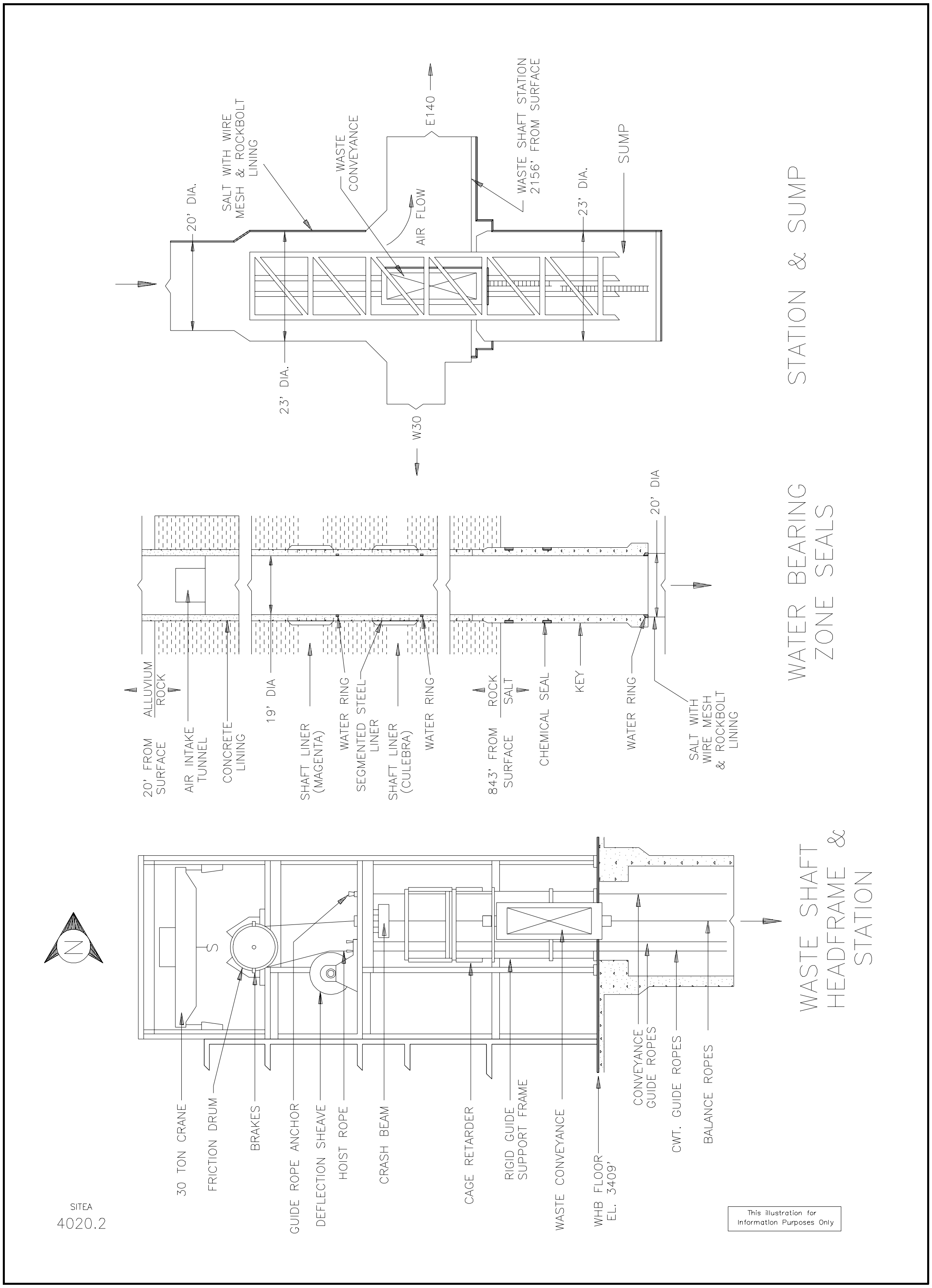


Figure 4.2-20, Waste Shaft and Hoist Arrangement

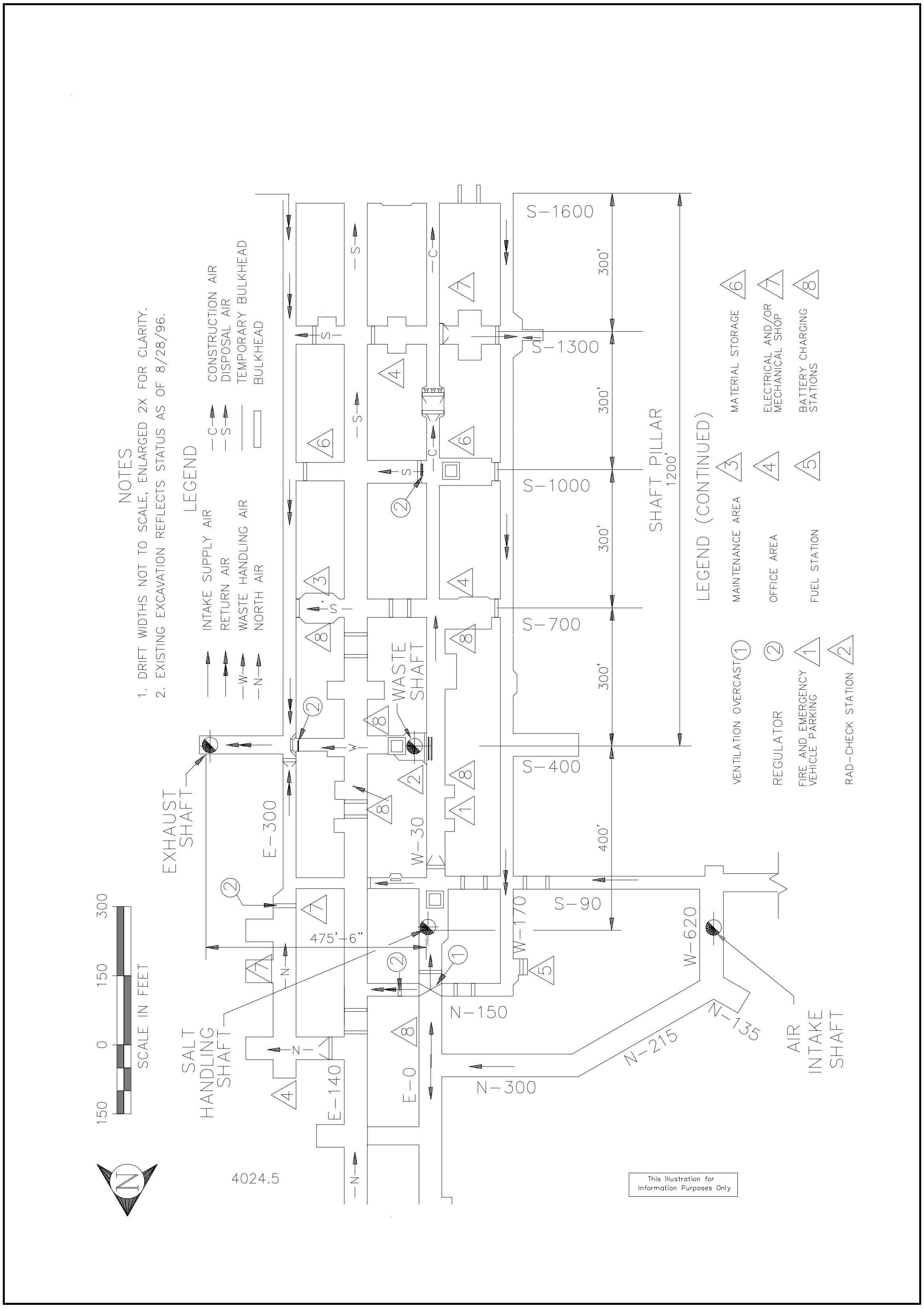


Figure 4.2-21a, Shaft Pillar Area Layout and Ventilation Flows

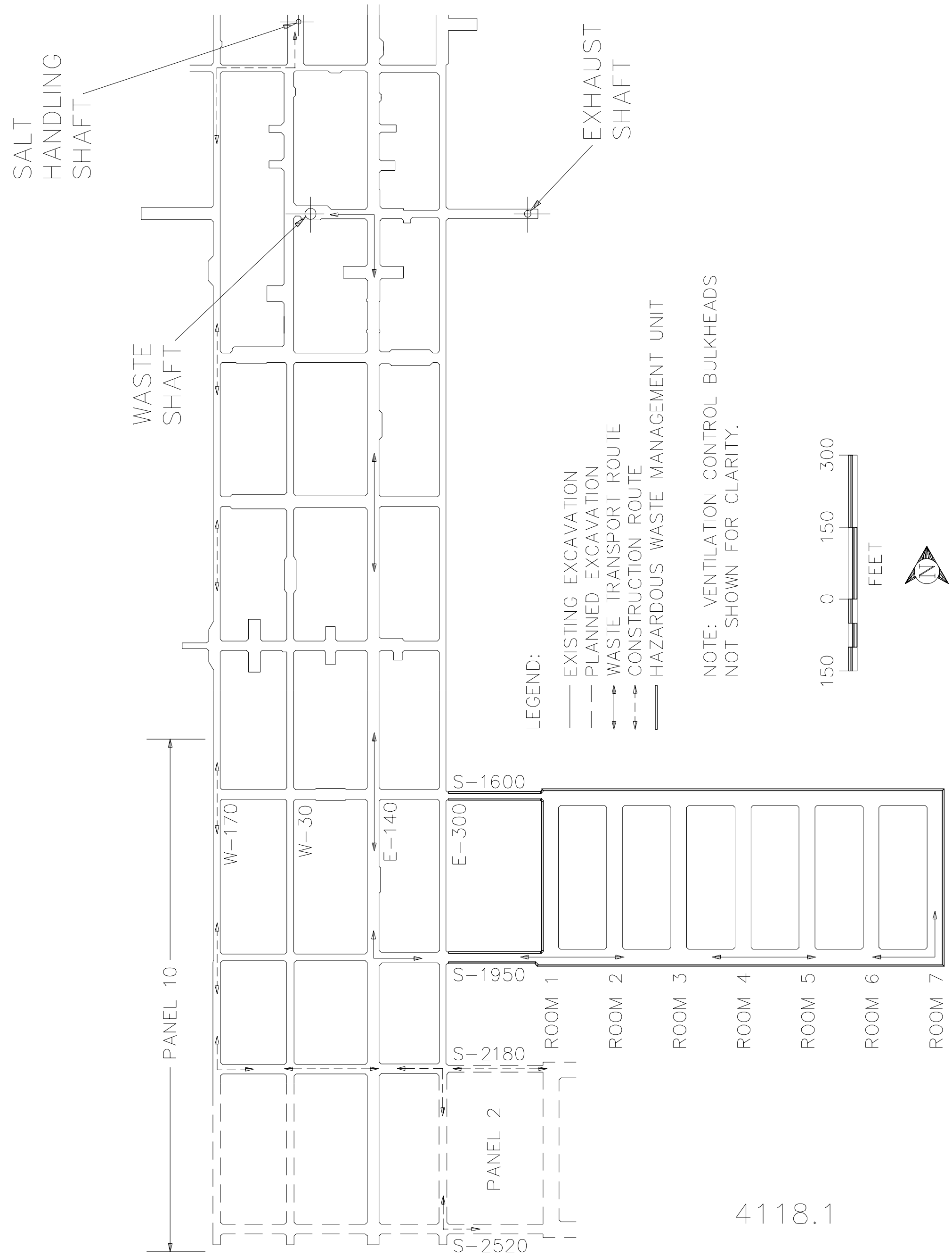


Figure 4.2-21b, Underground Transport Routes

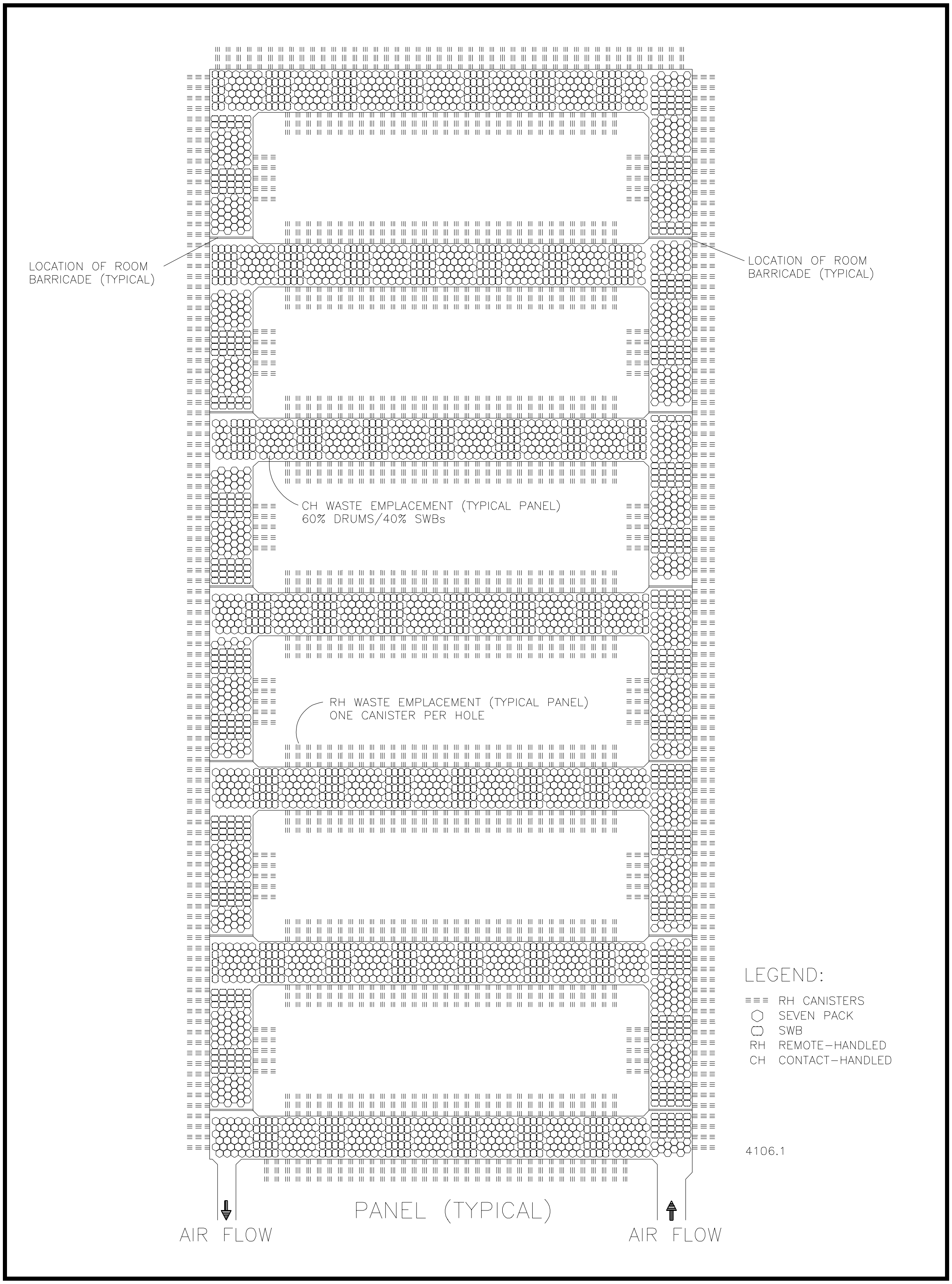


Figure 4.2-22, Typical RH and CH Transuranic Mixed Waste Disposal Configuration

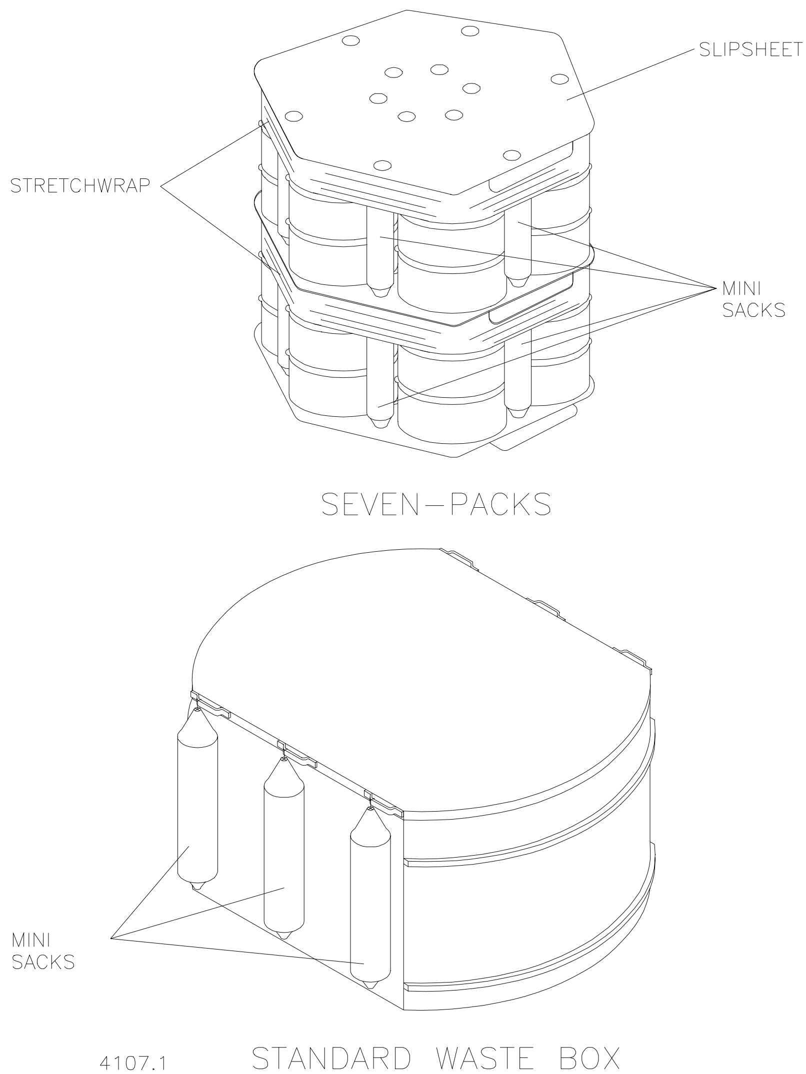


Figure 4.2-23, Waste Containers with Mini Sacks Attached

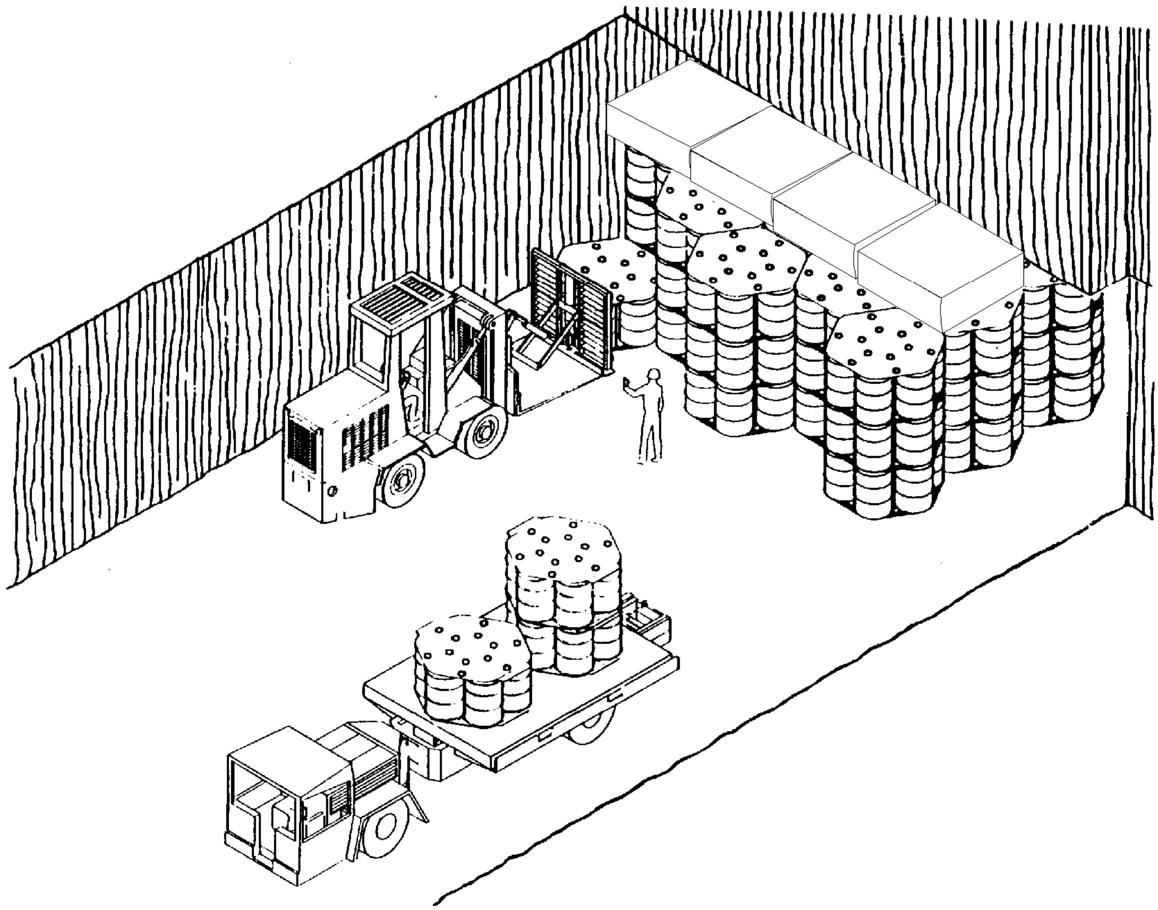


Figure 4.2-24, Backfill Emplaced in a Room

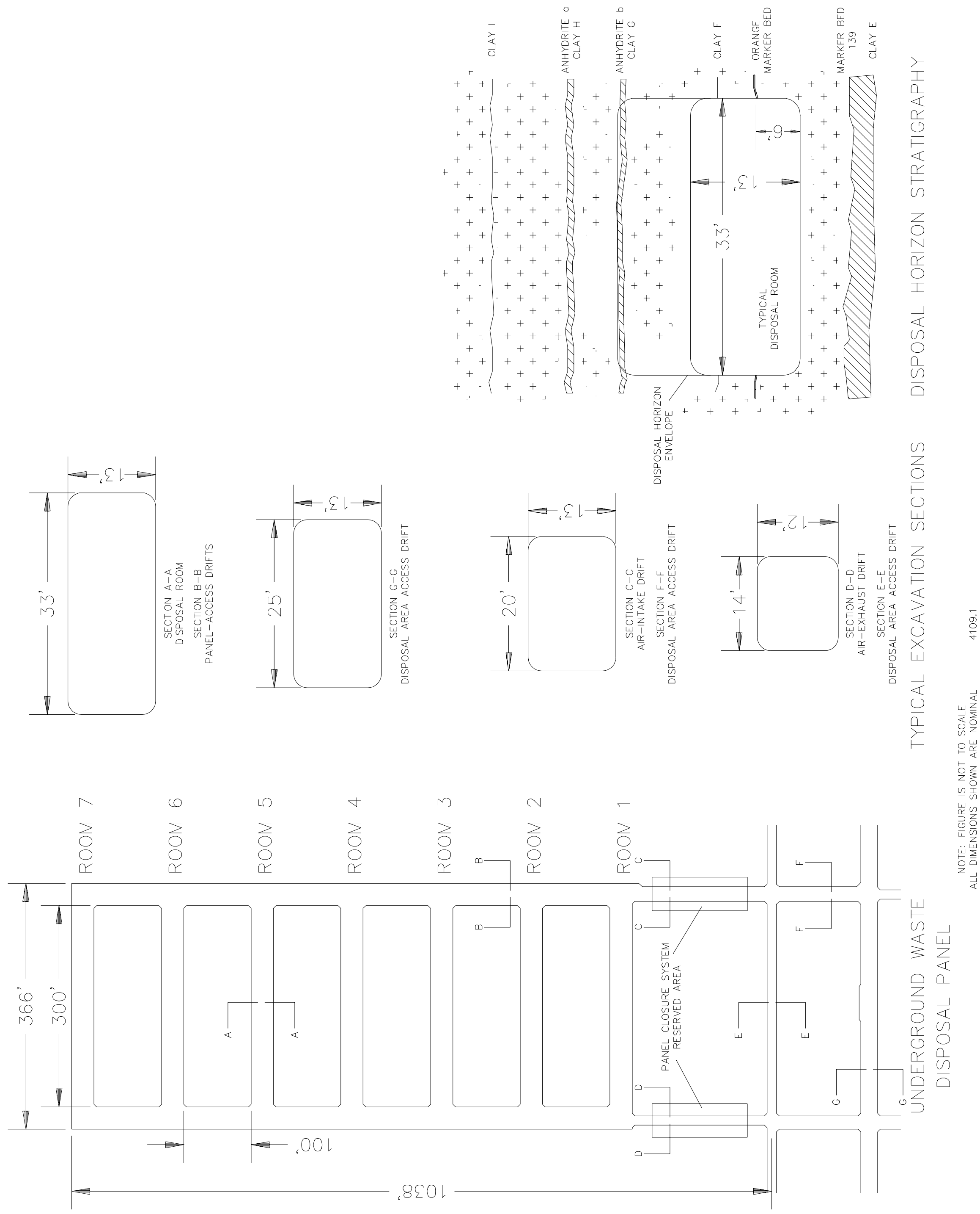


Figure 4.2-25, Typical Disposal Panel

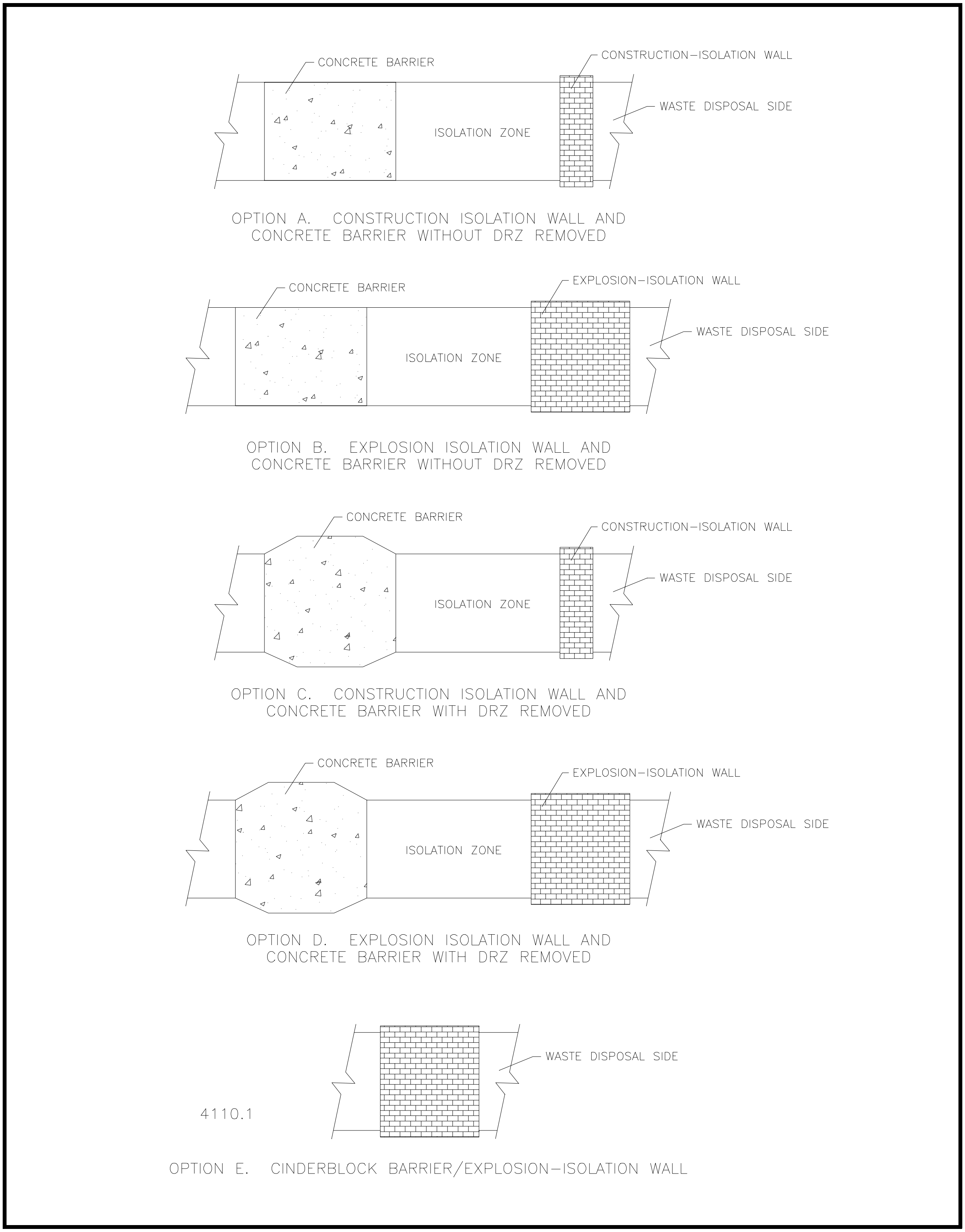


Figure 4.2-26, Design of a Panel Closure System

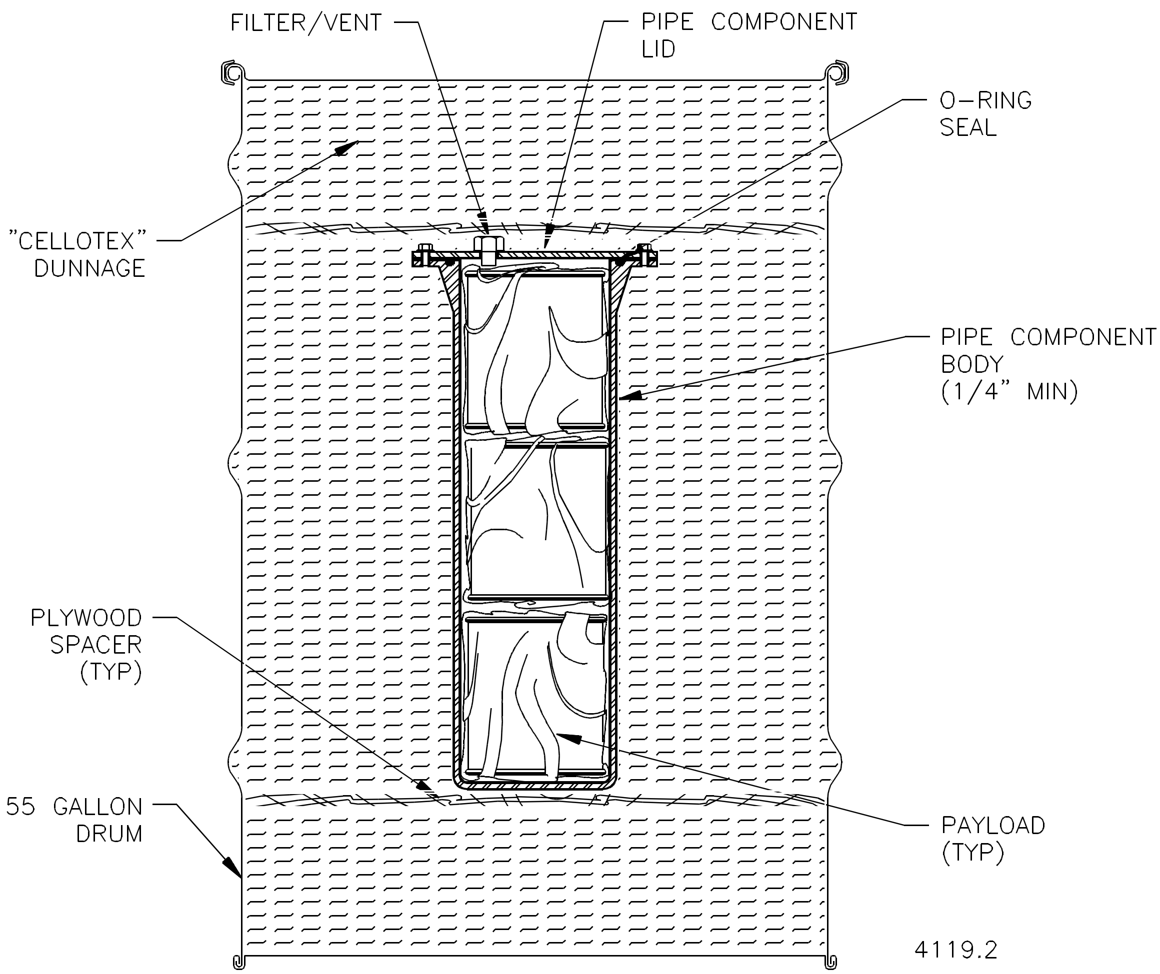


Figure 4.2-27a, Pipe Overpack

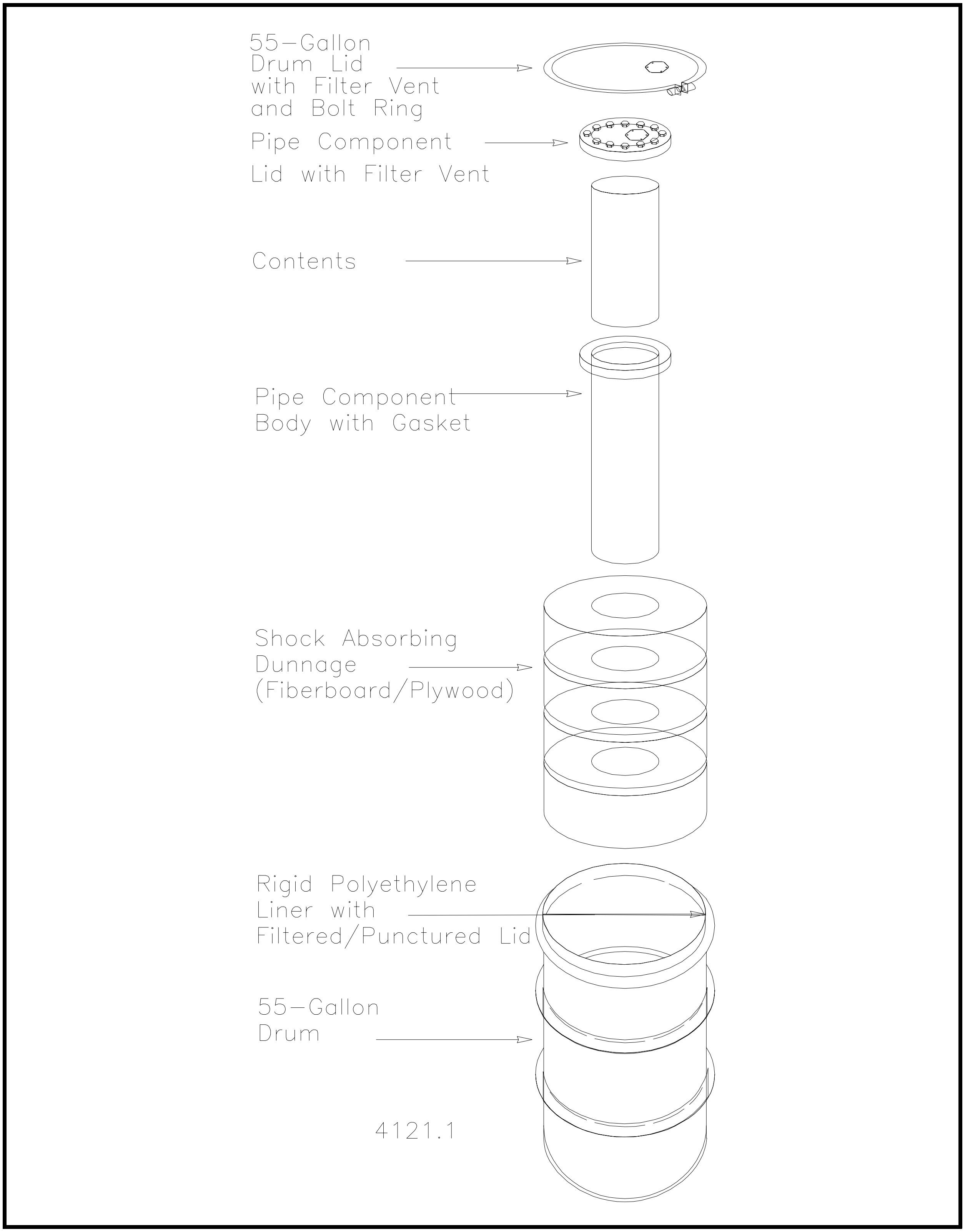


Figure 4.2-27b, Pipe Overpack

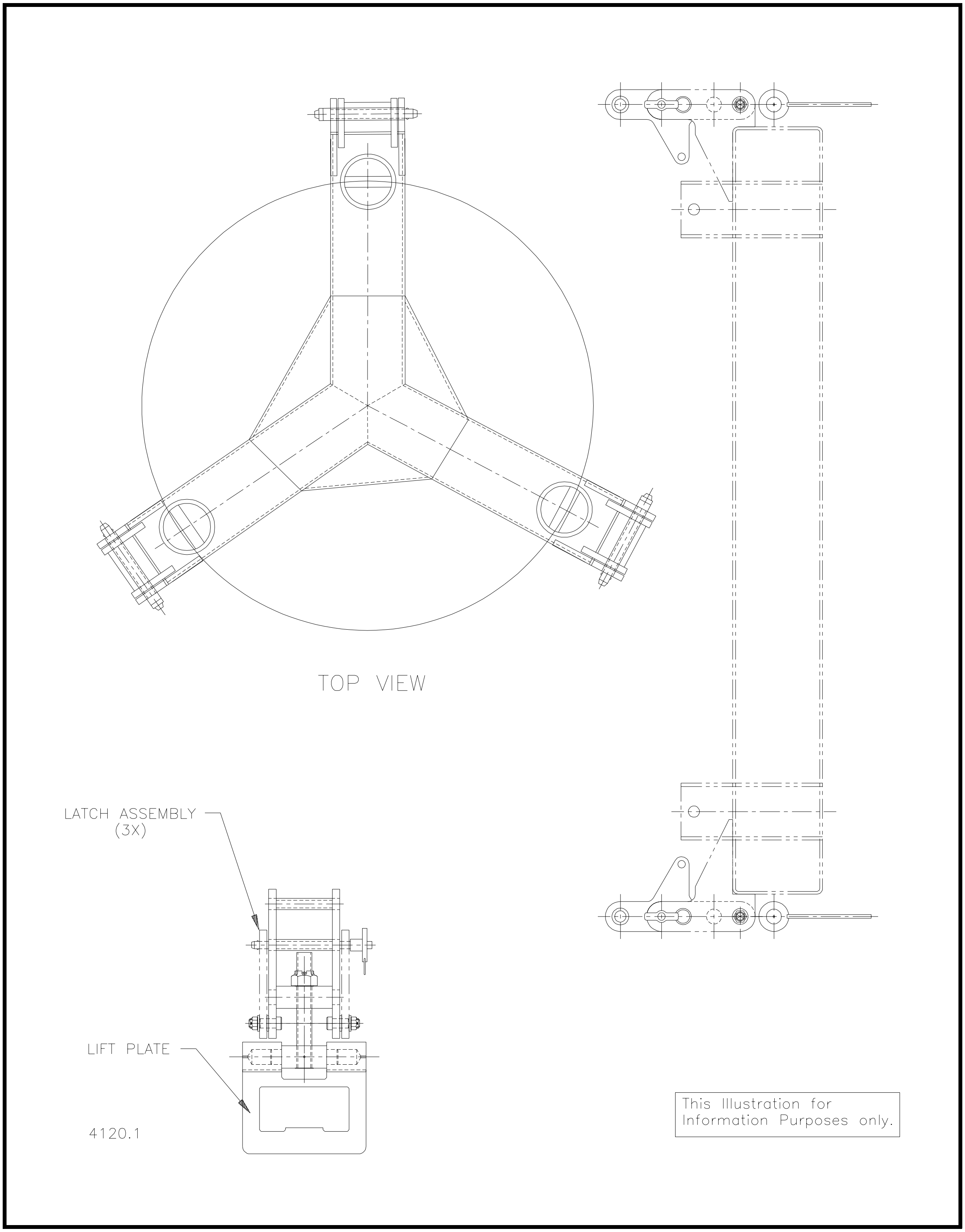


Figure 4.2-28, Ten Drum Overpack Lift Fixture Adaptor

This page intentionally blank

4.3 Process Description

This section describes the processes and systems in place for handling CH and RH TRU waste at the WIPP facility. Process descriptions begin at the gate of the WIPP facility where CH TRU and RH TRU waste will arrive by truck. Rail shipments are not addressed at this time since they are not a current shipping mode. Descriptions of the transportation system are beyond the scope of the SAR.

This chapter addresses WIPP facility operation relative to design bases (e.g., 35-year operational life, design disposal capacity and throughput, etc). Process descriptions in this chapter are independent of the actual quantity of waste handled.

CH TRU process procedures are included in the WIPP WP 05-WH Waste Handling Operations Procedures.[1]

4.3.1 CH TRU Waste Handling System

The function of the CH TRU waste handling system is to receive the TRUPACT-II shipping packages bring them into the WHB, remove and inspect the waste containers, and move the containers to the underground disposal area. A flow diagram of the operations sequence is shown in Figure 4.3-1. TRUPACT-IIs (Figure 4.3-2) are shipped to WIPP using special trailers (Figure 4.3-3). The CH TRU loading/unloading dock area, accessed by any of three air locks, consists of two TRUDOCKS, each capable of staging two TRUPACT-IIs, for unloading.

4.3.1.1 CH TRU Waste Receiving

Each shipment is inspected; inspection includes verifying the shipment documentation, performing a security check, and conducting an initial radiological survey of the shipment as it arrives on the site. If any levels of radiation, contamination, or significant damage in excess of acceptance criteria are found, actions will be taken in accordance with the approved procedures.

Following turnover of the shipping documentation, the driver transports and parks the trailer, unhooks the transporter either outside the CA in the security yard receiving area, or inside the CA at one of the trailer staging positions. The driver is subsequently released. If outside the CA, the disconnected trailer is attached to a yard tractor and brought into the CA by operations personnel for placement to be unloaded. Final external contamination surveys are performed in the CA. After unloading, empty TRUPACT-IIs are loaded on the trailer and returned to the security yard receiving area following radiological surveys and release.

The TRUPACT-IIs are unloaded from trailers outdoors in the CA using 13-ton electric forklifts, transported through an air lock designed to maintain differential pressure in the WHB, and placed in a vacant TRUDOCK. Electric forklifts are used to minimize the impact of diesel exhaust particulates on the WHB HEPA filters. The physical arrangement and location of the air locks and TRUDOCKS are described in Section 4.2, and each air lock is sized to accommodate a TRUPACT-II on a 13-ton electric forklift.

4.3.1.1.1 CH Bay

After entry into the WHB, the TRUPACT-II is placed in a TRUDOCK, the container opened, and the waste containers removed (Figure 4.3- 4). Before the waste containers are removed from the TRUPACT-II, radiological surveys are conducted on all accessible surfaces. As the containers are removed, further radiological surveys are conducted.

The outer lid tamper seal is first removed. The outer lid is removed (If required, a vacuum is applied to the outer lid vent port to compress the lid toward the vessel body, enabling the locking ring to rotate, unlocking the lid. During this process, the atmosphere between the inner lid and outer lid is vented through industrial grade HEPA roughing filters). The underside of the outer lid and top of the inner lid are surveyed for contamination. The outer lid is removed and placed in an adjacent lay-down area with the aid of a 6-ton overhead bridge crane and specially designed lifting fixture. The vacuum pull process is repeated for the inner lid. The only difference is that a radiological assessment filter is attached to the vent port tool, upstream of the industrial grade HEPA roughing filters. The inner cavity atmosphere is vented first through the radiological assessment filter and then the industrial grade HEPA roughing filters. The radiological assessment filter is subsequently checked for radioactive contamination. The TRUDOCK Vent-Hood System (TVHS) is attached to the inner containment vessel (ICV) lid, and the lid raised. The TVHS provides atmospheric control and confinement of headspace gases at their source. It also prevents potential personnel exposure and facility contamination due to the spread of radiologically contaminated airborne dust particles, and minimizes personnel exposure to volatile organic compounds (VOC). The air from the vent hood is monitored by an alpha CAM prior to passing through an in-line industrial grade HEPA filter system. The air is then released to the WHB return air ducts. Functionally, the TVHS consists of 1) vent-hood assembly, 2) industrial grade HEPA filter assembly, 3) fan to provide forced airflow, 4) ductwork, and 5) a flexible hose.

Prior to moving the lid aside, contamination surveys under the vent hood are performed on the inner lid and accessible waste container surfaces. If no contamination is detected, the vent hood is removed, and the ICV lid set aside using the same overhead bridge crane and lifting fixture. Additional contamination surveys are performed on the waste containers. If no contamination is detected, the overhead 6-ton crane is used to remove and transfer the TRUPACT-II payload to the prepositioned facility pallet. A typical TRUPACT-II contains fourteen 55-gallon (208 L) drums that are stretch wrapped or banded together into two seven-packs. Each seven-pack, or assembly, sits on a molded slip sheet that is made of high molecular density polyethylene or kraft board (cardboard). A second slip sheet is placed on top of the seven-pack, and the entire assembly is held together by stretch wrap or steel banding.

Final contamination surveys are conducted, and the waste container identification numbers are recorded using a bar code reader system for transfer to the inventory tracking system. For inventory control purposes, TRU mixed waste container identification numbers will be verified against the shipping documentation. Inconsistencies will be resolved with the generator before TRU mixed waste is emplaced. If inconsistencies cannot be resolved, the TRUPACT-II and waste containers will be shipped back to the generator/storage site. Waste awaiting the resolution of discrepancies will be stored in the storage area located in the southeast corner of the CH Bay. The loaded facility pallet is transported, using a 13-ton electric forklift, to the northeast area of the CH bay for normal storage. This storage area, which is shown in Figure 4.3-5, will be clearly marked to indicate the lateral limits of the storage area. A maximum capacity of seven pallets (1,441 ft^3 [40.8 m^3]) of waste may be stored in the normal storage area and the TRUDOCK area combined during normal operations (Figure 4.3-5).

The pallets will typically be staged in the normal storage area prior to downloading to the disposal area.

Aisle space will be maintained in all CH Bay waste storage areas. The aisle space will be adequate to allow unobstructed movement of fire-fighting personnel, spill-control equipment, and decontamination equipment that would be used in the event of an off-normal event. An aisle space of 44 in. (1.1 m) between facility pallets will be maintained in all CH TRU waste storage areas.

In addition, four TRUPACT-IIs, may occupy the staging positions at the TRUDOCK. If waste containers are left in the TRUDOCK area, they will be in the TRUPACT-II shipping package or on facility pallets. The volume of waste in four TRUPACT-IIs is 411.7 ft^3 (11.7 m^3).

A derived waste storage area is shown in Figure 4.3-5 on the north wall of the CH Bay. This area will contain containers up to the volume of a SWB for collecting derived waste from all waste handling processes in the WHB. The DOE is permitting this area so that containers in size up to a SWB can be used to accumulate derived waste. Using a SWB facilitates safer, easier, and more efficient handling of filled derived waste containers. The volume stored in this area will be up to 65.4 ft^3 (1.85 m^3). A 3-ton electric forklift is used for general purpose transfer operations. This forklift has attachments and adapters to handle individual CH TRU waste containers, if required.

Normal operations for receipt and emplacement of seven-packs of drums containing CH TRU waste do not include removal of empty drums received as dunnage in the seven-pack. Seven-packs consisting entirely of empty drums will be dispositioned in the most cost-efficient manner (returned to the generator site, scrapped, etc.).

After the waste containers are removed from the TRUPACT-IIs, a final radiological survey and maintenance inspection are performed on the package, and the unit is prepared for reuse and removal from the WHB. This is accomplished by a series of inspections, and by replacing the pallets and container closures. The TRUPACT-II is reloaded on a trailer and prepared for departure to a shipping site.

4.3.1.1.2 Shielded Holding Area

An area has also been designated for the temporary storage of waste containers for which manifest discrepancies were noted after the TRUPACT-IIs were opened. Discrepant payloads will either be placed onto a facility pallet or placed back into the TRUPACT-II and placed into the Shielded Storage Room (also known as Shielded Holding Area). The storage capacity of this area is one pallet load (i.e., 4 SWBs, 2 TDOPs, or 28 drums, or combinations of all three). If discrepancies cannot be resolved within 30 working days, the waste will be returned to the generator site.

Use of this area is in accordance with the WIPP WP 05-WH Waste Handling Operations Procedures.[1]

4.3.1.1.3 Conveyance Loading Room

The conveyance loading room is an air lock adjacent to the waste shaft. A pallet of waste containers is moved by forklift into this air lock and placed on the conveyance loading car. The conveyance loading car (Figure 4. 2-14) is an electrically driven car on rails, designed with an adjustable-height flat bed used to transfer the CH TRU facility pallets on or off the pallet support stands located in the waste hoist cage. With the outer air lock door closed, the conveyance loading car moves the pallets on the hoist cage and transfers the pallets to the pallet support stands in the waste hoist cage. The waste hoist cage (or conveyance) operating in the waste shaft is a multi-rope, friction type hoist, and has inside dimensions of 9 ft (2.7 m) by 15 ft (4.6 m) by 24 ft (7.3 m) high. Normally, one facility pallet (two TRUPACT-II loads consisting of 28 drums, four SWBs, or two TDOPs) will be carried at a time. Finally the hoist lowers the waste containers to the disposal horizon. Personnel may be carried on the upper deck when waste is not being hauled.

4.3.1.1.4 CH TRU Waste Shaft Station

At the waste shaft station, the underground waste transporter backs up to the waste hoist cage, and the pallet is pulled onto the integral tractor trailer transporter (Figure 4.3- 6). The tractor is a commercially available, diesel-powered unit modified as necessary to interface with the trailer, and comply with mine and other safety codes. The trailer is designed specifically for transporting palletized CH TRU waste and is sized to accommodate the CH TRU facility pallet (Figure 4.3- 7). The transporter then moves the waste containers to the waste disposal room. Underground transporters are equipped with fuel tanks resistant to rupture, and speed governors to minimize the potential consequences of underground accidents. As shown in Figure 4.2-21b, the separation of the excavation and transport routes removes the potential for collisions with the underground transporter along the waste transportation route. No other vehicles will be moving in the waste transport route while moving waste in the underground.

4.3.1.1.5 CH TRU Waste Disposal Area

At the waste disposal room, the waste containers are removed from the transporter using diesel and battery powered CH TRU waste underground lift trucks, and stacked in the disposal face. The lift trucks are equipped with push/pull rack attachments and specially designed fixtures to lift and move individual seven-packs, single drums of waste containers (drums), TDOPs, or SWBs. Seven-packs, single drums, TDOPs, and SWBs are stacked in such a manner that the criticality Technical Safety Requirements (TSR) administrative controls are not violated (Figure 4.3-8a). Drums, boxes, and TDOPs are intermixed, as practical and for stability; overpack containers in four-pack assemblies are always placed on the top row of the waste stack, TDOPs are placed on the bottom row (Figure 4.3-8b). After the waste containers are removed from the facility pallets and the TRUPACT-II pallets, these pallets are returned to the surface for reuse.

The waste will be emplaced room by room in Panels 1 through 8. Panels 9 and 10 may also be used to reach the full authorized capacity of 6.2 million ft^3 (175,600 m^3). Each panel will be closed off when filled. If a waste container is damaged during the Disposal Phase, it will be immediately overpacked or repaired. CH TRU waste containers will be equipped with filter vents. The filter vents will allow aspiration, preventing internal pressurization of the container and minimizing the buildup of flammable gas concentrations.

Panel construction may occur during the waste emplacement. Once a waste panel is mined and any initial ground control established, flow regulators will be constructed to assure adequate control over ventilation during waste emplacement activities. The first room to be filled with waste will be Room 7, which is the one that is farthest from the main access ways. The disposal phase will begin with CH waste only in Panel 1. When combined CH and RH operations begin, the first activity in the appropriate room will be to drill RH TRU emplacement holes into the ribs. Once this is complete, the RH drilling machine will be moved to next lower number (7 to 6, or 6 to 5, etc.) room. A ventilation control point will be established for the Room just filled, outside the exhaust side of the next Room (Figure 4.3-9a). This ventilation control point will consist of a bulkhead with a ventilation regulator. The initial waste emplacement activity in the panel will be the placement of RH canisters in the predrilled holes in the ribs. Each room and associated access drifts will hold approximately 90 canisters of RH waste. Once RH emplacement is completed, CH emplacement will commence.

Stacking of CH waste will begin at the ventilation control point and proceed down the access drift, through the room and up the intake access drift until the entrance of next room is reached (Figure 4.3-9b). At that point, a fire resistant, Mine Safety and Health Administration approved, brattice cloth and chain link barricade (Figures 4.4-8 and 4.4.-9) will be emplaced. This process will be repeated for the remaining rooms, and so on (Figures 9a through 9e) until the panel is filled (Figure 4.3-10). At that point, the panel closure system will be constructed.

The anticipated schedule for the filling of each of the underground Panels 1 through 8 is as follows. The following assumptions are made in estimating the time to fill each panel:

- Throughput for CH waste is 784 drums per week (7 pallets per day, 4 days per week, 28 drums per pallet).

- The capacity of a panel is 81,000 drums.

Under these assumptions, a minimum of 104 weeks is needed to emplace the waste. Allowing a 25 percent contingency for maintenance delays and time to transition from one room to another, it is estimated that a panel will be filled 2.5 years after emplacement is initiated. Panel closure in accordance with the Closure Plan in Chapter I, RCRA, Part B Permit Application[3] is estimated to require an additional 150 days.

4.3.2 RH TRU Waste Handling System

The RH TRU waste handling system, including each function, the equipment used, and the operations performed, is discussed in this section. A schematic flow diagram of the RH TRU handling is given in Figure 4.3-11, and a pictorial view of the surface operation is given in Figure 4.3-12. The RH TRU waste handling area is designed to provide for an outdoor storage area and space exists to store six RH TRU waste trailers.

The RH TRU waste shielded road cask (shipping container) is a legal weight DOT Type B truck cask designed to transport a single canister of RH TRU waste per shipment. The cask provides two levels of containment and will be certified by the NRC per 10 CFR 71.63(b). Stainless steel is the primary structural material used for the inner and outer vessels. The outer vessel incorporates lead shielding to assure the surface radiation levels are below DOT limits. The general road cask arrangement, shown in Figure 4.3-13, includes impact limiters at each end of the road cask which function to provide protection of the seal areas during the hypothetical transport accident events.

The RH TRU waste handling system is designed to overpack up to two percent of the canisters handled at the WIPP facility.

4.3.2.1 RH TRU Waste Receiving

Each incoming shipment is inspected, the inspection process checks the shipment manifest, verifies the shipment contents, performs a security check, and performs an initial exterior radiological survey of the shipment as it arrives on the site. If any levels of radiation, contamination, or significant damage in excess of acceptance criteria are found, actions will be taken in accordance with the waste handling operations procedures.

The two impact limiters are removed from the road cask while still on the trailer. With the impact limiters removed, the gross weight of the loaded road cask is 20 tons. Overall dimensions of the shielded road cask with the impact limiters removed are a diameter of 42 in (107 cm) and an overall length of 142 in (361 cm). A bridge crane engages the shielded road cask and rotates it to the vertical position for subsequent transfer to the road cask transfer car. The crane has a main hook capacity of 140 tons and a 25-ton auxiliary hook. Other equipment includes load measuring devices capable of measuring 150 percent of capacity, and a handling yoke for upending and lifting the shielded road cask.

4.3.2.1.1 Road Cask Preparation

The road cask preparation area includes the road cask transfer car with an integral work platform, where the road cask is prepared for unloading. The road cask transfer car (Figure 4.3-14) is an electrically powered, tracked vehicle for supporting and transferring the shielded road cask between the road cask preparation area and the road cask unloading room of the WHB. The road cask transfer car incorporates position sensors that stop car travel when the cask is centered under the shielded road cask unloading room port of the hot cell in preparation for cask closure removal.

The outer closure is removed using appropriate radiological surveys for surface contamination and radiation level.

The shielded road cask inner closure bolts are loosened and the shielded road cask seal collar is installed. Radiological monitoring is required for these and subsequent operations that call for personnel to work in direct contact with the loaded road cask.

4.3.2.1.2 Road Cask Unloading

The shielded road cask, mounted on the road cask transfer car, is moved to the road cask unloading room and positioned under the hot cell unloading port which mates with the shielded road cask seal collar. At this point, personnel leave the area and close the shield door.

4.3.2.1.3 Hot Cell Canister Handling

Inspection of the RH TRU waste canisters occurs in the hot cell. The hot cell is an exclusion area when canisters of RH TRU waste are present, and any reentry after RH TRU waste handling requires a radiological survey of the cell area. The hot cell area has its own 15-ton capacity bridge crane and grapple for canister handling inside the cell, and handling operations are performed in the following sequence:

- The shield plug between the hot cell and the road cask unloading room is removed from the hot cell floor and placed in the hot cell laydown area.
- The inner cask head is then lifted into the hot cell and placed in the laydown area.
- A seal protector is installed on the shielded road cask from the hot cell.
- The canister is lifted from the shielded road cask and moved to the hot cell inspection station.

- The inspection station contains the equipment holding the canister in a vertical position. Manipulators are used to swipe the canister and the swipes are removed using the shielded transfer drawer to check for contamination. If the canister is contaminated or physically damaged, the canister is placed in an overpack and the overpack head placed on the unit and welded. Upon completion of the overpack operation, the overpack is swiped to determine contamination level.

- The canister is transferred to the canister transfer cell.

4.3.2.1.4 Canister Transfer Cell and Facility Cask Loading Room

The canister is transferred from the hot cell to the shuttle car in the canister transfer cell. The canister shuttle car (Figure 4.3-15) is a long, rail-mounted, electric-powered car located in the canister transfer cell and designed to transfer waste canisters from the port in the floor of the hot cell to the port in the floor of the facility cask loading room. The shuttle car has a capacity for seven canisters, one of which can be overpacked and can be used for temporary canister storage or movement of the canisters to the facility cask loading room. Remote controlled closed circuit television (CCTV) cameras are used to monitor operations in the very high radiation area when canisters are present. The following steps are performed:

- The canister shuttle car is moved to position an empty tube directly under the hot cell shield valve and then the hot cell/canister transfer cell shield valve is opened.

- Using the crane and grapple, the canister is removed from the inspection station and lowered into the canister shuttle car, the grapple is retracted, and the shield valve closed. The canister shuttle car is moved to position the canister directly under the facility cask loading room shield valve.

- The facility cask (Figure 4.3-16) is a double end loading shielded container designed to transfer one RH waste canister at a time from the facility cask loading room to the disposal location. The shielded road cask has two gate-type shield valves for loading and unloading canisters using the hoist in the facility cask loading room, and the RH TRU waste emplacement machine during emplacement. The front trunnion is used to rotate and hold the shielded road cask in the horizontal or vertical position, as required. The facility cask is positioned horizontally on the facility cask transfer car in the facility cask loading room and as the facility cask is moved into position over the loading port, a rotating fixture engages the upper trunnions and rotates the shielded road cask to a vertical position.

- The telescoping shield is raised to mate with the facility cask and the facility cask loading room shield valve is opened. The shield bell is mated with the upper shield valve on the facility cask and both facility cask shield valves are opened.

- The loading room grapple is lowered through the facility cask into the canister transfer cell where the grapple engages the canister lifting pintle of the canister positioned under the loading port and lifts the canister into the facility cask.

- The facility cask lower shield valve and the facility cask loading room shield valve are then closed, the telescoping shield is retracted, and the canister is lowered on the lower facility cask shield valve. The grapple is disengaged and retracted into the shield bell, the upper facility cask valve closed, and the shield bell is raised from the facility cask into its storage position.

- As the facility cask transfer car is moved toward the waste hoist, the facility cask rotates from a vertical to a horizontal position and the rotating device is disconnected. The facility cask and facility cask transfer car move on the waste hoist cage.

4.3.2.1.5 Waste Shaft Entry Room

In the waste shaft entry room with the waste hoist cage properly positioned, the shaft gates are opened, the pilot rails are positioned, and the facility cask and facility cask transfer car are loaded on the waste hoist cage. The hoist cage is lowered to the disposal horizon. The facility cask and facility cask transfer car are moved to the underground transfer area (Figure 4.3-17).

4.3.2.1.6 Transfer Area

In this area the facility cask is removed from the facility cask transfer car by forklift and moved to the disposal room.

4.3.2.1.7 RH TRU Waste Disposal

The underground handling and emplacement equipment consists of diesel-powered forklifts, and a horizontal emplacement and retrieval machine. The RH waste handling equipment is the largest equipment transporting waste in the waste disposal area and therefore defines the minimum operating sized opening of 11 ft (3.35 m) vertical and 14 ft (4.3 m) horizontal for waste handling transport.

A horizontal hole has been drilled in the disposal room for canister emplacement. The RH TRU waste emplacement and retrieval machine interfaces with the forklifts and facility cask, and an alignment fixture is utilized to establish alignment of the emplacement equipment with the borehole (Figure 4.3-18 through Figure 4.3-22). The alignment fixture is positioned by forklift to locate the shield collar in line with the drilled hole. The leveling jacks are adjusted until the fixture is at the proper elevation and parallel to the longitudinal axis of the hole.

The facility cask is then positioned by forklift on the emplacement machine bed which ensures that the cask is accurately located on the emplacement machine (Figure 4.3-20). The facility cask is moved forward to mate with the shield collar and the transfer carriage is advanced to mate with the rear facility cask shield valve. The shield valves are opened and the transfer mechanism advances to push the canister into the hole (Figure 4.3-21). After retracting the transfer mechanism into the facility cask, the forward shield valve is closed, and the transfer mechanism is further retracted into its housing. The transfer carriage is moved to the rear about 6½ ft (2 m) and the shield plug carriage containing a shield plug is placed on the emplacement machine. The transfer mechanism is used to push the shield plug into the facility cask. The front shield valve is opened and the shield plug is pushed into the hole (Figure 4.3-22) completing the process.

The transfer mechanism is retracted, the shield valves closed on the facility cask, and the facility cask removed from the emplacement machine. After all the equipment is removed from the hole, a stop bar is mounted over the installed shield plug and canister. The emplacement machine is now available for transfer to another location.

4.3.3 Process Interruption Modes

General waste handling systems of the WIPP facility are described in Section 4.3.1 and Section 4.3.2. Process interruption modes are discussed in this section and fall into two categories: routine and emergency.

4.3.3.1 Routine Interruptions

Routine interruptions are plant process interruptions, including scheduled maintenance, unscheduled maintenance, and plant inspections during the life of the facility.

Actions taken during an interruption are conducted in accordance with established procedures, and monitoring of the plant parameters during the interruption is continued to ensure that no radiological problems are encountered. Any additional surveillances that are necessary during the interruption are specified in the procedures.

Under normal operations, removable surface contamination on the shipping package or the waste containers will not be in excess of the DOE's free release limits (i.e., 20 disintegrations per minute (dpm) alpha or 200 dpm beta/gamma per 100 cm^2). In such a case, no further decontamination action is needed. The shipping container and waste container will be handled through the normal process. However, should the magnitude of contamination exceed the free release limits, yet still fall within the criteria for small area (spot) decontamination (i.e., less than or equal to 100 times the free release limit, and less than or equal to 6 ft^2 [0.56 m^2]), the shipping container or the waste container will be decontaminated. In addition, if during the waste handling process at the WIPP, a waste container is breached, it will be overpacked or decontaminated as needed. Should WIPP structures or equipment become contaminated, waste handling operations in the affected area will be immediately suspended.

All decontamination operations will be performed under the controlled conditions of a Radiological Work Permit (RWP) and the standard operating procedures found in the WIPP WP 12-HP Operational Health Physics series Procedures.[2] Decontamination activities will use water and cleaning agents so as to not generate any waste that cannot be considered derived waste. Items that are radiologically contaminated are also assumed to be contaminated with the hazardous wastes that are in the container involved in the spill or release. A complete listing of these waste components can be obtained from the WIPP Waste Identification System (WWIS), for the purpose of characterizing derived waste.

Written procedures specify materials, protocols, and steps needed to put an object into a safe configuration for decontamination of surfaces. A RWP will always be prepared prior to decontamination activities. TRU mixed waste products from decontamination will be managed as derived waste. The DOE had previously proposed use of an Overpack and Repair Room to deal with major decontamination and overpacking activities. The DOE has eliminated the need for this area by: 1) limiting the size of contamination events that will be dealt with as described in this section, and 2) by performing overpacking at the point where a need for overpacking is identified instead of moving the waste to another area of the WHB. This strategy minimizes the spread of contamination.

Small area (spot) decontamination will occur at the TRUDOCK or other locations where contamination is detected. Overpacking would only occur in the event the WIPP staff damages an otherwise intact container during handling activities. In such a case, a radiological boundary will be established, inside which all activities are carefully controlled in accordance with the WIPP WP 12-HP Operational Health Physics series Procedures[2] protocols for the cleanup of spills or releases. A plan of recovery will be developed and executed, including overpacking the damaged container in either a 85-gal (321 L) drum, SWB, or a TDOP. The overpacked container will be properly labeled and sent underground for disposal. The area will then be decontaminated and verified to be free of contamination (essentially, this is done with "swipes" of the surface for counting in sensitive radiation detection equipment).

In the event a large area contamination is discovered on a TRUPACT-II during unloading, the waste will be left in the TRUPACT-II and the shipping package will be resealed. The DOE considers such contamination problems the responsibility of the shipping site. Therefore, the shipper will have several options for disposition. These are as follows:

- The TRUPACT-II can be returned to the shipper for decontamination and repackaging of the waste. Such waste would have to be re-approved prior to shipment to the WIPP.

- The TRUPACT-II may be shipped to another DOE site for management in the event the original shipper does not have suitable facilities for decontamination. If the repairing site wishes to return the waste to WIPP, the site will have to have Waste Acceptance Criteria (WAC)[4] certification authority and would have to re-certify the new shipment.

- The waste could go to a third (non-DOE) party for decontamination. In such cases, the repaired shipment would go to the original shipper and be recertified prior to shipment to the WIPP.

4.3.3.2 Emergency/Abnormal Interruptions

Emergency interruptions are those process interruptions in the plant due to accident conditions, which include earthquakes, severe weather emergencies, and fires.

Earthquake Interruptions - Normal plant operations may be suspended following an earthquake. If the earthquake is of sufficient magnitude (i.e., seismic event of 0.015 g or greater acceleration), inspection of structures and equipment will be required prior to resuming normal operations. The length of the interruption will depend upon the results of the inspection and all plant recovery corrective actions will be directed toward returning the plant to normal operation.

Severe Weather Emergencies - Normal plant operations may be suspended during a tornado warning or a high wind condition. A tornado warning or high wind condition will exist based on information provided by the National Weather Service or a local observation. If a severe weather emergency condition occurs at the WIPP facility, inspections of structures and equipment may be required prior to resuming normal operations. The length of the interruption will depend on the results of the inspection, and all plant recovery corrective actions will be directed toward returning the plant to normal operation.

Fires - Fire accidents, although not expected, may result in a process interruption. The occurrence of a major fire requires the evacuation of personnel and response by appropriate emergency personnel. After extinguishing the fire, the area will be surveyed, controls will be established to mitigate any problems, and the area returned to normal operations.

Abnormal Interruptions are any unplanned and unexpected change in a process condition or variable adversely affecting safety, security, environment, or health protection performance sufficient to require termination (stopping or putting on hold) of an operating procedure related to the flow path of radioactive waste processing for greater than four hours.

Loss of Off-Site Power - The loss of off-site power affects all electrical equipment. The plant is designed with a manually started backup power supply, which picks up selected electrical loads such as the AIS hoist, lighting, and ventilation system. Certain equipment has uninterruptible (battery) backup for loss of power so that functions such as parts of the central monitoring system (CMS) continue without power interruption. The site backup power system can maintain the containment functions (e.g., negative pressure ventilation balance), and is discussed in Section 4.6.

4.3.4 WIPP Waste Information System

The WIPP WAC[4] requires specific information from the waste generators to meet the waste certification requirements. The WIPP waste information system (WWIS) provides an online source of data required by the WAC,[4] showing the waste form, packaging, weight, and radionuclide inventory.

The WIPP WWIS is a system of computerized tools in a multiuser relational database designed to facilitate the effective management and tracking of TRU waste from DOE waste generator sites to the WIPP. The WWIS will gather, store, and process information pertaining to TRU waste designated by the Secretary of Energy for disposal at the WIPP. The system will support those organizations who have responsibility for managing TRU waste by collecting information into one source and providing data in a uniform format that has been verified or certified as being accurate. The WWIS will be a reliable, secure, and accurate system to store all information pertaining to characterization, certification, and emplacement of waste at WIPP. Waste information for WWIS will be supplied by the generator sites of the TRU waste and the WIPP facility.

The WWIS includes features to automate the transfer of the data required by the WAC[4] from the waste generators to the WIPP and also includes the limiting criteria from the WAC[4] summarized in Chapter 3. Data input by the waste generators that does not meet these criteria is automatically flagged for review. In addition to providing WAC[4] related information for the repository, the WWIS provides operational information, and routine and special reports. See WP 05-WA.06[5], Appendix A for an example of the WWIS Data Dictionary .

The WWIS provides the following primary functions:

- Entry and validation of waste characterization data for waste destined for the WIPP.
- Entry and validation of waste certification data for waste destined for the WIPP.
- Entry and validation of waste transportation data for waste destined for the WIPP.
- Entry and validation of waste emplacement location data for waste emplaced at the WIPP.

During the waste handling process, the waste container bar code is entered into the WWIS to track the location of the waste, and to verify that the information contained in shipping documents was correct. Once the waste is emplaced, a final set of documents summarizing the contents and final disposition of the waste is generated by the WWIS and added to other pertinent documentation to create the required records. The records generated will be used to show WIPP's compliance with the applicable regulations relative to the type of wastes destined for disposal at WIPP.

4.3.4.1 CH TRU Waste Emplacement

For inventory control purposes, waste container identification numbers are checked against the data in the WWIS at the time the waste is unloaded. The underground disposal location for each waste container is entered at the time the waste is placed in the disposal array.

4.3.4.2 RH TRU Waste Emplacement

The identification number of each RH TRU waste canister is verified against the data container while the canister is in the hot cell.

4.3.5 Underground Mining Operations

4.3.5.1 Mining Method

Mining is performed by continuous mining machines. Prior to mining in virgin areas, probe holes are drilled to relieve any pressure that may be present. After mining, vertical pressure relief holes are drilled up at the main intersections of drifts and crosscuts.

One type of continuous mining machine is a roadheader or boom type continuous miner operating a milling head. The milling head rotates in line with the axis of the cutter boom, mining the salt from the face. The mined salt is picked up from the floor by the loading apron. The muck (mined salt) is pulled through the miner on a chain conveyor, through a slewing conveyor, and then loaded in one of the haul vehicles.

Another type of continuous mining machine is a drum miner operating with a head that rotates perpendicular to the axis of the cutter boom, and cuts the salt away from the working face. The muck is pulled through the miner on a chain conveyor and then loaded in one of the haul vehicles.

During and immediately after mining, a sounding survey of the roofs of drifts is made to identify areas of drummy or slabby rock, which might represent safety or stability problems. A comprehensive underground safety and maintenance program has been established and can be found in the WIPP WP 04-AU1007, Underground Openings Inspections.[8]

Remedial work, including hand scaling of thin drummy areas, removal of larger drummy areas up to 18 in thick with the continuous miners, or rock bolting, is accomplished immediately after soundings in any areas identified as potentially unstable. Additional scaling is performed, as required, using a mechanical scaler, improving the safety of this operation.

Rock bolts are used extensively throughout the underground openings for remedial work and for safety. In addition, roofs in the first waste disposal panel and high traffic areas are pattern bolted for extra safety. Both resin and mechanical bolts are used in most ground control activities. Only certified bolts are used at the WIPP; the specifications in References 8 and 9 are used in defining bolting requirements for the underground.

The WIPP engineering staff is responsible for ensuring that ground control systems comply with all rules and regulations.

4.3.5.2 Interface Between Mining and Waste Disposal Activities

Separate mining ventilation and disposal ventilation circuits are maintained by means of temporary and permanent bulkheads. Air pressure in the mining side is maintained higher than in the disposal side to ensure that any leakage results in airflow to the disposal side. The underground ventilation system is discussed in Section 4.4.2. Rooms being mined are within the mining ventilation circuit, and rooms under disposal are within the disposal ventilation circuit.

4.3.5.3 Mined Material

The salt removed during underground mining is brought to the surface by the salt handling system. From the surge pocket, salt is loaded into the 8-ton salt handling skip with a skip measuring and loading hopper, the skip is raised to the surface, and dumped through a chute to surface haulage equipment which transports the salt to an on-site storage pile.

4.3.5.4 Ground Control Program

The WIPP facility ground control program ensures underground safety from any potential unplanned roof or rib falls. Care is taken from the moment a drift is mined and throughout the life of the opening to remove or restrain any loose or potentially unsafe pieces of ground. As the opening ages, areas of the roof, ribs, and floor may require some ground control. To ensure this is achieved in a timely and efficient manner, a very comprehensive ground control monitoring program has been established.

Ground Control Planning

An internal ground control operating plan is used to guide both short and long-term planning. For the purpose of ground control activities, the underground facility at the WIPP site is divided into over 100 zones. These zones facilitate detailed evaluation and documentation of the status and conditions of the underground. A database has been developed which documents the current status of each ground control zone. The current status refers to the physical state of an underground excavation (zone) with respect to geometry, excavation age, ground support, and operational use. The data collected for the plan and the evaluation of those data are most useful when used or considered immediately after collection. Detailed work packages are developed specifically for each ground control activity. The plan also serves as a foundation document for the development of the Long-Term Ground Control Plan.[6]

The Long-Term Ground Control Plan[6] provides a strategy for development and selection of the most applicable and efficient means of maintaining and monitoring the ground conditions of the WIPP in order to assure safe and operational conditions from the present time to closure of the facility. The plans for the most current years covered by the plan are explained in more detail than the later years, since it is easier to predict the immediate future than the distant future. The Long-Term Ground

Control Plan[6] addresses technical aspects of the underground facility which are concerned with the design, construction, and performance of the subsurface structures and support systems. In particular, this plan addresses the requirement for maintaining the ground conditions in the underground facility in a safe and operational state for its anticipated lifetime.

Topics associated with the stability of the roof of the underground facility are the primary focus of the Long-Term Ground Control Plan.[6] During the period of time that the underground has been active, a variety of ground control issues have been encountered ranging from minor spalling to roof falls. Minor spalling is small pieces of the back flaking off or falling. The ground control program consists of many aspects which include continuous visual inspections of the underground openings, extensive geotechnical monitoring, numerical modeling, analysis of rockbolt failures, implementation of ground control procedures, and comprehensive in situ and laboratory testing and evaluation of ground control components and systems.

Each year the Long-Term Ground Control Plan[6] is rolled forward one year. This rolling revision takes into account developments in both WIPP and industrial support practices and materials, and any changes in WIPP life and operational requirements. WIPP ground control plans are living documents that keep ground control practice at WIPP both current and responsive.

Ground Control Practice

A comprehensive ground control program for the entire underground facility is followed at WIPP to ensure safe conditions, operational efficiency, reliability and confidence, and regulatory compliance for personnel and equipment.

Qualified and experienced personnel in Geotechnical Engineering, Mine Engineering, and Underground Operations are responsible for and committed to the success of this program. The elements of the program are monitoring; initial and on-going evaluation; engineering design and specification; data collection and analysis; implementation; and maintenance as necessary. These elements include the following main activities.

- Monitoring: The geotechnical performance of the underground facility is regularly evaluated by the Geotechnical Engineering section. This evaluation is focused to provide early detection of conditions that could affect safety and operations, and to permit further engineering analysis of the performance of WIPP excavations in salt. At present there are over 1,000 instruments installed underground, and additional instruments are installed as conditions warrant. Daily and weekly visual examinations are performed by Mine Operations staff.

- Evaluation: Geotechnical and mining engineers then perform a variety of rock mechanics analyses to ensure that rock mass behavior is correctly understood and proper ground control measures are instituted from the beginning.

- Engineering Design and Specification: The ground support system is designed and specified to ensure the safety of staff and to facilitate operations. Maintenance activities are specified in performance standards and procedures so that ground conditions presenting a potential hazard are safely rectified. Ground control problems are addressed on an individual basis so that the most appropriate method of remediation is implemented. Geotechnical Engineering is constantly improving ground support systems in order to provide the most effective and safe methods and materials possible for the underground facility

- Data Collection and Analysis: Field activities are established for data collection from geotechnical instrumentation, fracture and excavation effect surveys, and general observations. Ground conditions are examined on a regular basis (at the beginning of each shift, weekly, monthly, and annually according to regulatory requirements and operating plans). Monitoring results are analyzed in comparison with established design criteria, and are utilized in a variety of computer models. The results of these studies are published in a variety of formats ranging from specific reports through frequent regular assessments (e.g., bi-monthly summaries) to comprehensive annual reports (e.g. Geotechnical Analysis Report), which are available to the public in reading rooms. All data and related documentation are maintained in databases which are regularly subjected to quality assurance audits. These data are available to those who make independent assessments.

The fundamentals on which the ground control program at the WIPP facility are based are as follows:

- Ground stability is maintained as long as access is possible.
- Ground control maintenance efforts increase with the age of the openings.
- Ground control plans are specific but flexible.
- Regular ground control maintenance is required.

The ground control program at the WIPP facility uses observational experience and analysis of salt behavior underground to enable various projections regarding future ground support requirements. This approach recognizes that salt moves or creeps. Because of its plastic nature, salt will flow into an excavated opening. To provide long-term ground support, the ground control system must:

- Accommodate the continuous creep of salt.
- Retain broken fractured rock in the back or rib.

Two major categories for support systems are rock bolts and supplementary systems. The rock bolt systems are mechanically-anchored bolts and resin-anchored threaded rods. The supplementary systems include cables with mesh, trusses, and the Room 1, Panel 1 design.

Initial Roof Support System (Rock-Bolt System)

Prior to waste emplacement in any specific area (room), the plans (for Panels 2-8) are to spot bolt with short, mechanically anchored bolts only as necessary, if spalls or loose ground are encountered during and after the mining process. Mesh may be used in conjunction with these bolts to secure any loose ground encountered during normal inspection processes. These bolts would not penetrate through to the next clay/anhydrite interface, and would be anchored within the beam formed by the mine roof and the clay/anhydrite interface above. This is the primary or initial support which will be used in Panels 2-8.

However, based on experience with the Site and Preliminary Design Validation (SPDV) rooms and the rooms in Panel 1, pattern bolting is not expected to be required until 2-5 years after excavation. Disposal rooms may be pattern bolted prior to waste emplacement. The expert panel convened to study Panel 1 in 1991 concluded that the then current support technology of 10 ft (3.05 m) long mechanical bolts used in Panel 1 should be adequate to ensure stability for 7 to 11 years from the time of excavation. These bolts were installed beginning approximately two years after initial excavation on a pattern described as a 5 ft by 5 ft (1.5 m x 1.5 m) offset pattern (one bolt per 25 ft ^{2} [2.3 m^2]). Experience in Panel 1 confirms the conclusion of the expert panel. Plans call for bolt systems installed in future bolt patterns to be equal to or exceed the bearing characteristics of the mechanically anchored bolts used in the primary pattern in Panel 1.

The justification for choosing these systems includes their demonstrated ability to support the expected loads. In the case of yielding systems, they will be chosen based on their support capabilities and the ability to accommodate expected rock deformation.

Primary support will consist of Grade 75 steel mechanically-anchored bolts of at least 5/8 in. (1.6 cm) diameter. Depending on the need, the bolts may be as short as 24 in. (61 cm) and as long as 72 in. (183 cm). Mesh may be chain-link, welded wire, or polymer.

Pattern bolting will be designed using the best support technology available at the time. Because yielding systems are still under evaluation, current plans call for use of Grade 60 threaded bars of at least 7/8 in. (2.2 cm) diameter installed on a maximum 5 ft by 5 ft (1.5 m x 1.5 m) pattern in the center half of the room. The bars would be resin-anchored above the first clay/anhydrite interface. Four or 6 ft (1.2 or 1.8 m) long mechanical bolts would be used near the ribs.

Materials procured for installation as primary support, spot bolting, and pattern support will meet the requirements of 30 CFR 57, Subpart B.[9] This requirement will be verified as part of the quality assurance program. Primary support installation requires quality control by the installation crews. Proper installation is confirmed as part of the audit function of the underground safety and Quality Assurance groups. Quality control and assurance is more rigorous during a pattern bolting sequence. Work instructions for the sequence will require Quality Assurance to perform at least one random inspection to verify that material requirements and hole construction specifications are met. Operations (construction) supervisors will also be responsible for monitoring the construction. Finally, before turnover or completion of the installation, Quality Assurance will review the work, and certify their approval. Independently, MSHA inspectors also perform a Quality Assurance function during their frequent inspection visits to the WIPP, making certain that support construction is performed in accordance with 30 CFR 57, Subpart B.

Supplementary Support Systems

Similar to the plan for pattern bolting, any supplementary system will be designed using the best support technology available at the time. Should a supplementary support system be required, it is anticipated that, if not already in place, mesh will be installed over the primary and pattern support. The mesh will be augmented either by cables (wire ropes) anchored near the ribs and suspended across the rooms or by steel mats. The cables or mats and, therefore, the mesh will be further pinned to the roof by bolting. The use of either the cables or mats in conjunction with meshing and rebolting should be adequate in supporting even a highly fractured roof beam.

Support System Performance

Several distinct ground-support systems are installed in Panel 1. They can be generally grouped as rigid, non-yielding systems and yielding systems. Rigid, non-yielding systems are not designed to accommodate salt creep. However, they do respond to creep. and continue to provide support during ductile behavior. Based on experience with Panel 1, if Panels 2-8 are excavated and filled within five to seven years each, these non-yielding systems should provide the necessary support. If pattern bolting is performed just prior to waste emplacement in each room or area, experience at the WIPP has shown that these rigid systems can certainly accommodate the salt creep that will occur during the one to two years of emplacement.

The ground support system installed in Room 1, Panel 1 is a yielding system only as long as access can be maintained. This is because of the necessity to manually reduce the tension of the bolts. If the detensioning process is stopped, the system becomes a rigid, non-yielding system and will undergo the same ductile behavior as other rigid systems.

Other yielding systems are installed in the WIPP underground and each is still being evaluated. Each of these systems is designed to yield at predetermined loads. All are designed to work over their prescribed yield interval without maintenance. Some of the systems are designed to respond to the loading by salt creep and provide over one ft of yield without system degradation. A detailed evaluation of the adequacy of these systems is not possible at this time.

The initial roof support system, consisting of mechanical anchor bolts, was installed in 1988. The ground control design was developed based on information obtained from the SPDV rooms. Panel 1 rooms were pattern bolted with 10 ft (3.05 m) long, 3/4 in (19 mm) diameter, mechanical anchor bolts on a 3.0 ft (0.9 m) by 3.9 ft (1.2 m) center spacing through the middle third of each room. The outer third along each rib uses the same roof bolt but on a 3.9 ft (1.2 m) by 6 ft (1.8 m) center spacing pattern.

The original design for the waste disposal rooms at the WIPP provides a limited period of time during which to mine the openings and to emplace wastes. Each panel, consisting of seven disposal rooms, is scheduled to be mined and filled in less than five years, at which time it would be closed. Field studies, as part of the SPDV Program, showed that unsupported openings of a typical disposal room configuration would remain stable, and that creep closure would not impact equipment clearances during at least a five year period following excavation. The information from these studies verified that the design of openings for the permanent disposal of wastes under routine operations was acceptable.

Panel 1 was developed to receive waste for a demonstration phase that was scheduled to start in October 1988. The original plan consisted of the storage of drums of CH TRU waste in panel rooms for a period of 5 years. During this time and immediately following it, the rooms were to be inaccessible, but the option to reenter was to be maintained so that waste could be removed, if required. The demonstration phase was later deferred, and an experimental program was added in Room 1, Panel 1. This led to more stringent requirements for roof stability.

To ensure the roof stability for the revised tests and durations, a supplemental roof support system was designed. The Supplemental Roof Support System is designed to contain and support the weight of a detaching salt wedge of the immediate roof, if one begins to form, while allowing it to be deformed by creep behavior. The system is not designed to prevent the creep of salt into the room. The Supplemental Roof Support System consists of 26 steel channel support sets, installed laterally across the room on approximately 10 ft (3.05 m) centers. Each channel support set is carried by 11 resin anchored roof bolts. The bolts are anchored over the interval between 8.5 (2.6 m) and 11.5 ft (3.5 m)into the roof, which is above the expected failure surface. The roof area between the channel sets is covered by a network of steel wire lacing cables, which hold a mat of steel wire mesh and expanded metal against the rock salt surface.

The design of this system was subjected to exhaustive scrutiny by two formal Design Review Panels. The first review was conducted by qualified project personnel from the Westinghouse Waste Isolation Division (WID) Engineering, Operations, Quality Assurance, and Safety groups with the participation of SNL. A second formal review was conducted by a panel of rock mechanics experts not associated with the WIPP project. This Expert Review Panel consisted of representatives from the mining industry, U.S. Bureau of Mines, Mine Safety and Health Administration (MSHA), academia, and independent consultants. These Design Review Panels approved the design based on evaluation of design documents, on-site observations at the WIPP underground facility, and detailed discussions with members of the design team.

The support system is adjusted (Room 1, Panel 1 only) to ensure that the loads on the anchors do not exceed the working loads specified by the design. Support system monitoring results are used to determine when load adjustments (or other maintenance) are required. When the load on the bolt approaches 20,000 lbs (9070 kg), the bolts are adjusted to about 5000 lbs (2268 kg). Modifications were made to the support system to improve the reading accuracy of the monitoring system. This provided a better interaction between the rock and the support system.

A monitoring program for Room 1, Panel 1 has been in place since initial excavation of the room. Room stability has been assessed from monitoring of room closure, rock deformations in and around the room, and fracture development and separation. The deformation data collected by the monitoring system is then compared against previously acquired data to identify deviations from expected performance. This program has provided a great deal of information on support system performance, room and rock mass behavior, and ground control techniques and materials.

4.3.5.5 Geotechnical Monitoring

Geotechnical data on the performance of the repository shafts and excavated areas are collected as part of the geotechnical field-monitoring program. The results of the geotechnical investigations are reported annually. The report describes monitoring programs and geotechnical data collected during the previous year.

Instrumentation, Monitoring, and Evaluation

The WIPP geotechnical programs are conducted in accordance with written procedures, and provide in-situ data to support continuing assessments of the designs for the shafts and underground facilities. The safety of the underground excavations is, and will continue to be evaluated on the basis of criteria established from actual measurements of room behavior. These criteria are regularly evaluated and modified as more field data are collected, and additional experience is gained with the performance of the WIPP underground excavations.

Geotechnical monitoring programs provide measurement of rock mass performance for design validation, routine evaluation of the safety and stability of the excavations, and the short-term and long-term behavior of underground openings. The minimum instrumentation for Panels 2 through 8 is one borehole extensometer installed in the roof at the center of each disposal room. The roof extensometers will monitor the dilation of the immediate salt roof beam and possible bed separations along clay seams. Additional instrumentation may be installed as conditions warrant.

The evaluation of the performance of the excavation is performed by Geotechnical Engineering. These evaluations will provide an assessment of the effectiveness of the roof support system and an estimate of the stand-up time of the excavation. If the trend is toward adverse (unstable) conditions, the results of these assessments are reported to the Operations Manager to determine if it is necessary to terminate waste disposal activities in the open panel.

Data collection, analyses, and evaluation criteria ensure that geotechnical monitoring results provide timely indications of changes in measured room closure rates over time, and when those measured room closure rates exceed projected values. Closure rates are compared to projected values based on statistical evaluations of closure data that are updated annually. Areas with observed rates which significantly vary from projected values are monitored more closely to determine the cause of the variance. If the cause cannot be related to operational considerations, such as mining activity, then additional field investigation is undertaken to characterize the conditions. Should the field data indicate that ground conditions are deteriorating, corrective actions are taken as required.

Geologic investigations provide ongoing data collection on the geotechnical performance of the underground facility, and include geologic and fracture mapping, seismic monitoring, and special activities performed as-needed. Further assessments of the geotechnical performance of the excavations are made using borehole inspections to detect displacements, fractures, and separations occurring within the strata immediately surrounding the excavations. The results of geologic investigations provide continued confidence in the performance and geology of the site with respect to site characterization.

All data obtained are maintained for data reduction, tabulation, analysis, and archiving. The annual Geotechnical Analysis Report provides the principal documentation of data, describes the techniques used for data acquisition, and summarizes the performance history of the instruments. The Geotechnical Analysis Report also details the geotechnical performance of the various underground facilities including shafts, and provides an evaluation of the geotechnical aspects of performance in the context of the relevant design criteria developed during the SPDV phase. The Geotechnical Analysis Report is reviewed by the DOE and its contractors for technical accuracy. These reports have been regularly prepared, audited for quality assurance, and made publicly available since 1983.

The assessment and evaluation of the condition of WIPP excavations is an interactive, continuous process using the data from the monitoring programs. Criteria for corrective actions are continually reevaluated and reassessed based on total performance to date. Actions taken are based on these analyses and planned utilization of the excavation. Because WIPP excavations are in a natural geologic medium, there is inherent variability from point to point. The principle adopted is to anticipate potential ground control requirements and implement them in a timely manner rather than to wait until a need arises.

References for Section 4.3

1. WP 05-WH, WIPP Waste Handling Operations Procedures.

2. WP 12-HP, WIPP Operational Health Physics series Procedures.

3. DOE/WIPP, 91-005, RCRA, Part B Permit Application, Rev. 6.

4. WIPP-DOE-069, Westinghouse Electric Corporation, TRU Waste Acceptance Criteria for the Waste Isolation Pilot Plant, Rev 5., April 1996.

5. WP 05-WA.06, WIPP Waste Information System Software Requirements Specification, Rev. 0

6. WIPP/WID 96-2180, Long-Term Ground Control Plan for the Waste Isolation Pilot Plant.

7. NQA-1, Quality Assurance Program, 1989.

8. WP -AU1007, Underground Openings Inspections.

9. Title 30, Code of Federal Regulations Part 57, Safety and Health Standards - Underground Metal and Nonmetal Mines, 8th edition, 1994.

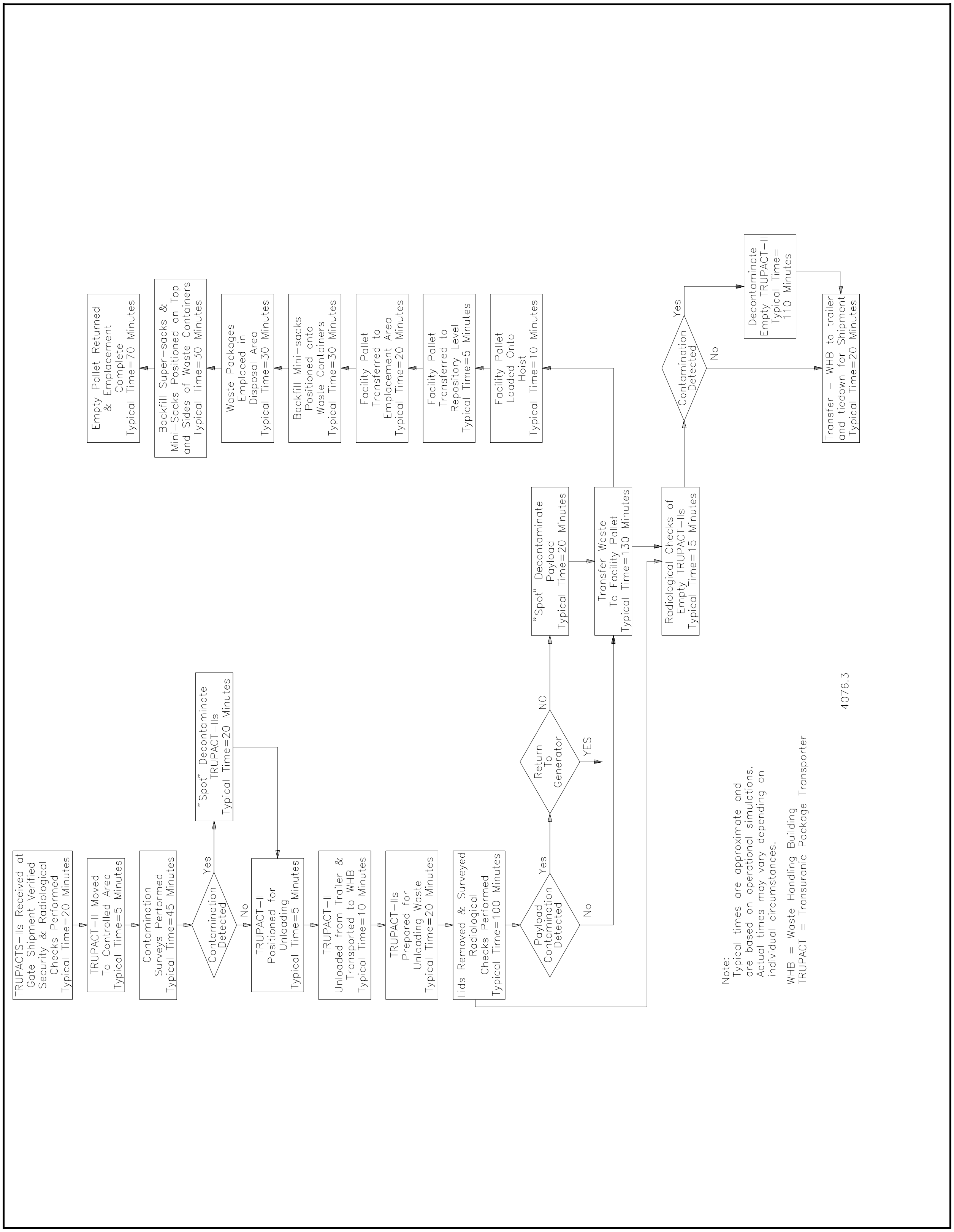


Figure 4.3-1, Surface and Underground CH Flow Diagram

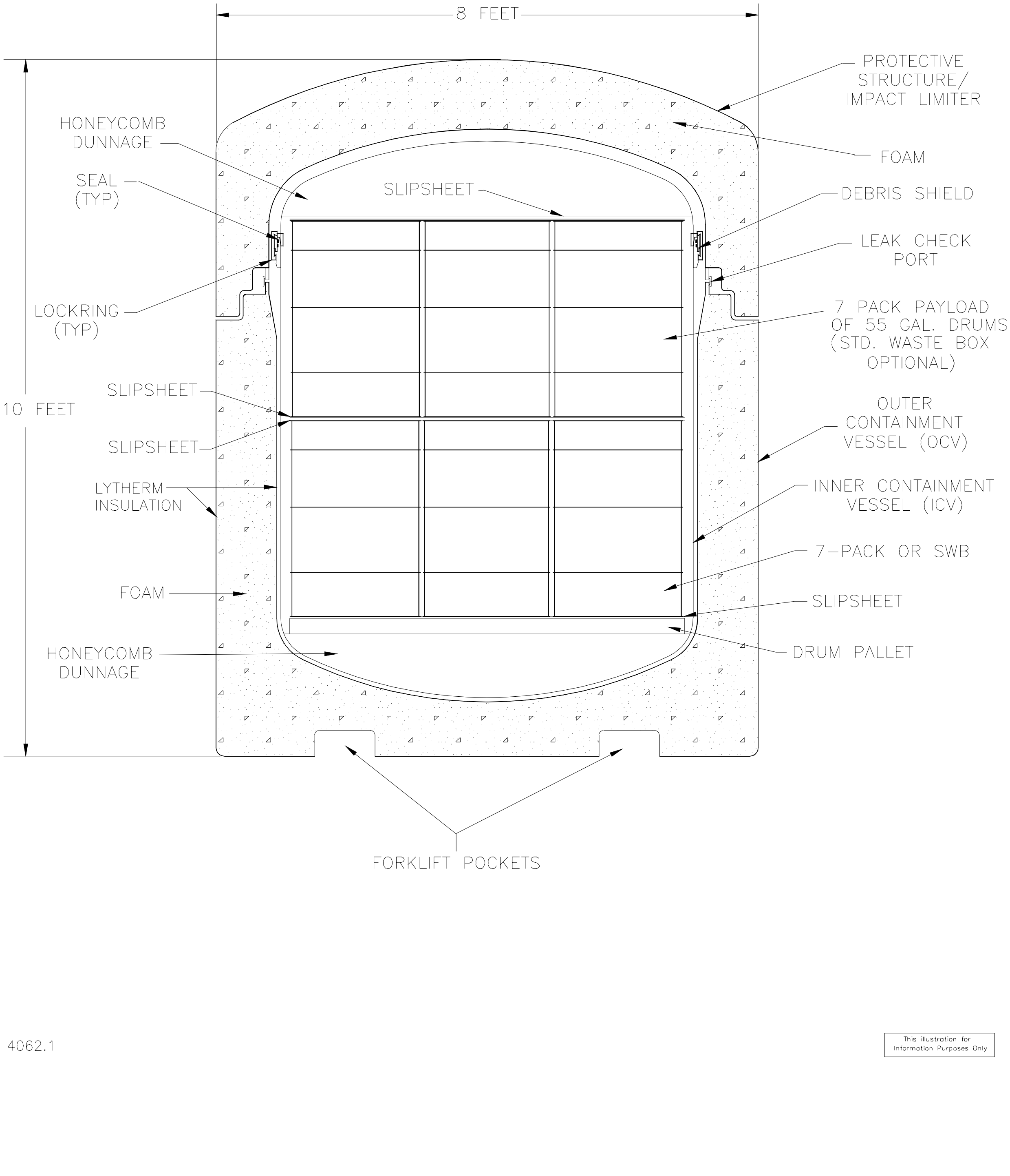


Figure 4.3-2, TRUPACT-II

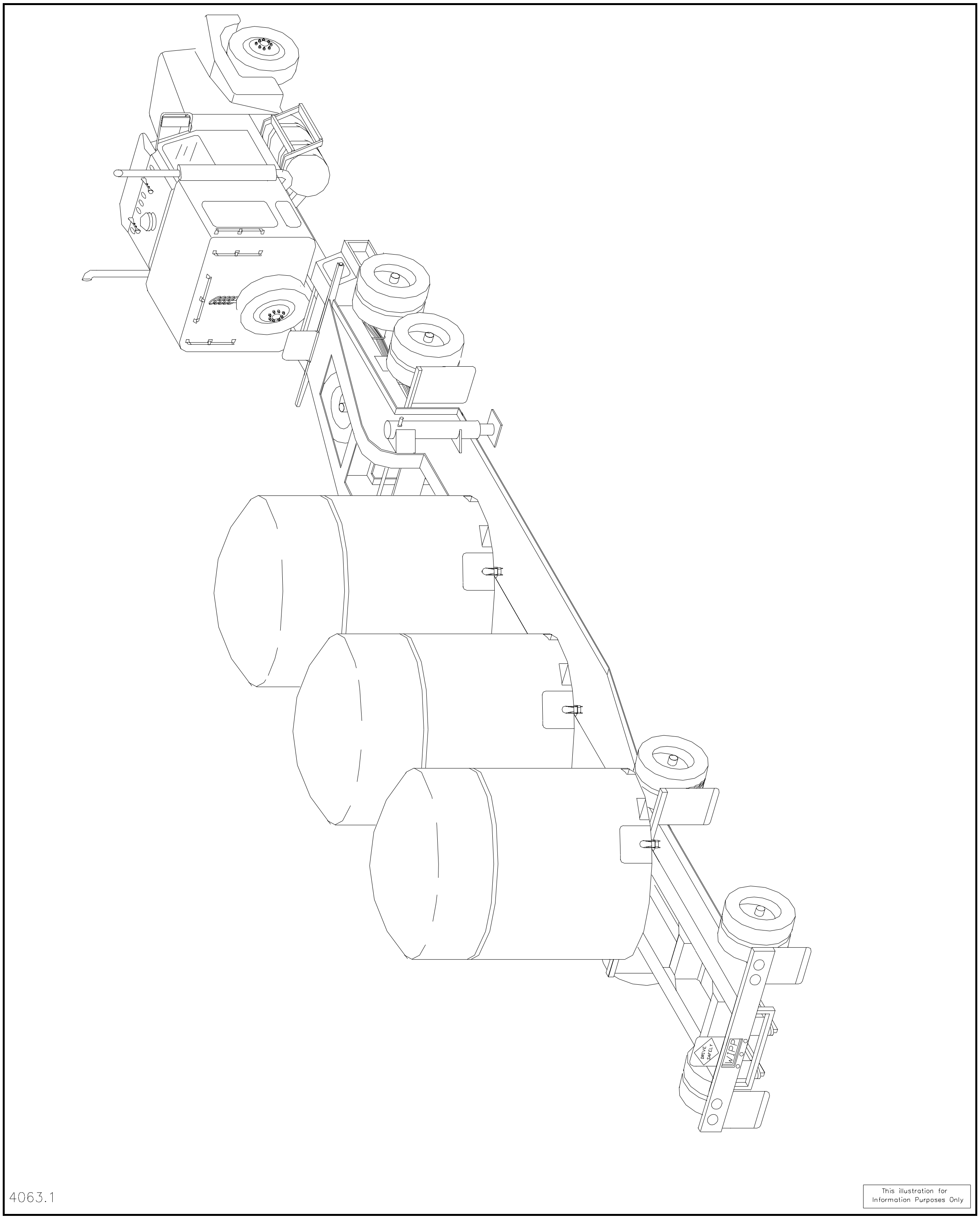


Figure 4.3-3, Truck, Trailer, and TRUPACT-IIs

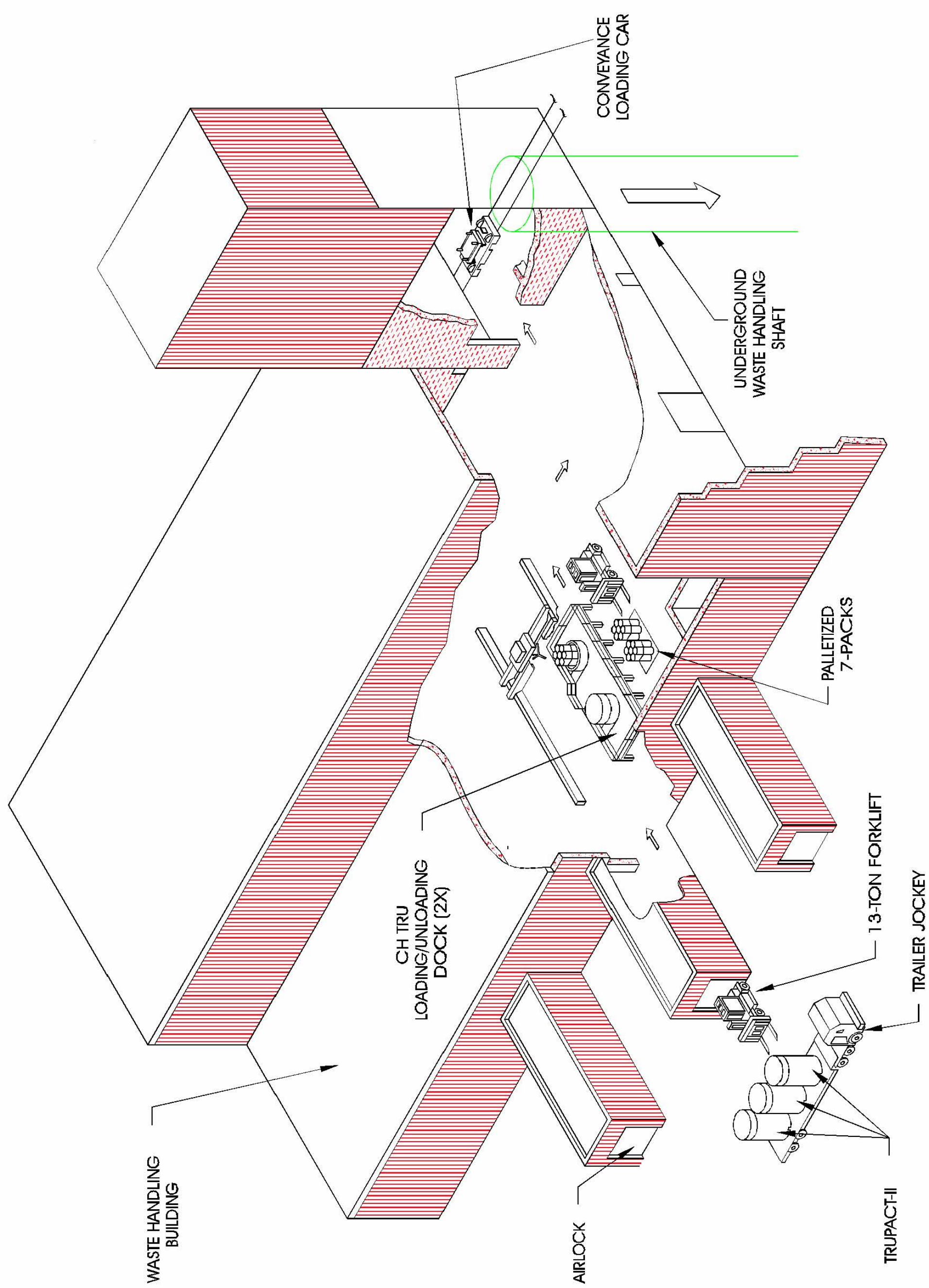


Figure 4.3-4, CH TRU Waste Handling (Surface)

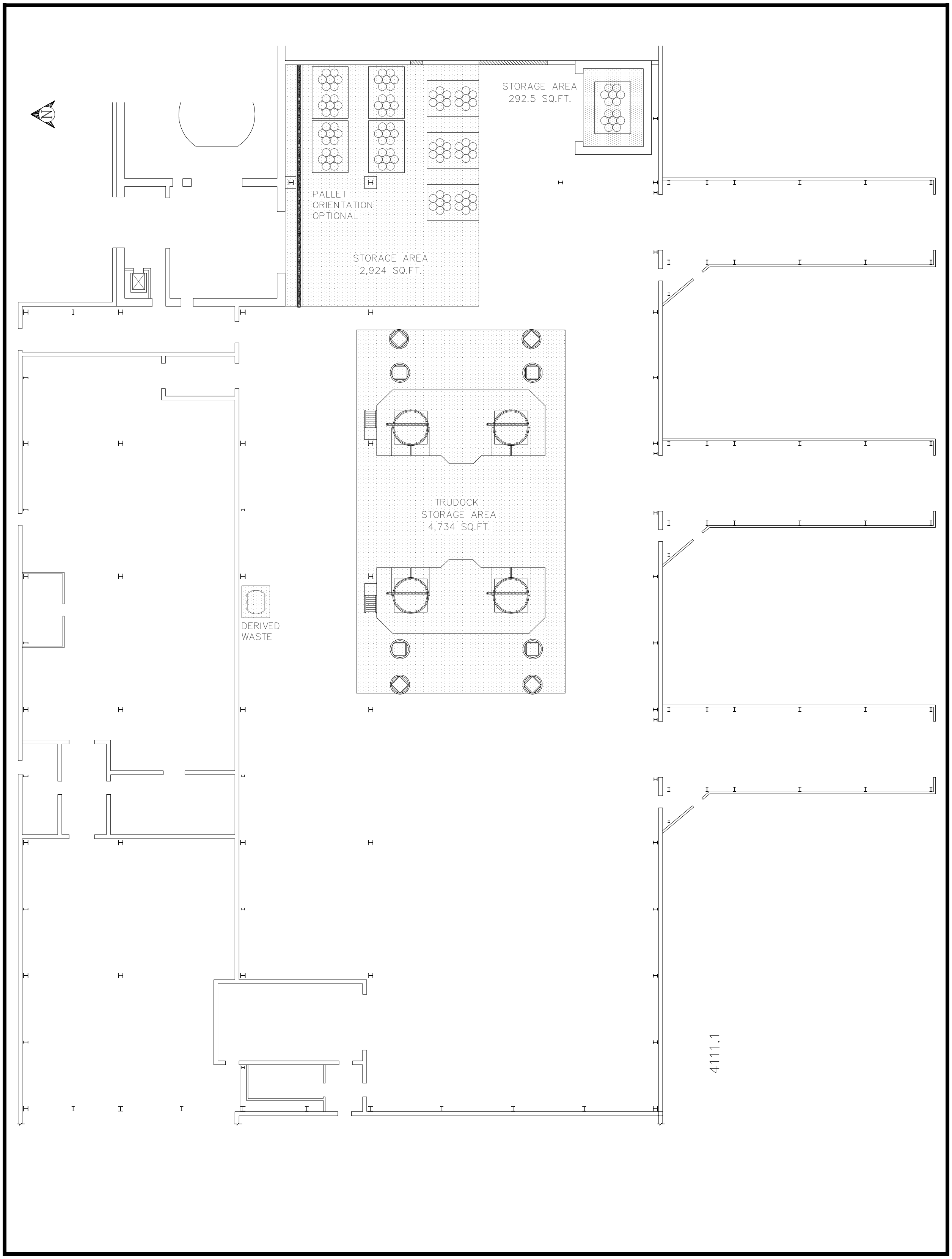


Figure 4.3-5, Waste Handling Building Temporary Storage Areas for CH Waste Containers

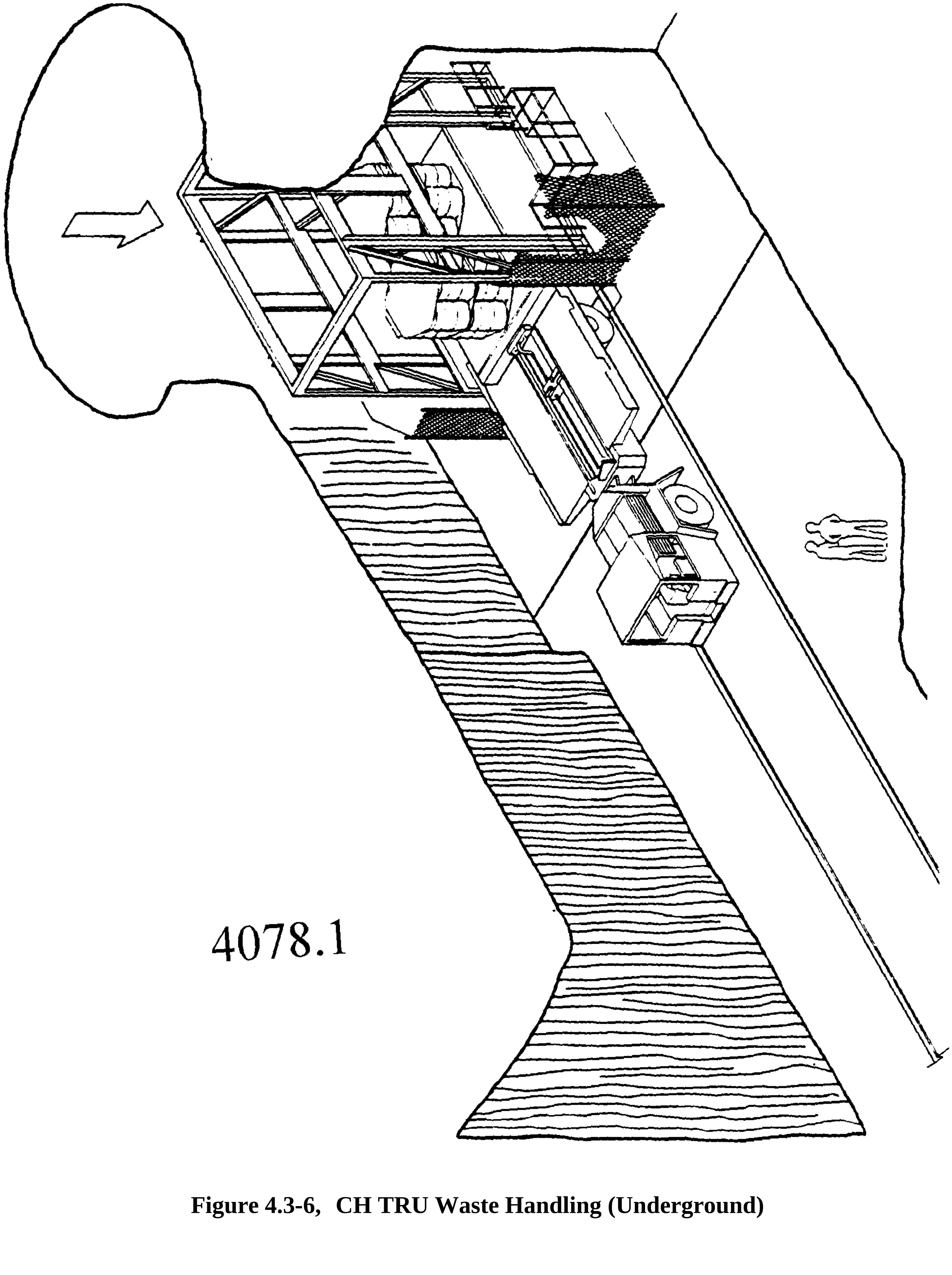


Figure 4.3-6, CH TRU Waste Handling (Underground)

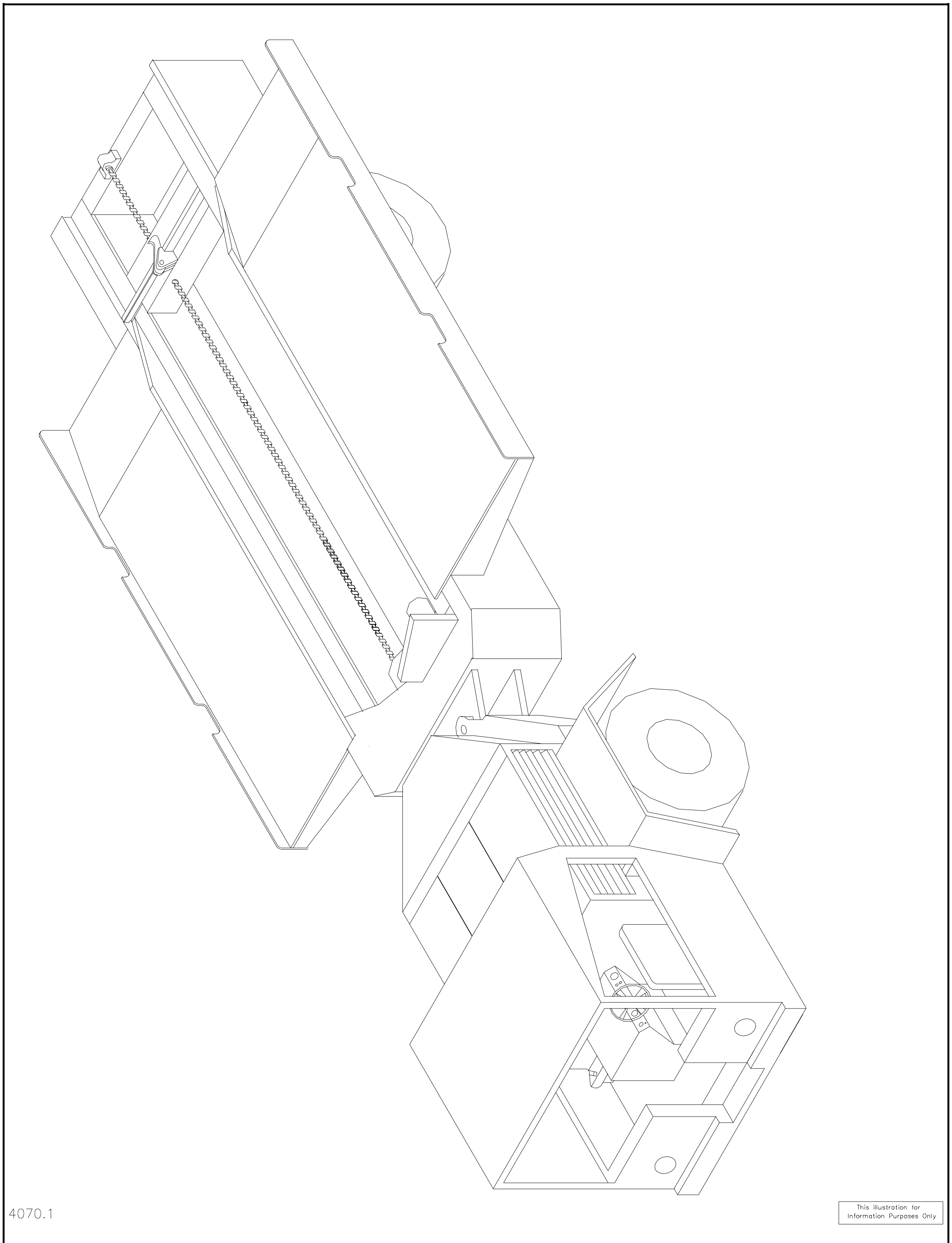


Figure 4.3-7, CH TRU Underground Transporter

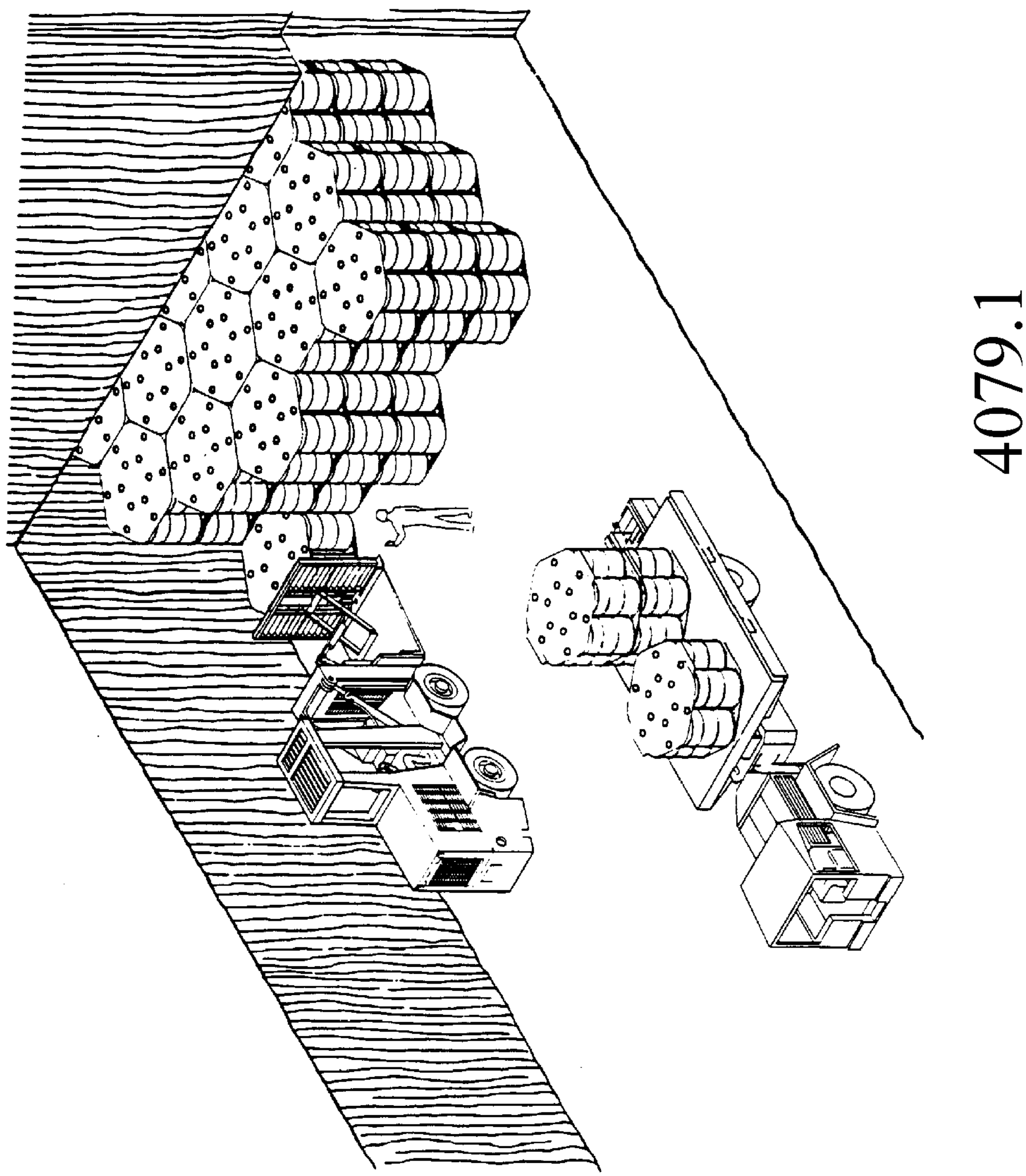


Figure 4.3-8a, CH TRU Emplacement

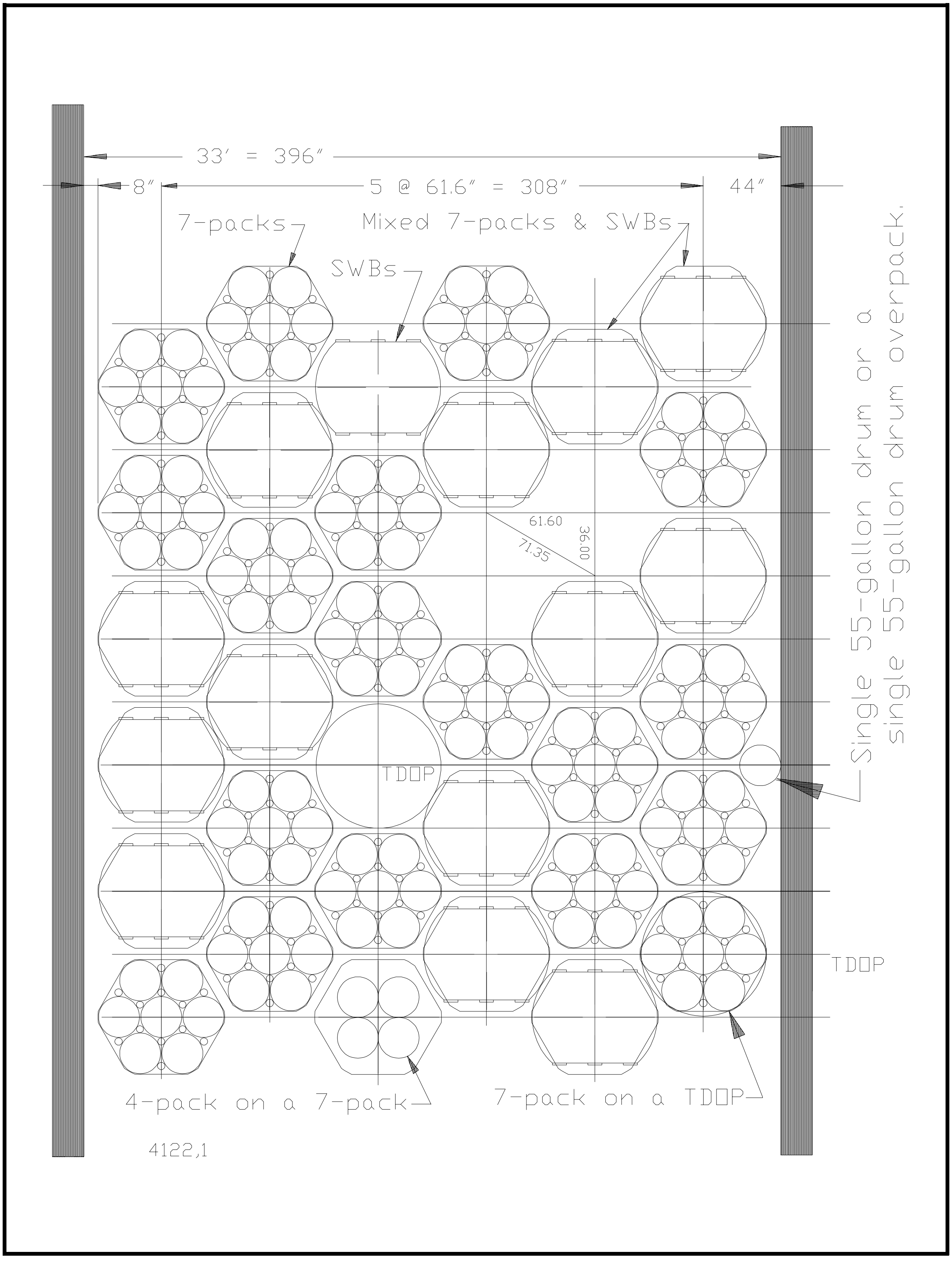


Figure 4.3-8b, Arrangement of Typical Waste Stacks

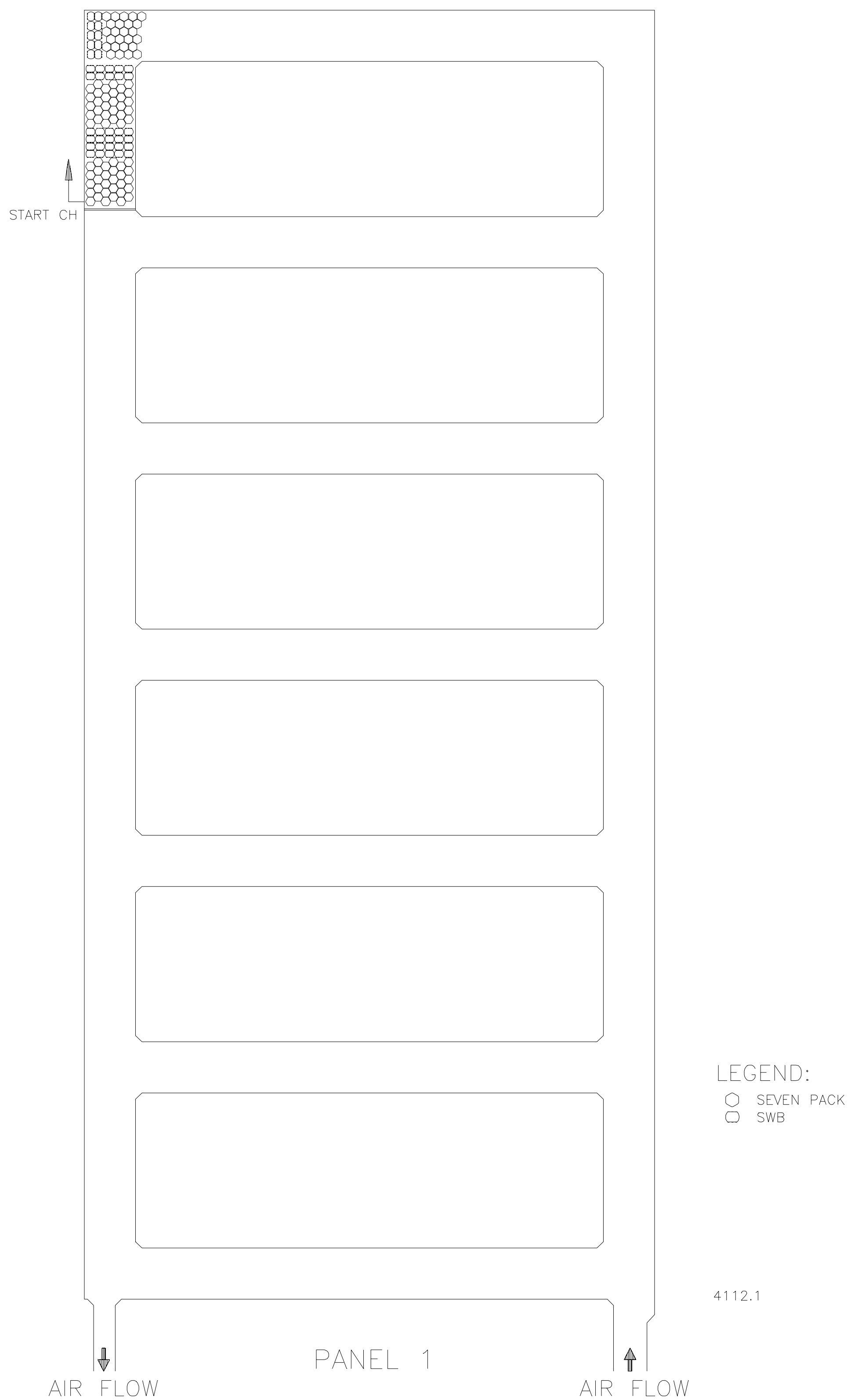


Figure 4.3-9a, Underground Waste Emplacement Process

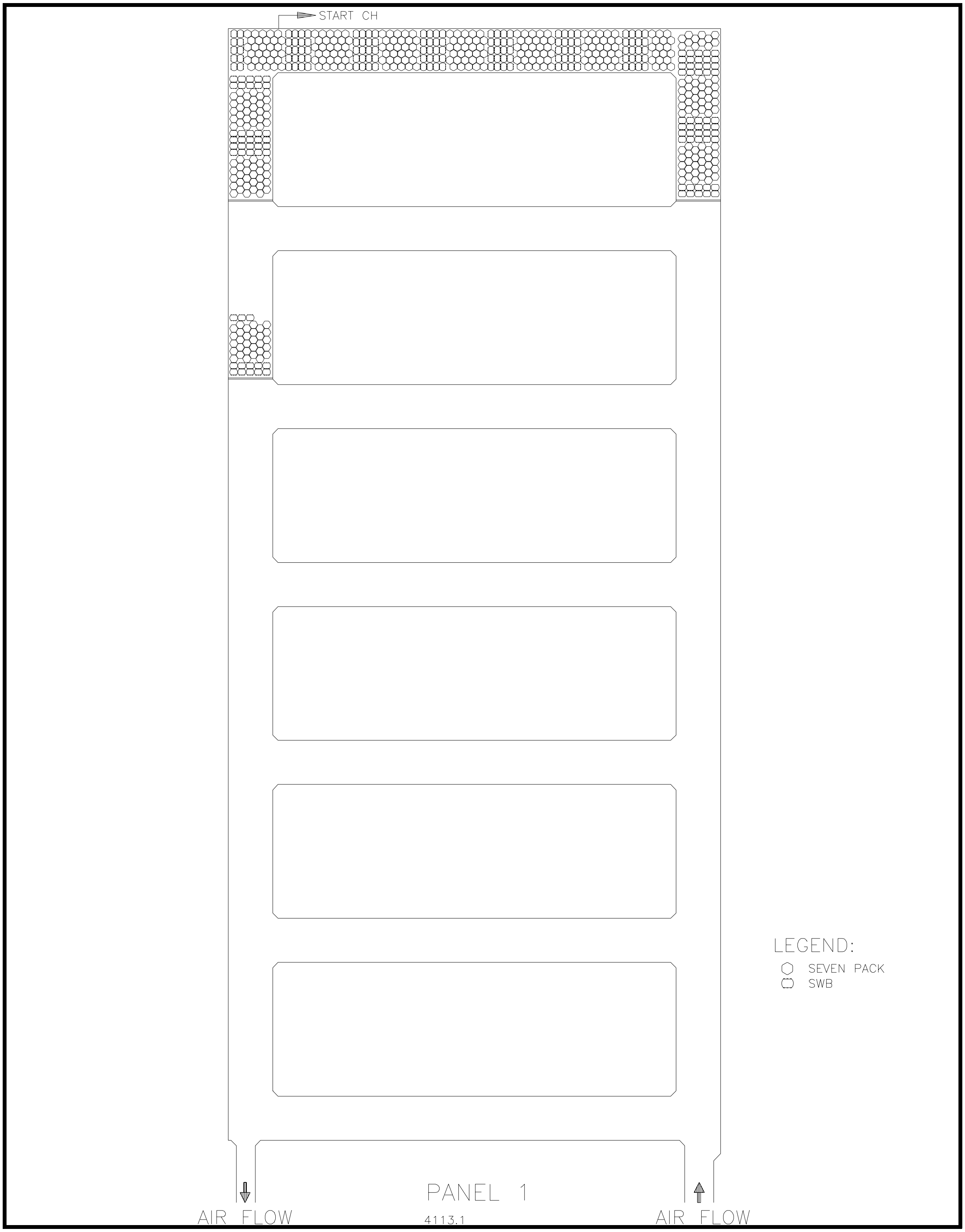


Figure 4.3-9b, Waste Emplacement Process

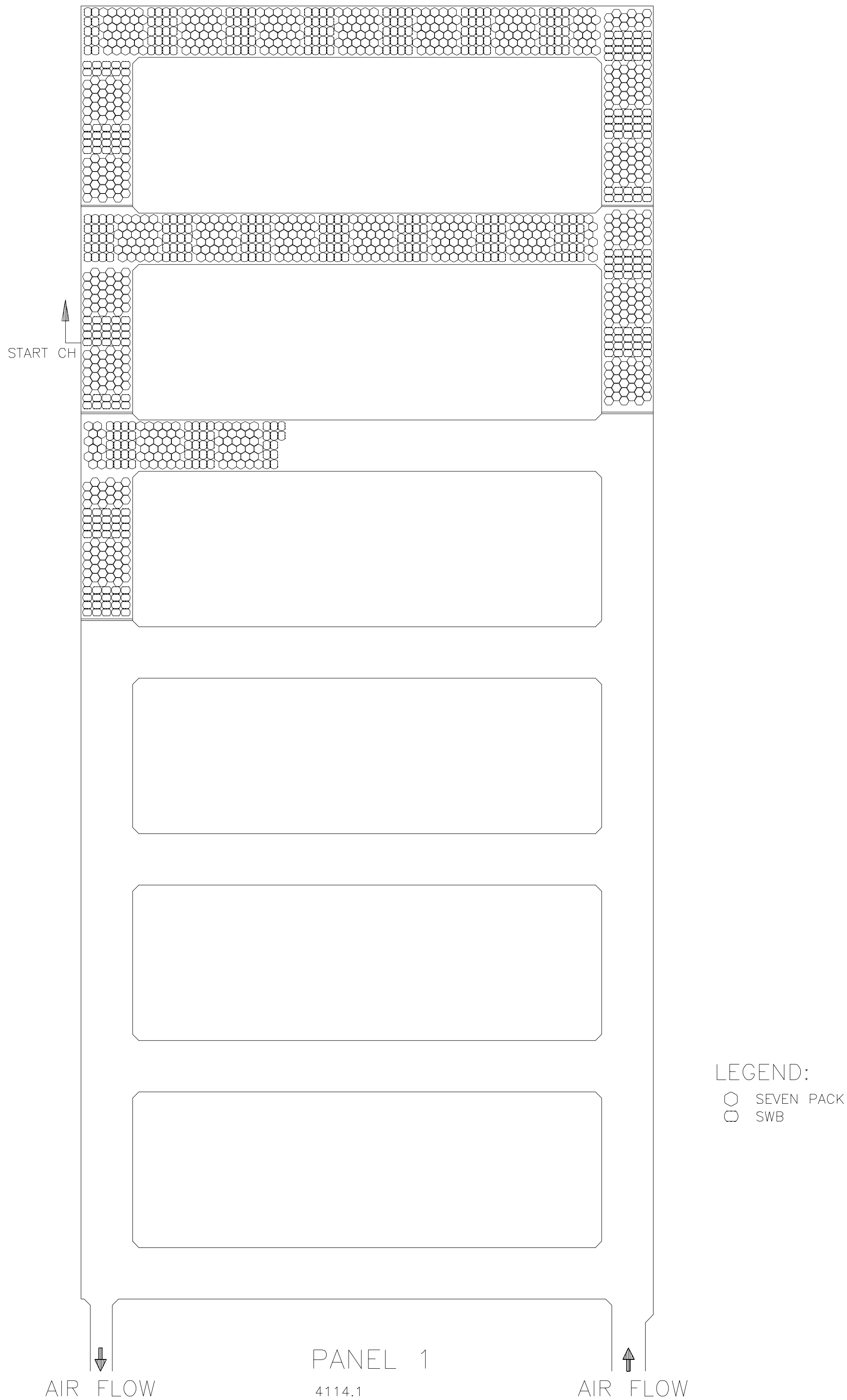


Figure 4.3-9c, Waste Emplacement Process

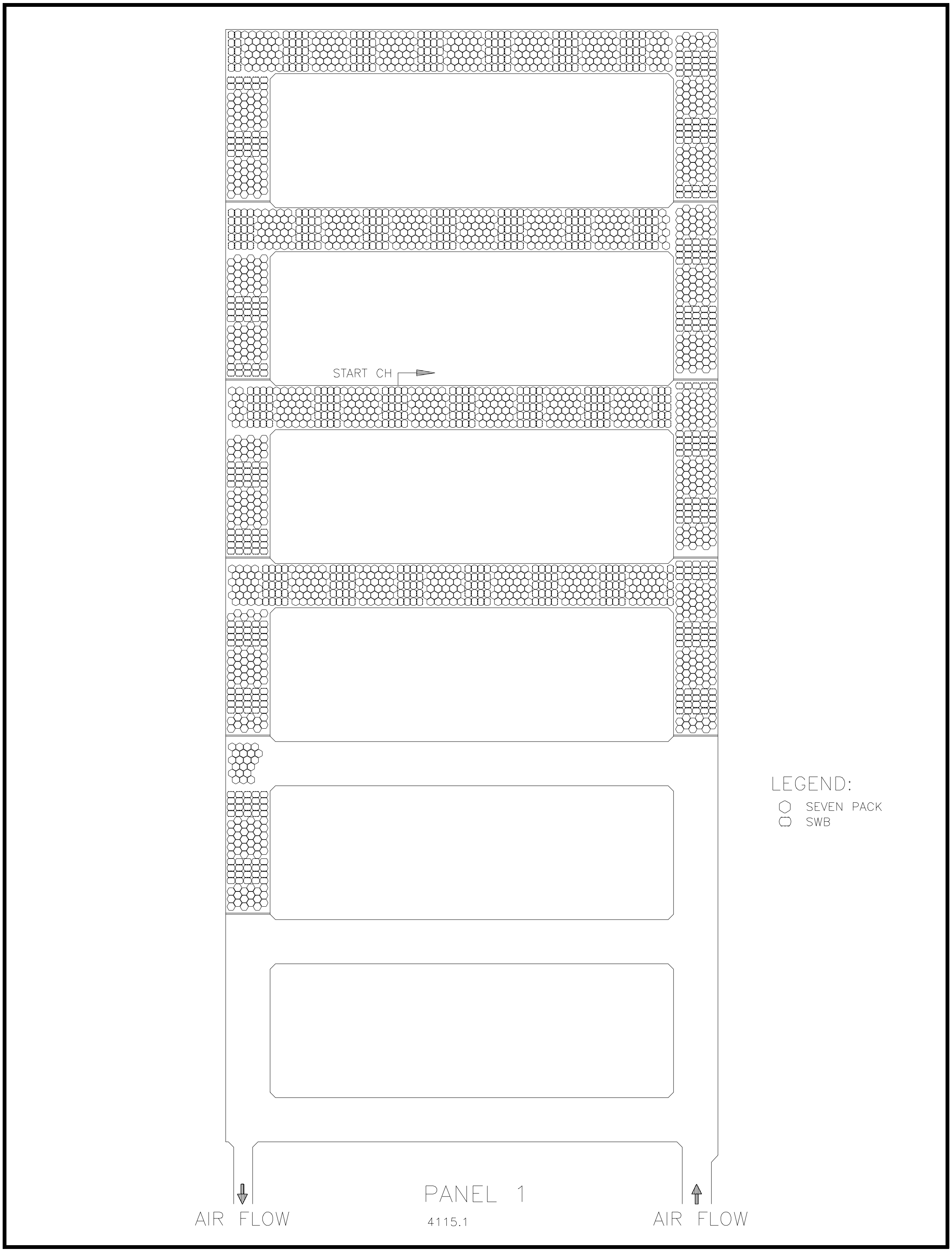


Figure 4.3-9d, Waste Emplacement Process

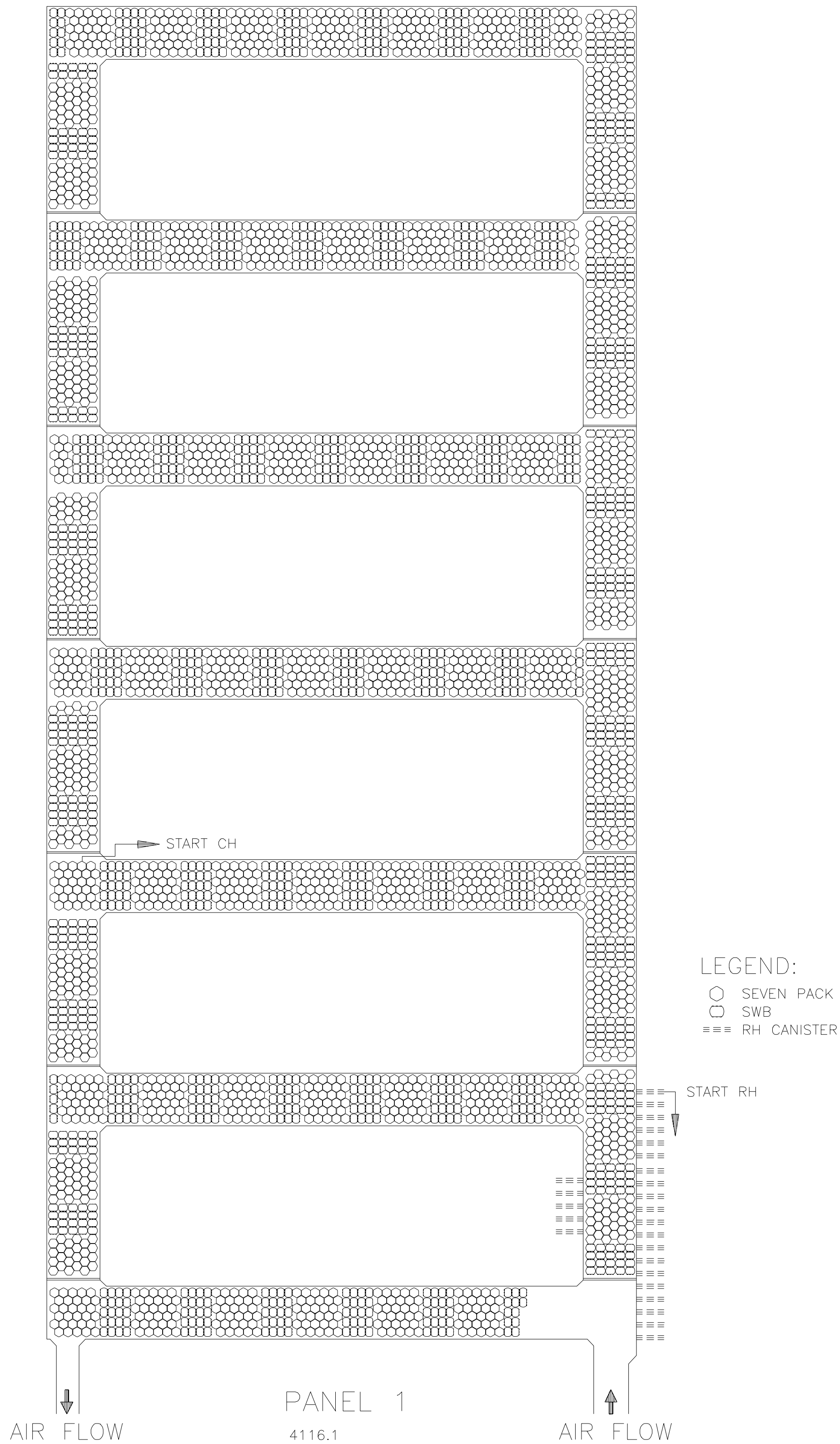


Figure 4.3-9e, Waste Emplacement Process

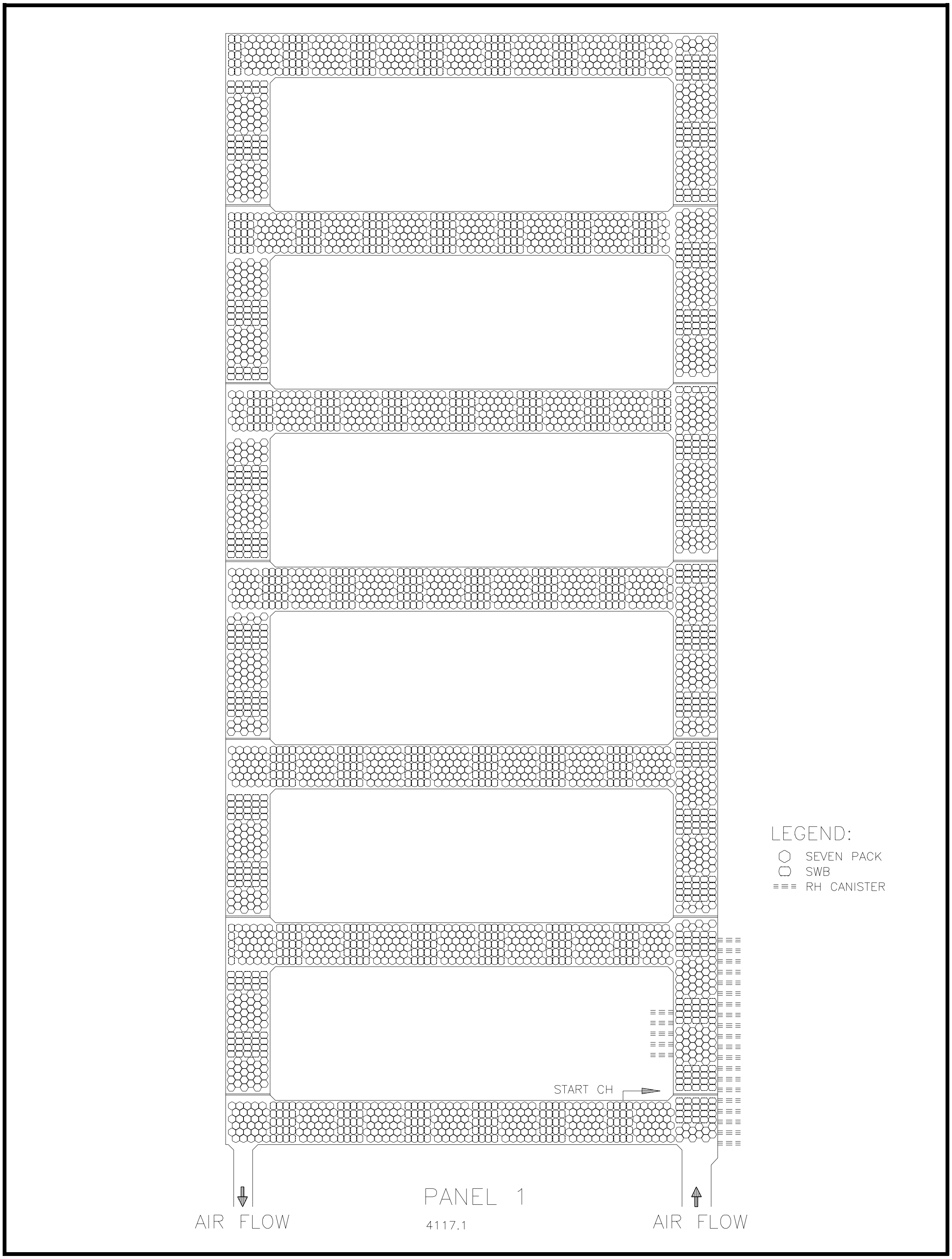


Figure 4.3-10, Panel 1 Filled with Waste

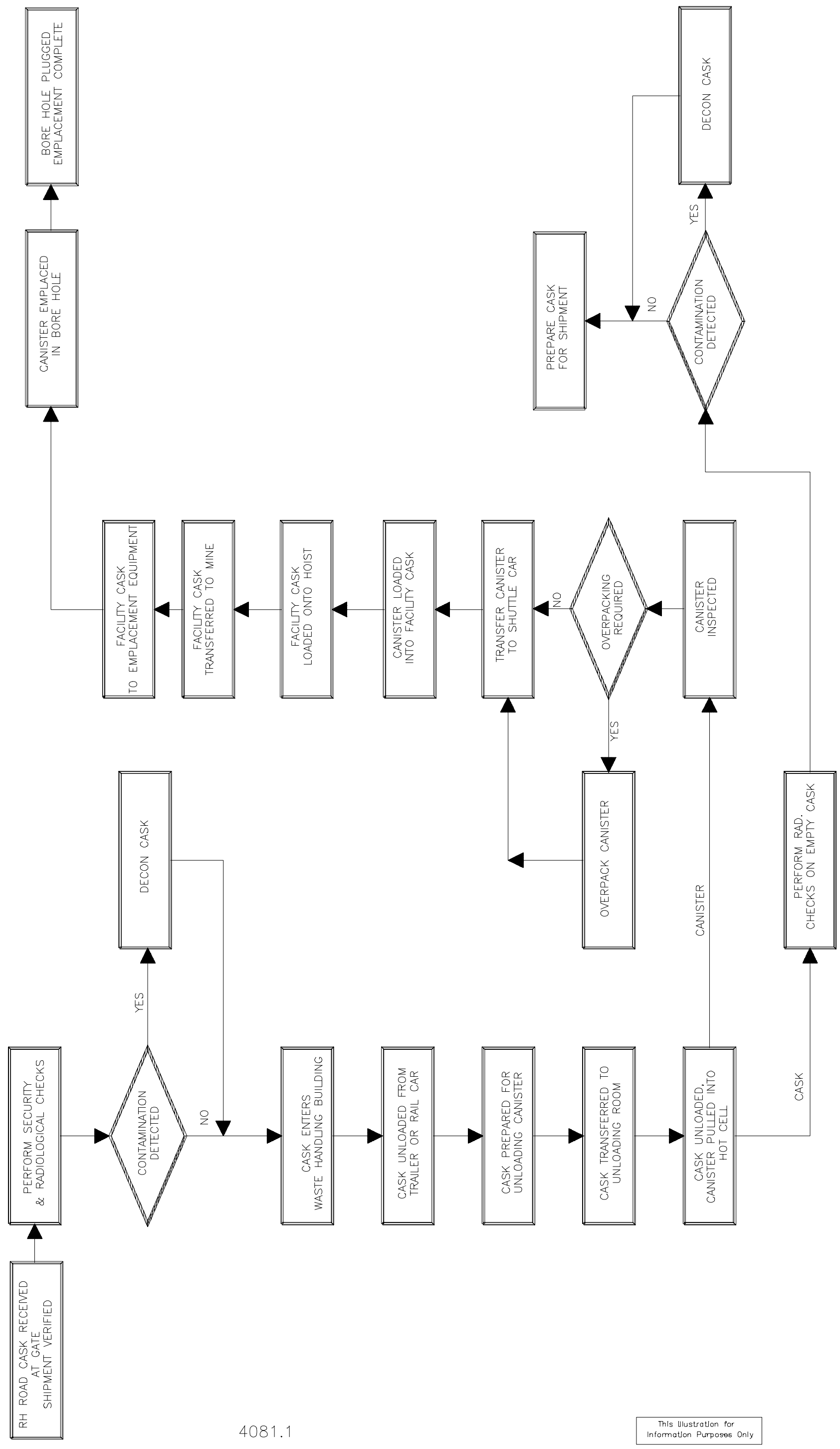


Figure 4.3-11, Surface and Underground RH TRU Waste Process Flow Diagram

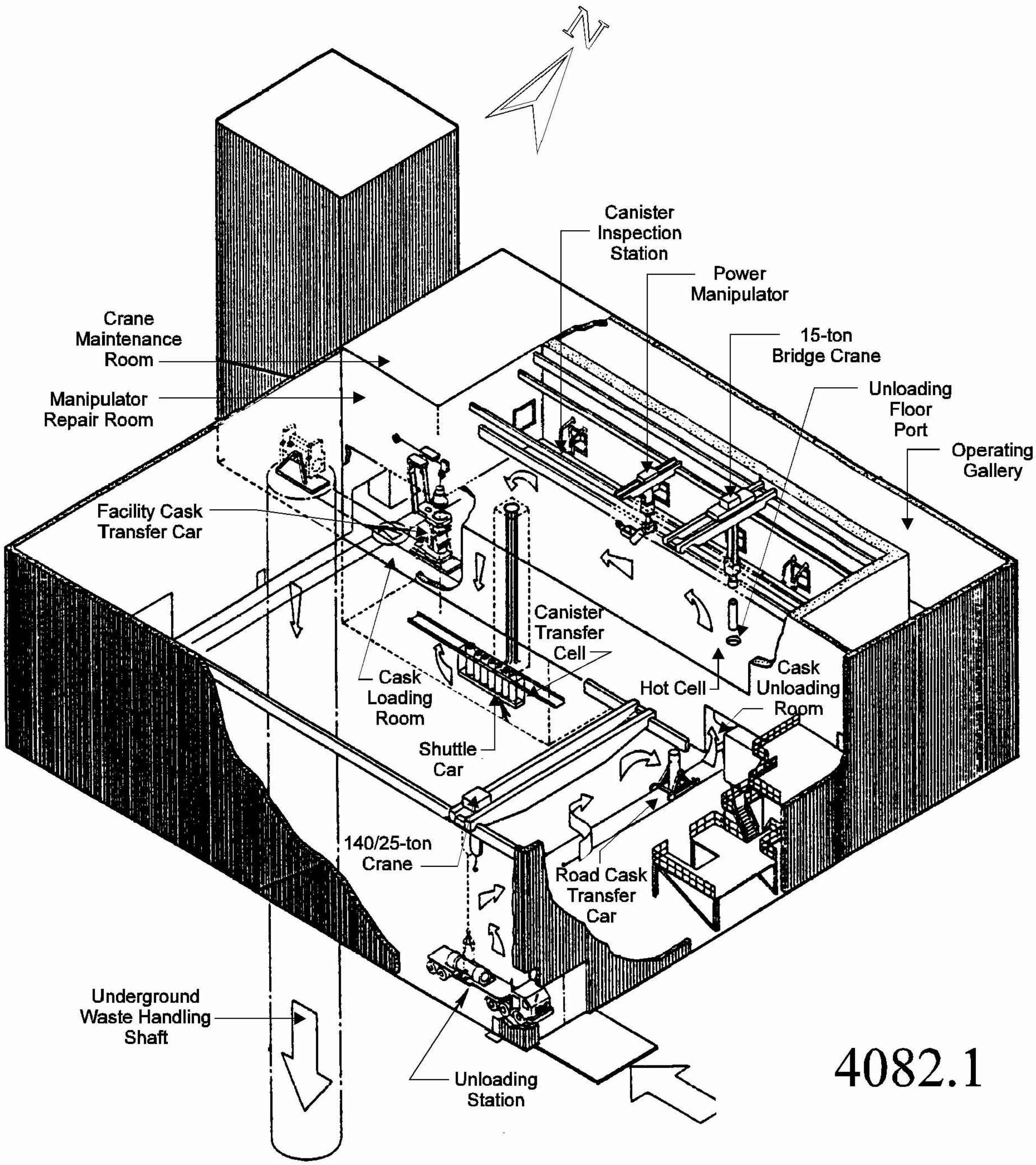


Figure 4.3-12, Pictorial View of the RH TRU Surface Operation

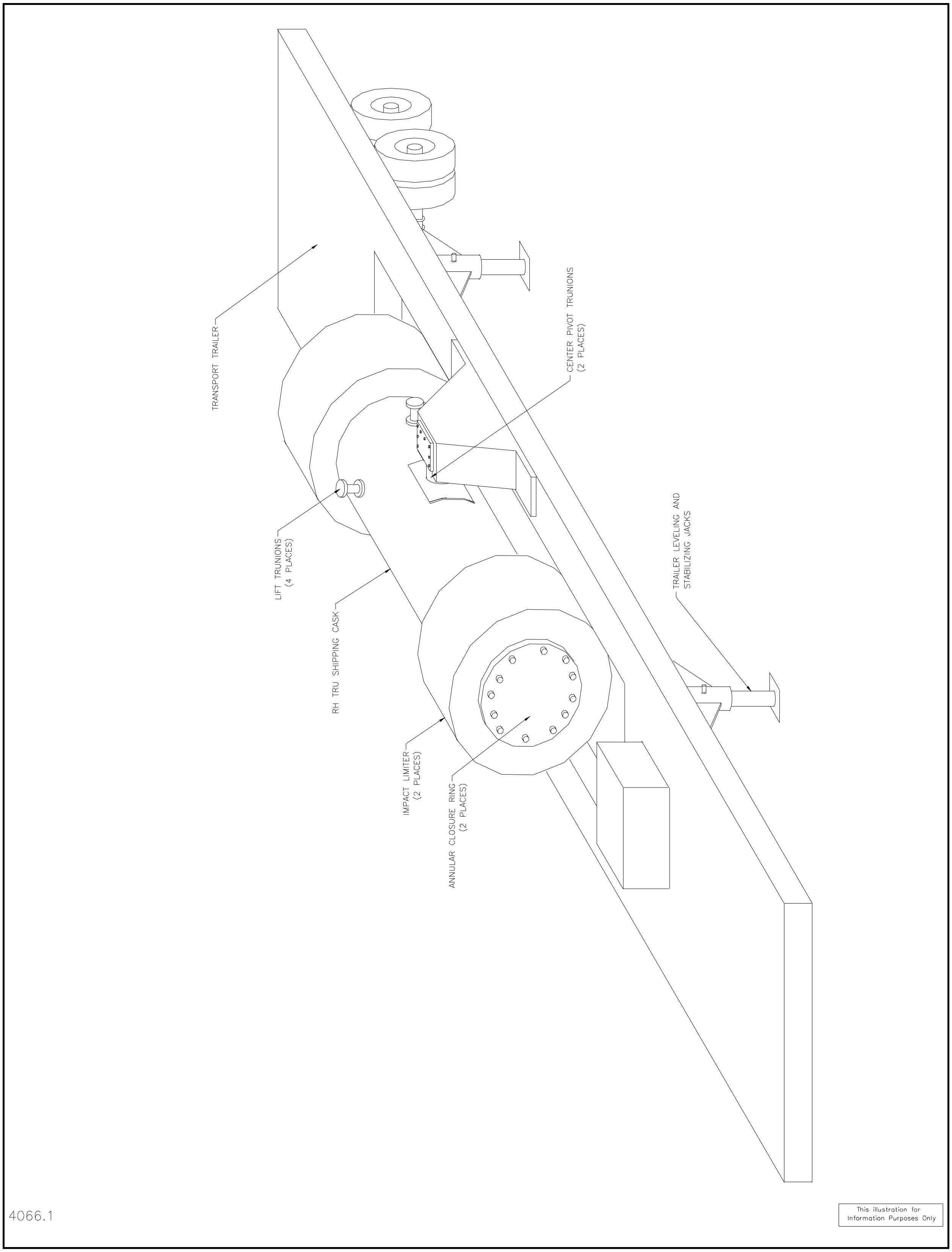


Figure 4.3-13, RH TRU Road Cask on Trailer

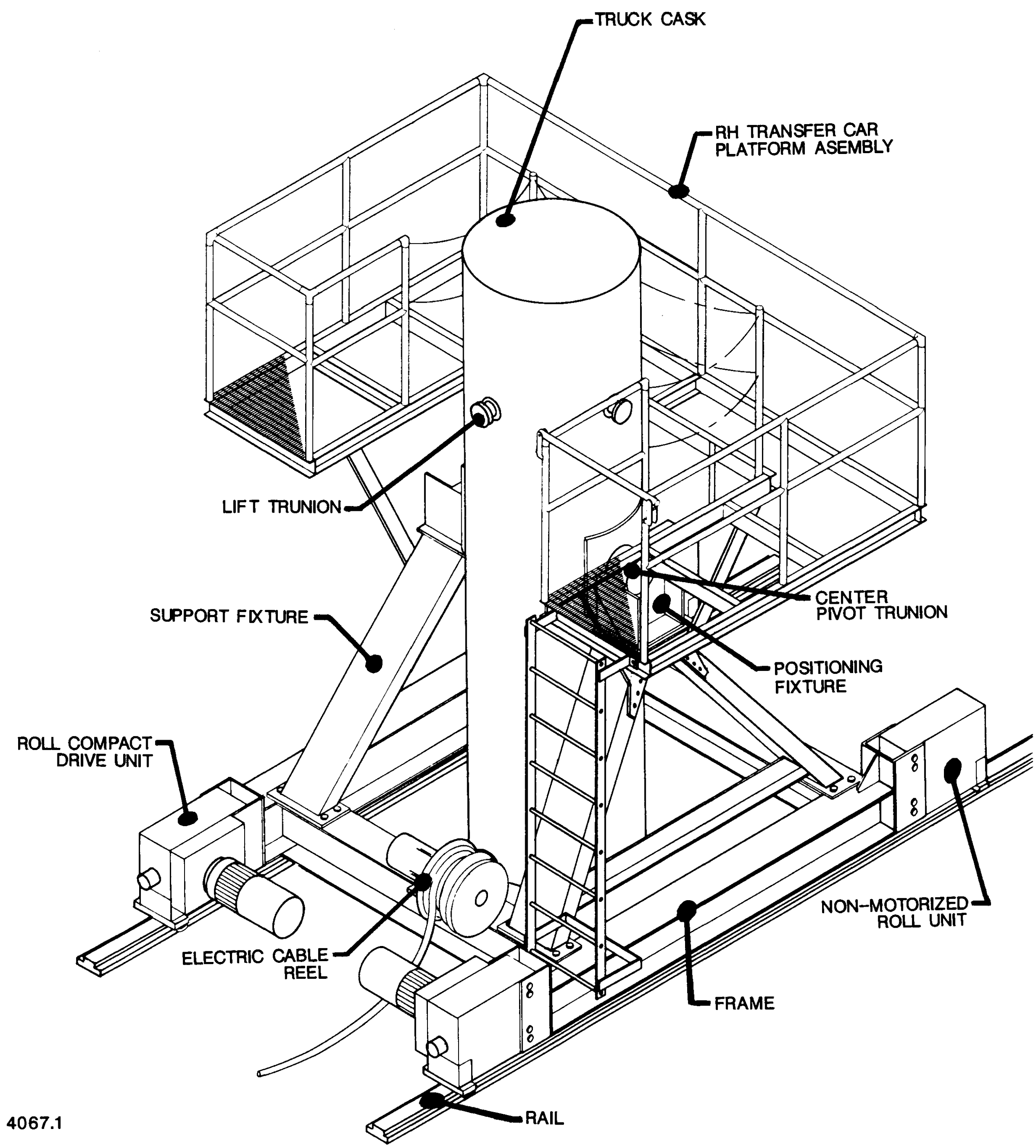


Figure 4.3-14, RH TRU Waste Shielded Road Cask on Transfer Car

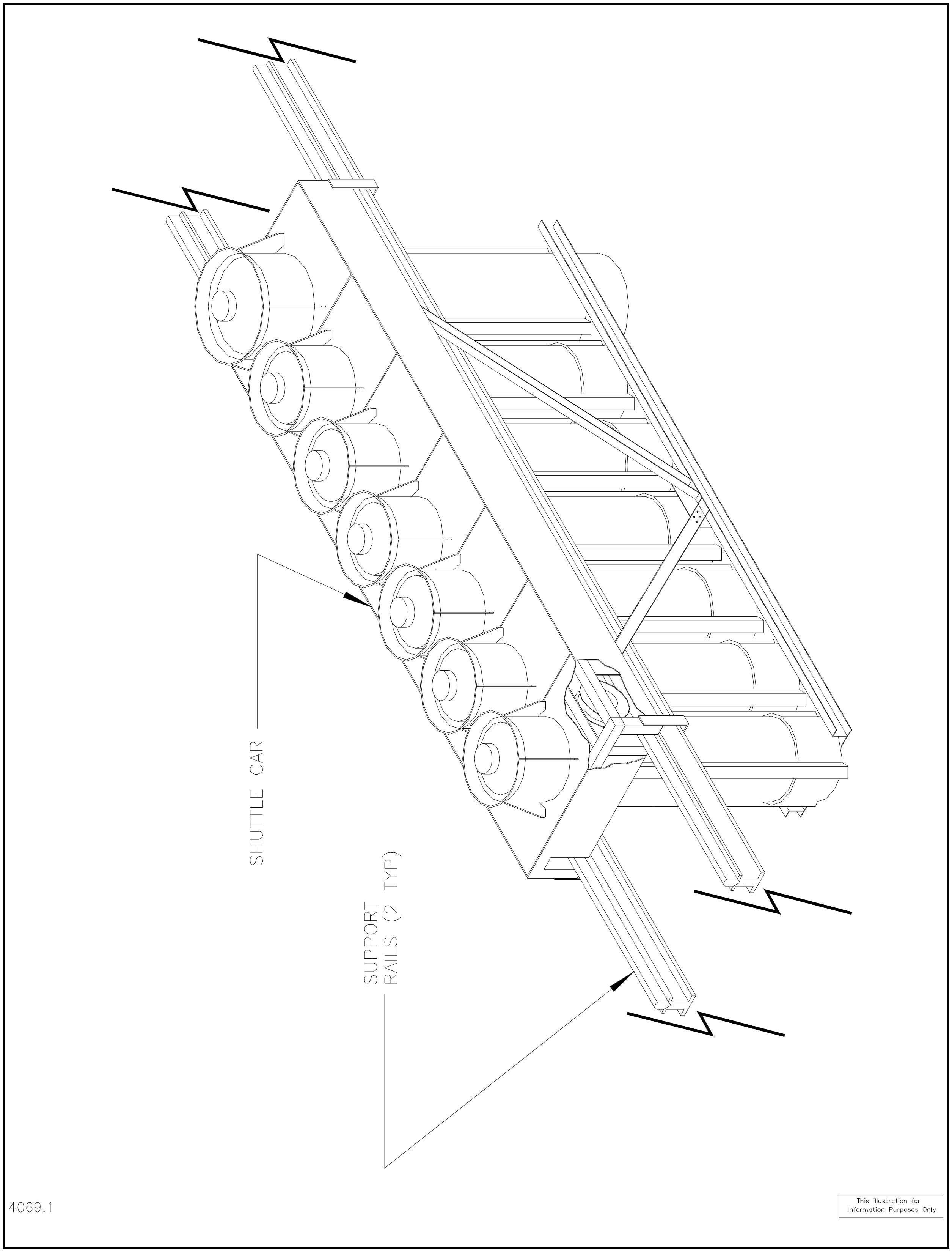


Figure 4.3-15, RH TRU Canister Shuttle Car

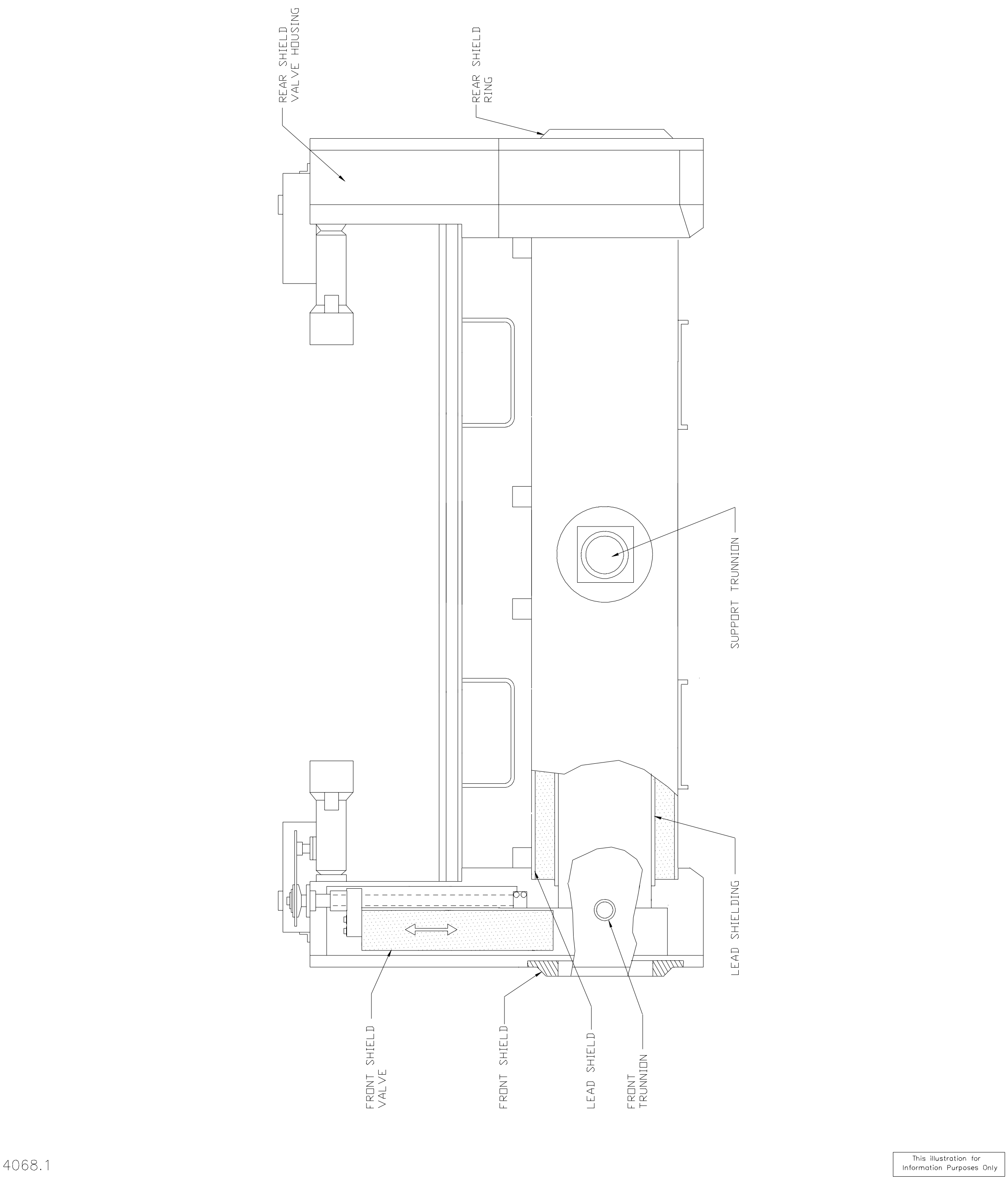


Figure 4.3-16, RH TRU Facility Cask

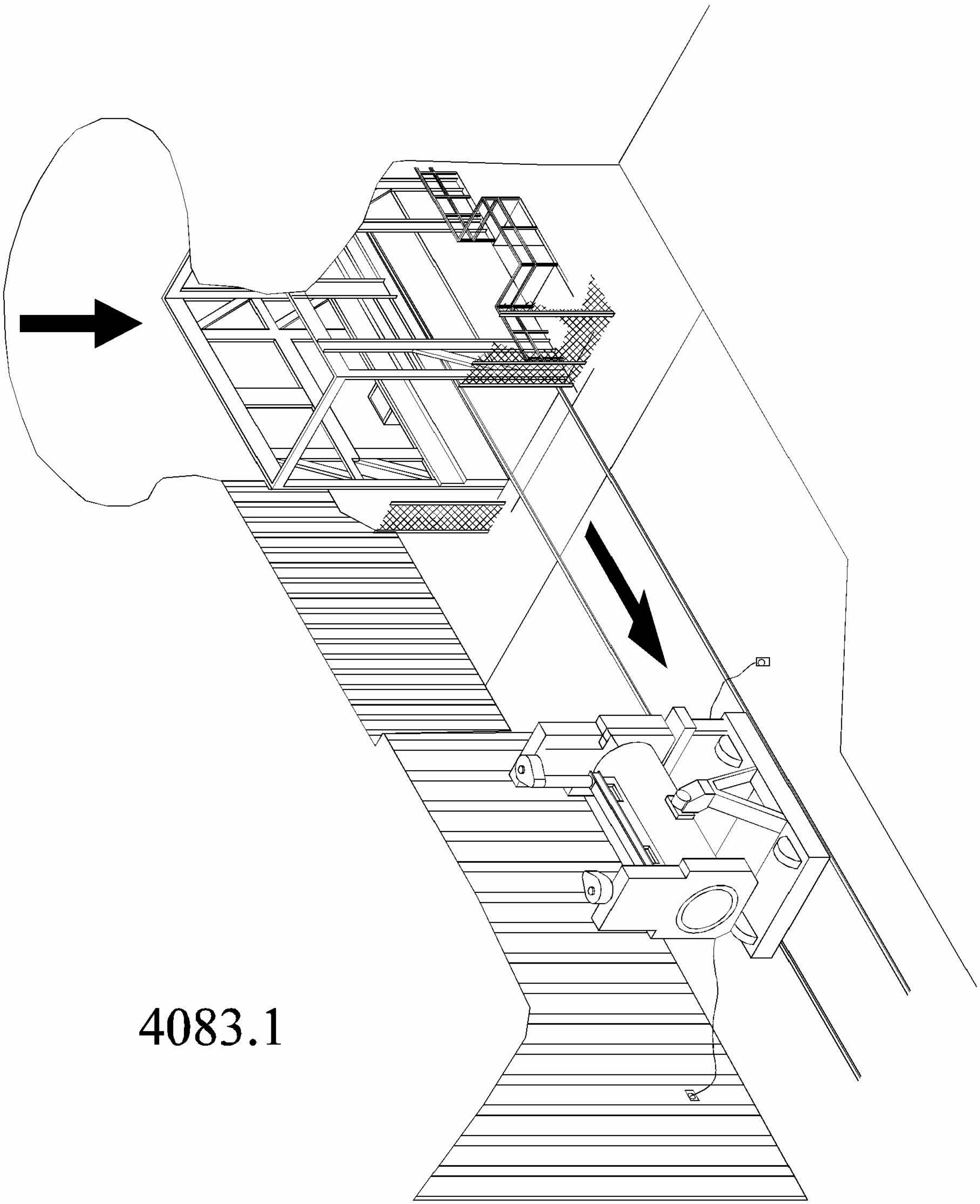


Figure 4.3-17, RH TRU Waste Handling Facility Cask Unloading from Cage

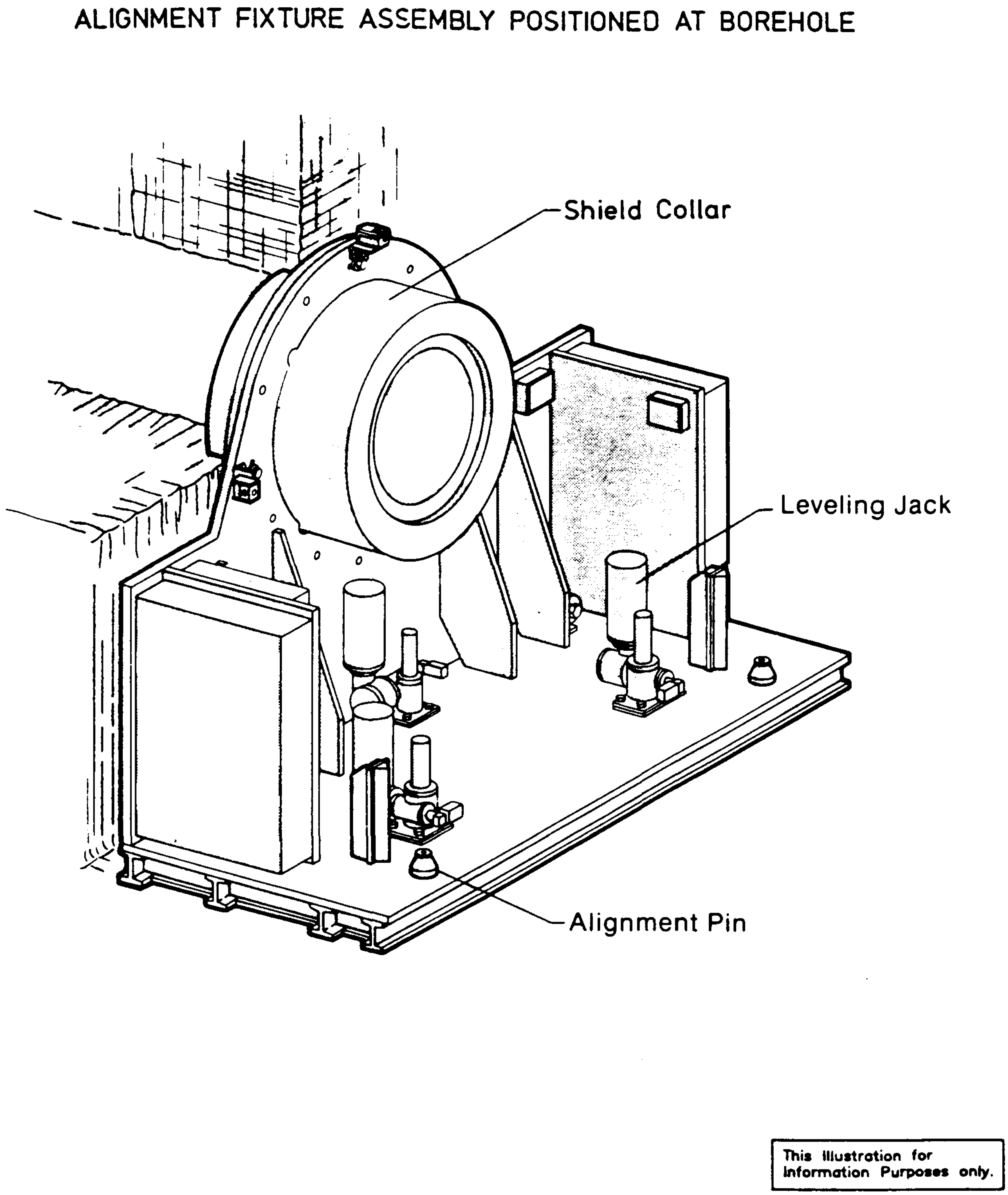


Figure 4.3-18, RH TRU Emplacement Alignment Fixture

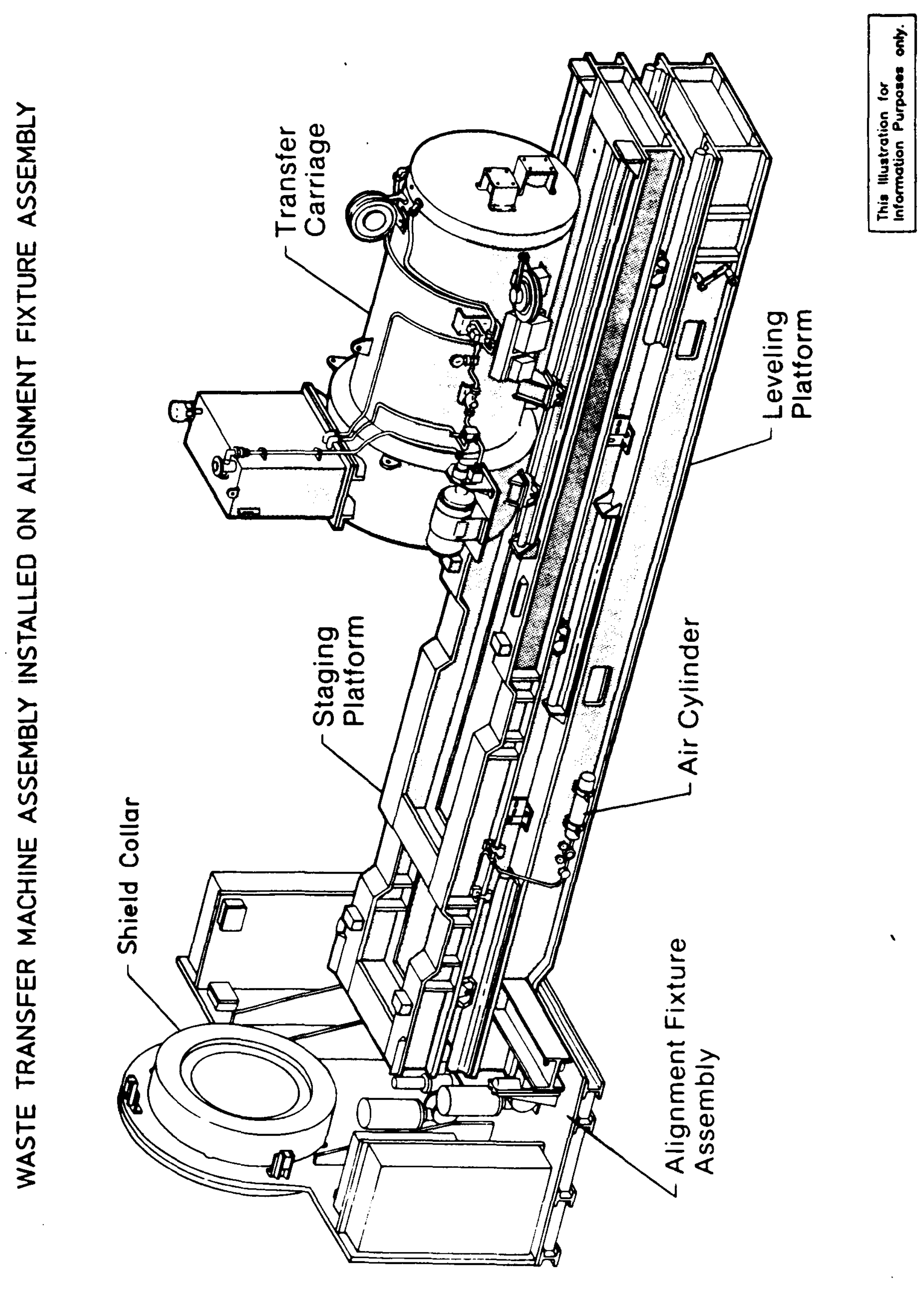
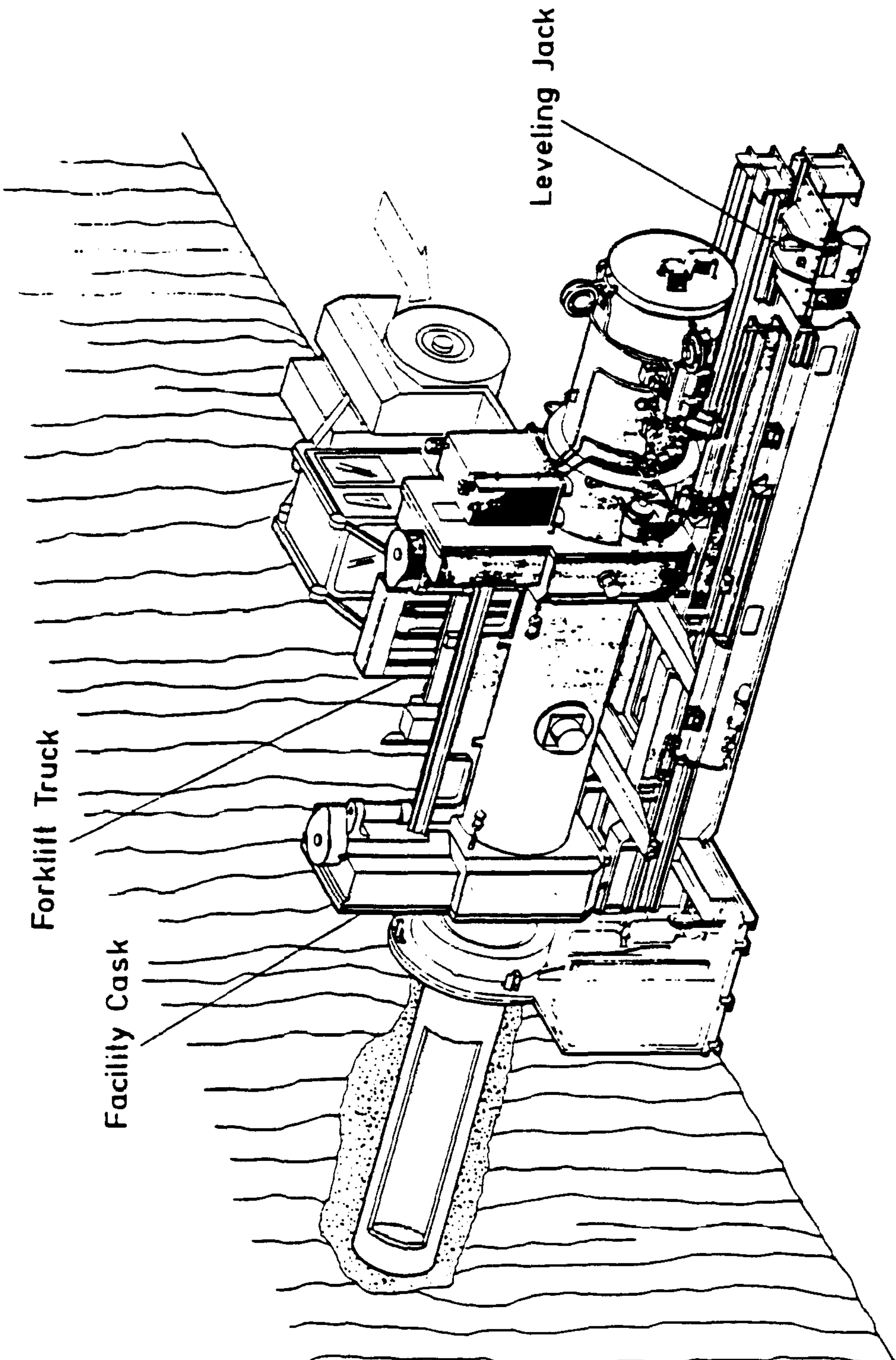


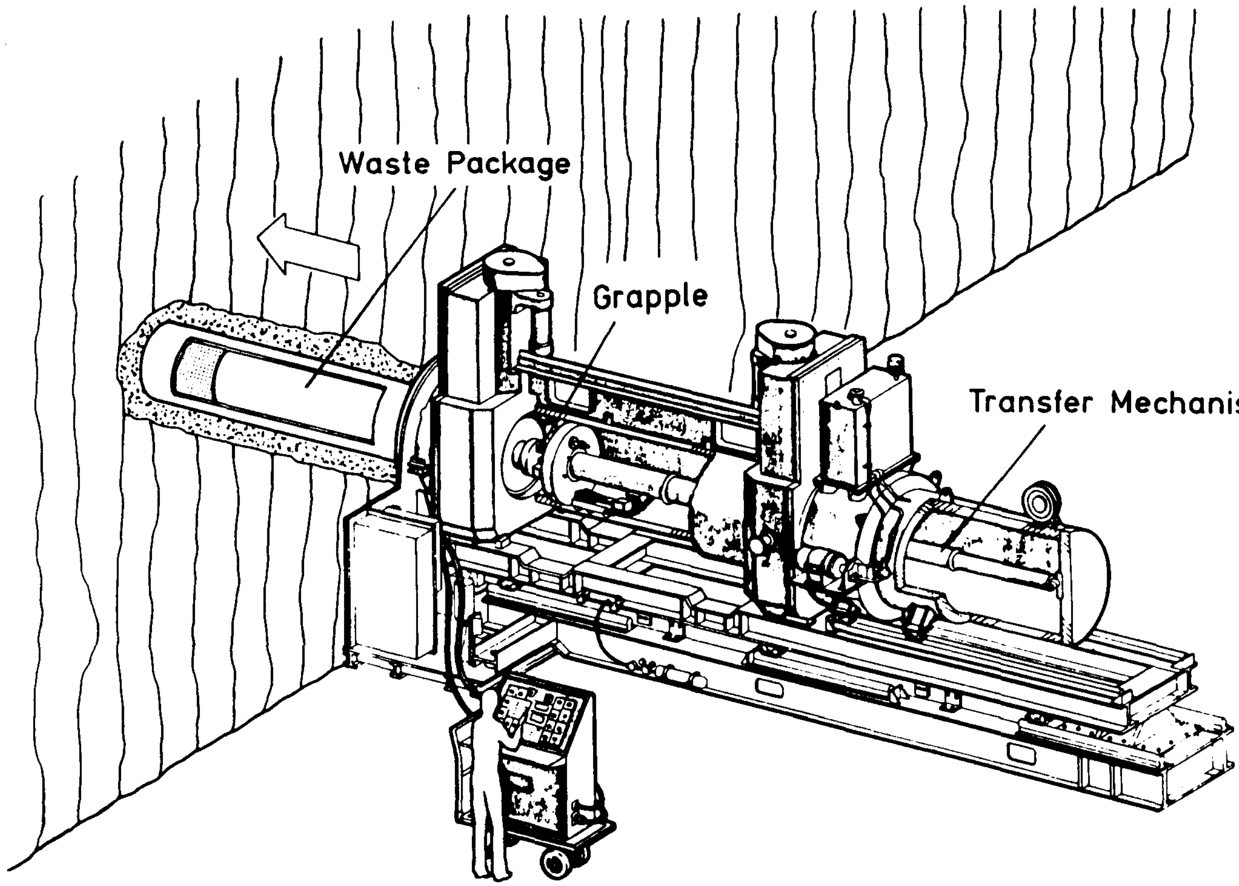
Figure 4.3-19, Waste Transfer Machine Assembly Installed on the Alignment Fixture



Source: DOE, 1990, 5.2-34.

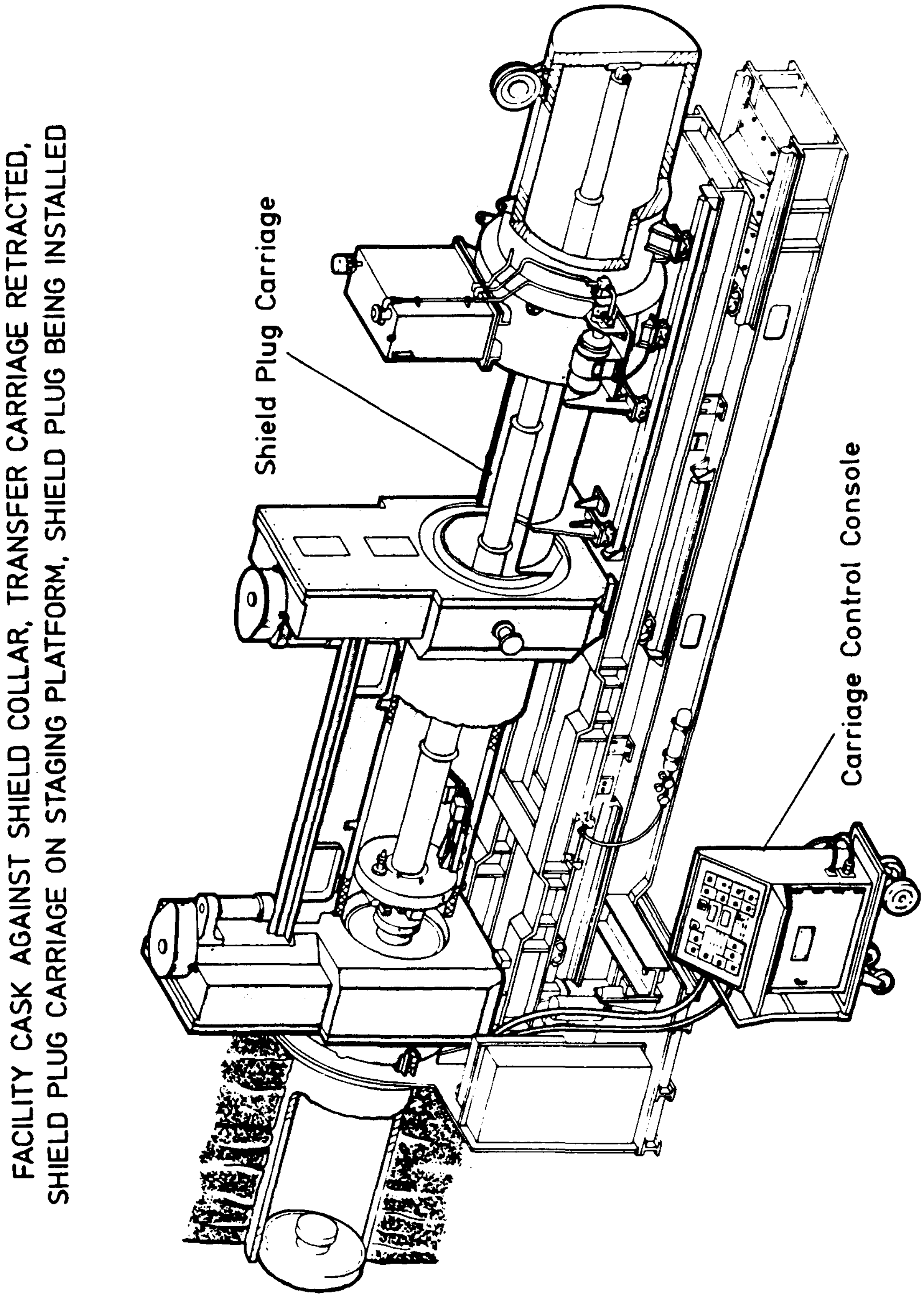
Figure 4.3-20, Facility Cask Installed on the Waste Transfer Machine Assembly

FACILITY CASK AGAINST SHIELD COLLAR, TRANSFER CARRIAGE AGAINST CASK,
WASTE PACKAGE BEING EMPLACED



This Illustration for Information Purposes only.

Figure 4.3-21, Waste Emplacement Equipment



This illustration for Information Purposes only.

Figure 4.3-22, Installing Shield Plug

This page intentionally blank

4.4 Confinement Systems

4.4.1 Confinement

The WIPP facility confinement system consists of static and dynamic barriers designed to meet the following requirements of DOE Order 6430.1A,[1] Section 1300-7:

- Minimize the spread of radioactive and other hazardous materials within the unoccupied process areas.
- Prevent, if possible, or minimize the spread of radioactive and other hazardous materials to occupied areas.
- Minimize the release of radioactive and other hazardous materials in facility effluents during normal operation and anticipated operational occurrences.
- Limit the release of radioactive and other hazardous materials resulting from Design Basis Accidents (DBAs) including severe natural phenomena and man-made events in compliance with the guidelines contained in DOE Order 6430.1A,[1] Section 1300-1.4.2, Accidental Releases.

Static barriers are structures that confine contamination by their physical presence, and dynamic barriers control the flow of contamination in the air. For the WIPP, static barriers consist of waste containers, building structures, geological strata, and HEPA filtration systems; Dynamic barriers consist of the surface and subsurface ventilation systems that maintain pressure differentials ensuring airflow is from areas of lower to higher contamination potential.

In addition to the above general requirements, the WIPP is designed to meet the specific confinement requirements of DOE Order 6430.1A,[1] Section 1324-6 and Section 1300-1.4.

For the WIPP, the primary confinement is the static barrier consisting of the waste containers, and the secondary confinement consists of those SSCs designed to remain functional (following DBAs) to the extent that the guidelines in DOE Order 6430.1A,[1] Section 1300-1.4.2, Accidental Releases, are met.

Consistent with DOE Order 6430.1A,[1] Section 1324-6, tertiary confinement is not required for the WIPP during disposal operations. Tertiary confinement will only be applicable during post-closure.

4.4.1.1 Waste Handling Building

Static and dynamic barriers are incorporated into the design of the WHB confinement system, and the primary confinement is the drum or container holding the waste.

The secondary confinement consists of the SSCs that house the primary confinement, including the shielded road cask, the TRUPACT shipping container, the rooms, the building walls, and the ventilation system, which maintains a static pressure differential between the primary confinement barriers and the environment. To assist the ventilation system, “air locks” are provided between separate areas where pressure differentials are necessary. The WHB HEPA filtration system connects with the ventilation systems and provides the final barrier for airborne particulates.

4.4.1.2 Underground

The primary confinement system for the underground is the drum or container being disposed in the underground. The secondary confinement consists of the natural barrier formed by the salt in the underground disposal areas and the underground bulkheads, which separate the disposal and mining areas. The underground ventilation system has provisions for exhausting to the exhaust filtration system, when in use, to mitigate any accidental releases of contaminated airborne particulates.

4.4.2 Ventilation Systems

The WIPP facility air handling systems are designed to provide a suitable environment for personnel and equipment during plant operations, and to provide contamination control for operational occurrences and postulated waste handling accidents. Certain components of the air handling systems are also used for functions related to space cooling and removal of heat.

The WIPP facility air handling systems serve three major plant areas: the surface facilities, the surface support facilities, and the subsurface facilities.

The air handling systems are designed to meet the emissions limitations in DOE Order 5400.5[2] using the following general guidelines:

- Transfer and leakage air flow is from areas of lower to areas of higher potential for contamination.
- In building areas that have a potential for contamination, a negative pressure is maintained to minimize the spread of contaminants.
- Consideration is given to the temporary disruption of normal air flow patterns due to scheduled and unscheduled maintenance operations by providing dual trains of supply and exhaust equipment. Air handling systems are provided with features to reestablish designed airflow patterns in the event of a temporary disruption. Generally, ducts that carry potentially contaminated air are routed away from occupied areas. In addition, potentially contaminated ducts are welded to the maximum extent practical to reduce system leakage.

The filtration system consists of prefilters and HEPA filters sized in accordance with design air flows utilizing the manufacturer's rating standards for maximum efficiency.

HVAC components are sized so that some components can be taken out of service for maintenance, allowing the system to continue operation. The schematic flow diagrams of the ventilation systems are shown in Figures 4.4-1 through 4.4-5.

4.4.2.1 Surface Ventilation Systems in Controlled Areas

There are independent ventilation systems for each of the following areas:

- Waste shaft hoist maintenance room
- CH waste handling area
- RH waste handling area
- WHB mechanical equipment room
- Waste handling shaft hoist tower

- Exhaust filter building

The waste shaft hoist maintenance room is outside the CA and the ventilation system that serves this area is not expected to contain radioactivity. The ventilation systems for the WHB and Exhaust Filter Building are "once through" systems designed to provide confinement barriers with the capability to limit the extent of releases of airborne radioactive contaminants. The ventilation systems are also designed to provide the necessary heating, ventilating, and air conditioning for personnel comfort and to remove heat.

The WHB ventilation system continuously filters the exhaust air from waste handling areas to reduce the potential for release of radioactive effluents to the environment. Some of air from the waste handling areas can flow down the waste shaft.

The design provides for differentials to be maintained between building interior zones and the outside environment, maintaining control of potentially contaminated air. The pressure differentials between different interior potential for contamination areas are based on the design contamination zone designations with respect to function and permitted occupancy. ERDA 76-21[3] is used as a guide in establishing zone differential pressures.

The ventilation systems supply 100 percent outside air conditioned to provide a suitable environment for equipment and personnel. Design air quantities limit the spread of airborne radioactive contaminants and maintain design temperatures.

Sufficient exhaust capacity and appropriate controls in the hot cell and canister transfer cell of the WHB maintain an average velocity of at least 125 linear ft/min (0.635 m/s), through maximum credible openings to capture potential airborne contaminants. The exhaust rate for chemical hoods is sufficient to maintain an average velocity of 150 ft/min (0.762 m/s)across the hood.

The design provides for “air locks” in the following circumstances:

- At entrances to potentially contaminated areas to maintain a static barrier
- Between areas of large pressure differences to provide a pressure transition and to eliminate high air velocity, dust entrainment, and eddy currents
- Between areas where pressure differentials must be maintained
- To minimize air movement from the WHB to the waste shaft

The ventilation systems are designed to provide adequate instrumentation monitoring the operating parameters. The following parameters are monitored:

- Pressure drop across each prefilter and HEPA filter bank
- Airflow rates at selected points, e.g., downstream of the filters
- Pressure differentials surrounding areas of high potential for contamination levels
- The radioactive material concentrations in the effluent released through the exhaust vent

Fresh air supply intakes are located away from the exhaust vent to minimize the potential for the intake and recirculation of exhaust.

The operation of the supply and exhaust fans is controlled by electrical motor interlocks to maintain the designed air flow patterns and sufficient air leakage into the building. The exhaust fans and controls are capable of being supplied by backup power in the event that normal power is interrupted.

4.4.2.1.1 CH and RH TRU Waste Handling Area

The CH and RH TRU waste handling areas are served by separate, independent ventilation systems, shown on schematic flow diagrams, Figures 4.4-1 through 4.4-3.

The supply systems are Design Class IIIB, and the exhaust systems are Design Class IIIA, with the exception of HEPA filter units and associated isolation dampers, which are Design Class II.

Fan operating status, filter bank pressure drops, airborne radioactivity levels, and static pressure differentials are monitored in the Central Monitoring Room (CMR). Excess filter pressure drops and low flows alarm in the CMR. Local readouts give flow rates and pressure differentials.

The Station C radiation effluent monitoring system has provisions for monitoring the effluent air discharged from the exhaust vent.

In the CH TRU waste handling area, the design of the battery charging area exhaust system limits the buildup of hydrogen to less than 4 percent as a result of battery recharging operations, and the charging area has a separate exhaust system with prefilters and HEPA filters. The ventilation system is designed with two 100 percent capacity exhaust fans each able to remove air from high points in the forklift battery recharging area at a rate sufficient to maintain hydrogen concentration below the lower explosive limits.

In the RH TRU waste handling area, particular design consideration is given to inhibit the potential for spreading airborne radioactive particles from the hot cell. The supply air to the hot cell room is cascaded from the surrounding RH waste handling area, and exhaust air from the hot cell passes through independent prefilters and HEPA filters before being discharged to the atmosphere via the exhaust vent. Sufficient exhaust capacity is provided to maintain the design pressure differential between the hot cell and the surroundings or to maintain at least 125 linear ft/min (0.635 m/s) inward flow through the maximum credible breach, minimizing the potential for contaminants to escape.

The supply air to the hot cell is provided using an air handling unit and a cooling coil to condition the supply air drawn in from the RH receiving area.

The waste shaft is separated from the RH waste handling area by an air lock minimizing the air movement between the RH waste handling areas and the shaft.

Major Components and Operating Characteristics - The ventilation supply and exhaust systems for each building subsystem supply air to the rooms of the areas served. Each supply air handling unit consists of filters, cooling coils, heating elements, fans with associated duct work, and controls to condition the supply air maintaining the designed temperature during winter and summer. Exhaust air is filtered and monitored by the radiation monitoring system.

Each exhaust subsystem provides a filtered air exhaust path consisting of one stage of prefilters, two stages of HEPA filters, and one 100 percent capacity exhaust fan that discharge air through the building vent at a nominal flow of 47,450 ft^3 (1,343.6 m^3) per min., which is monitored for airborne radioactivity.

In the event of a tornado, tornado dampers will **automatically** close to prevent the outward rush of air caused by a rapid drop in atmospheric pressure. Damper closure mitigates the destruction of HEPA filters and ducts by preventing a high-pressure differential from affecting the filters.

During the initial opening phases of a TRUPACT-II, the TRUDOCK Vent Hood System (VHS) will function as a local exhaust system to control potential airborne-particulate contamination through the use of industrial grade HEPA filters. Headspace gases will also be drawn into the WHB HVAC exhaust system.

Safety Considerations and Controls - The exhaust system remains functional to the extent that confinement and differential pressures are maintained, exhaust air is filtered, and during a tornado excessive flow that could cause duct damage is prevented by automatic tornado dampers.

In case of an off-site power failure, the capability exists to selectively switch one exhaust fan to the backup power system in order to continue to exhaust air in the designed flow pattern. The WIPP WP 04-ED series Facility Operations Procedures[5] provides procedures for applying backup power to the exhaust fans.

The supply and exhaust fans are designed and interlocked to maintain building pressure sub-atmospheric and maintain the design airflow pattern. During normal operation, if operating exhaust fan fails on subsystems other than the CH TRU area, the corresponding supply fan is stopped in order to prevent positive building pressure. If the operating CH area exhaust fan fails, the corresponding supply fan stops and the standby train is started manually. If a corresponding supply fan fails, the exhaust fan also stops.

Sufficient remote instrumentation is provided enabling the operator to monitor equipment from the CMR. The monitored parameters include fan operating status, filter bank pressure drop, level of radioactivity in the exhaust, and static pressure differential in areas of the hot cell, and the preparation station. Fan failure and excessive radiation levels (setpoints Alpha 40 cpm and Beta/Gamma 12,000 cpm) are annunciated and low flow (setpoint 0.2 scfm) conditions of the main exhaust fans produce an alarm in the CMR.

Filter differential pressure is displayed locally as well as in the CMR. An alarm for a pressure drop indicating filter replacement is needed actuates at a predetermined level across the HEPA filters.

Instruments and system components are accessible for, and will be subject to, periodic testing and inspection during normal plant operation.

For those HEPA filters which are on-line continuously in the WHB, the CMS monitors prefilter pressure differential (D/P) and HEPA D/P ensuring satisfactory system operation. The Exhaust Filter Building HEPA filters are normally off-line, and not subject to dust buildup during normal operation. All nuclear grade HEPA filters are tested for conformance with ANSI N510,[7] and have a combined 99.95 percent removal efficiency per stage.

4.4.2.1.2 Mechanical Equipment Room

The mechanical equipment room is maintained at a pressure slightly below atmospheric to minimize leakage of room air, which may contain airborne radioactive contaminants. Negative pressure is maintained by the same exhaust fan systems that exhaust air from the CH TRU and RH waste handling areas. This equipment room is maintained within design temperature limits for equipment and personnel.

4.4.2.1.3 Waste Handling Shaft Hoist Tower

The ventilation system provides filtration of supply air, unit heaters to prevent equipment from freezing, and a unit cooler to provide supplementary cooling of equipment in summer. Exhaust airflow is down through the tower and into the waste shaft, where it combines with incoming air from the waste shaft auxiliary air intake tunnel (Figure 4.4-3).

A pressurization system serves the air lock to the crane maintenance room at 142 ft-1 in (43.3 m) elevation and pressurizes the air lock preventing the release of potentially contaminated air from the crane maintenance room to the 142 ft-1 in (43.3 m) elevation access corridor.

4.4.2.1.4 Exhaust Filter Building

A schematic flow diagram of the Exhaust Filter Building ventilation system is shown in Figure 4.4-4.This building supports the operation of the underground ventilation system and contains the underground ventilation system filtration filters.

The function of the ventilation system in the Exhaust Filter Building, major components, operating characteristics, safety considerations, and controls, are similar to the CH TRU waste handling area in the WHB.

Each supply air handling unit in the Exhaust Filter Building consists of prefilters, an electric heating coil, and a fan to condition the air, as required to maintain the design temperature.

The Exhaust Filter Building ventilation system exhausts air from all potentially contaminated areas of the building through two filter housings, each containing a bank of prefilters and two stages of HEPA filters, and two exhaust fans before discharging to the atmosphere. The building's exhaust air is discharged to the underground exhaust duct so that it can be monitored for airborne radioactive contaminants.

4.4.2.2 Surface Support Structures Ventilation System

The following surface support facilities are served by separate heating, ventilation, and air-conditioning systems:

- The Support Building
- Main Warehouse/Shops Building
- Water Pump House
- Guard and Security Building
- Maintenance Shop
- Compressor Building (exhaust fans only)
- Safety and Emergency Services Building
- Engineering Building
- Training Building

The design of the surface support facilities HVAC systems provides for:

- Regulating temperature for the comfort of personnel and satisfactory operation of equipment
- Filtering the air supply for personnel
- Maintaining building spaces at slightly positive pressures with respect to the outside, except radioactive materials areas, where negative pressures shall be maintained relative to the outside and to adjacent accessible nonradioactive building spaces
- Confining ventilation air to designed airflow paths for discharge to the atmosphere
- Minimizing the possibility of exhaust air recirculation by an adequate distance between fresh air supply intakes and exhaust air outlets

The design of the ventilation system for the CMR requires functions to be performed with respect to environmental control for personnel and equipment following a postulated accident, such as a fire or radioactivity release. The CMR system is manually switched to the backup power supply to ensure operation monitoring, and control of the HVAC systems if the normal power supply is lost.

In addition, the independent CMR HVAC system provides for:

- 100 percent equipment redundancy (except ductwork)
- Make-up air being processed through HEPA filters in the event of a high airborne radioactivity signal
- Static pressure controls to regulate the amount of outside air that may be drawn into the system through the HEPA filters before it is supplied to the CMR permitting occupancy

Safety Considerations and Controls - The HVAC systems for these surface support facilities, with the exception of the CMR, are not required to perform functions that are essential to safety. Fan motor interlocks, dampers, temperature indicators, filter pressure differential alarms, and other required instrumentation and controls are provided.

CMR

The Support Building CMR area HVAC system serves the computer room, CMR and associated vestibule, vault, office, and storage room. Equipment redundancy is provided for the following: supply air handler, air cooled condensing unit, and exhaust fan.

The HVAC system provides a suitable environment for continual personnel occupancy, and equipment integrity under normal and emergency conditions and maintain a slightly positive pressure in the CMR. Air passes through at least a two-stage filtration system before it enters the above listed areas.

A HEPA filter and pressurizing fan system upstream of the supply units, bypassed during normal operation, may be automatically activated upon the detection of airborne radioactivity levels above the sensor set point at Station C.

Major Components and Operating Characteristics - Major components of this HVAC system consist of supply air handling units (containing fans, direct expansion cooling coils, and filters), air cooled condensing units, duct heaters, exhaust-return fans, booster fans, HEPA filter units, dampers, instrumentation, and controls.

The schematic airflow diagram for the CMR area HVAC system is shown in Figure 4.4-5.

The CMR area is served by two 100 percent capacity air-conditioning units. One in service and one in standby status, available for automatic start in the event the operating unit fails.

Under normal operating conditions (recirculation mode), outside makeup air and return air are filtered by a two-stage air filter system. The first stage of filtration consists of nominal 2-inch (5 cm) thick low efficiency filters and the second stage consists of high efficiency filters rated at 85 percent efficiency (atmospheric dust) by ASHRAE Standard 52-76.[8] After the second stage of filtration, the air supply temperatures are thermostatically controlled, as necessary to maintain designed temperatures. The filtered and conditioned air supply is distributed to the various rooms within the CMR area by means of ductwork and air outlets.

Safety Considerations and Controls - The main function of the HVAC system is to provide a suitable environment enabling the CMR area to be occupied under normal and emergency operating conditions including the prevention of airborne radioactive contaminants entering the supply systems.

A backup air conditioning system (air handler, air cooled condensing unit, and exhaust fan) is available to automatically start in the event an operating component fails. The supply and exhaust air handling systems are capable of being manually connected to the backup power system for operation during a loss of off-site power.

Locally-mounted instruments are provided for monitoring the HVAC system and filter pressure drop is monitored and alarmed, locally and in the CMR.

The supply and return exhaust fans are electrically interlocked, to maintain the designed airflow pattern, and the entire HVAC system is interlocked with the fire protection system.

4.4.2.3 Subsurface Facilities Ventilation System

The subsurface ventilation system serves all underground facilities and provides confinement of radioactivity, acceptable working conditions, and a life-sustaining environment during normal operational occurrences and postulated waste handling accidents. Operation of diesel equipment in the underground repository is limited to the available airflow in the area.

Subsurface ventilation is divided into four independent flow paths on the disposal horizon supporting the waste disposal area, the mining area, north area, and the waste shaft and waste shaft station area. The waste disposal, and mining and underground shop areas receive their air supply from common sources (see Figure 4.4-6) (the AIS and the SH shaft) and are independent of each other after the initial distribution/split is made. The waste shaft station receives its air supply from the waste shaft and is kept completely isolated from the other three. All four air circuits combine near the exhaust shaft, which acts as the common discharge from the system.

All bulkheads and ventilation controllers used to maintain the integrity of the underground ventilation circuits are made of fire resistant material, and can support the maximum pressure differential that could occur under normal operating conditions. These structures are designed, installed, and maintained in such a manner that they can accommodate the ground deformation (salt creep) occurring in the underground.

One of three filtration surface exhaust fans is capable of being connected to the backup power supply (one at a time) in the event that normal power is lost. Changeover to backup power is manual. The ventilation system is instrumented to provide for verification of proper system function.

The design and operation of the underground ventilation system meets or exceeds the criteria specified by 30 CFR 57[9] and the New Mexico Mine Safety Code for All Mines.[10] The underground mine ventilation is designed to supply sufficient quantities of air to all areas of the repository. During normal operating mode (simultaneous mining and waste emplacement operations), approximately 140,000 actual ft^3 (3,962 m^3) per min can be supplied to the panel area. This quantity of air is required to support the numbers and types of diesel equipment that are expected to be in operation in the area, to support the underground personnel working in that area, and to exceed a minimum air velocity of 60 ft (18 m) per min, as specified in the WIPP Ventilation Plan .

Approximately 35,000 ft^3 (990 m^3) per min will be required in each of three active rooms during operations. This quantity of air is required to support the numbers and types of diesel equipment that are expected to be in operation in the area, to support the underground personnel working in that area, and to exceed a minimum air velocity of 60 ft (18 m) per min, as specified in the WIPP Ventilation Plan. The remaining rooms in a panel will either be completely filled with waste; be idle, awaiting waste handling operations; or being prepared for waste receipt. The remainder of the air is needed in order to account for air leakage through inactive rooms and support facilities.

Air will be routed into a panel from the intake side. Air is routed through the individual rooms within a panel using underground bulkheads and air regulators. Bulkheads are constructed by erecting framing of rectangular steel tubing and screwing galvanized sheet metal to the framing. Figure 4.4-8 shows a typical bulkhead with an airflow regulator installed. In order to accommodate salt creep, bulkheads use telescoping extensions that are attached to the roof. Bulkheads use either a sheetmetal or rubber flashing attached to the salt to provide an effective seal. Flow is also controlled using brattice cloth barricades. These consist of chainlink or other suitable materials fence that is bolted to the salt and covered with brattice cloth; and are used in instances where the only flow control requirement is to block the air temporarily. Ventilation will be maintained only in active rooms within a panel. After all rooms within a panel are filled, the panel will be closed using a closure system described in Section 4.2.3.4.

Once a disposal room is filled and is no longer needed for emplacement activities, it will be barricaded against entry and isolated from the mine ventilation system by constructing chain link/brattice cloth barricades at each end. A brattice cloth air barricade is shown in Figure 4.4-9. There is no requirement for air for these rooms since personnel and/or equipment will not be in these areas.

The ventilation path for the waste disposal side is separated from the mining side by means of air locks, bulkheads, and salt pillars. A pressure differential is maintained between the mining side and the waste disposal side to ensure that any leakage is towards the disposal side. The pressure differential is produced by the surface fans in conjunction with the underground air regulators. Pressure differentials across these bulkheads between the mining and disposal sides (located nearer to the disposal panel) are monitored from the CMR.

The exhaust air is discharged through the exhaust shaft, by the exhaust system, under the following modes of operation:

Normal Mode - During normal operation, four different levels of Normal Mode ventilation can be established to provide four different air flow quantities as follows:

- Normal Ventilation: Two main exhaust fans operating to provide 425,000 scfm (224 m^3/s) unfiltered.

- Alternate Ventilation: One main exhaust fan operating to provide 260,000 scfm (123 m^3/s) unfiltered.

- Reduced Ventilation: Two filtration fans operating as ventilation fans to provide 60,000 scfm (28.3 m^3/s) each unfiltered.

- Minimum Ventilation: One filtration fan operating as a ventilation fan to provide 60,000 scfm (28.3 m^3/s) unfiltered.

- Maintenance Ventilation: Simultaneous operation of one main ventilation fan with one or two of the filtration fans in support of flow calibration and maintenance activities.

Filtration Mode - This mode mitigates the consequences of a waste handling accident by providing a HEPA filtered air exhaust path from the waste disposal areas and also reducing the air flow. Manual activation is required if the CMR is notified of an underground occurrence involving the waste packages. This mode may also be activated automatically by the Radiation Monitoring System active waste disposal room exit alpha CAM.

Fire Isolation Mode (Air Reversal Mode) - An underground fire or an emergency may necessitate air reversal in the affected area(s). The system provides air reversal modes in the mining area, the AIS and station, and the SH shaft and station, and Underground Shop (north) area. In these modes, the air is reversed by opening and closing certain ventilation doors and air regulators, and by operating the underground reversal fans in either forward or reverse direction. The surface exhaust fans will be stopped prior to attempting any air reversals underground. The AIS and SH Shaft may each be isolated by control doors on either side of the shaft during abnormal operation.

The ventilation system is designed as an exhausting system that maintains the working environment below atmospheric pressure. Schematic diagrams of the underground ventilation system are presented in Figures 4.4-6 and 4.4-7. All underground flows join at the bottom of the Exhaust Shaft before discharge to the atmosphere.

Outside air will be supplied to the mining areas, and the waste disposal areas and the North U/G Shop area through the Air Intake Shaft, the Salt Handling Shaft, and access entries. A relatively small quantity of outside air will flow down the Waste Shaft to ventilate the Waste Shaft station. The ventilation system is designed to operate with the Air Intake Shaft as the primary source of fresh air. In Normal Ventilation Mode, sufficient air will be available to simultaneously conduct all underground operations (e.g., waste handling, mining, and support).

If the nominal flow of 425,000 scfm (224 m^3/s) is not available, underground operations may proceed, but the number of activities that can be performed in parallel may be limited depending on the quantity of air available. Ventilation may also be achieved by operating one main fan (Alternate Ventilation Mode), or either one or two of the filtration fans (Minimum and Reduced modes respectively). To accomplish this, the isolation dampers will be opened, which will permit air to flow from the main exhaust duct to the filter outlet plenum. The filtration fans may also be operated to bypass the HEPA plenum. The isolation dampers of the filtration exhaust fan(s) to be employed will be opened, and the selected fan(s) will be switched on. ln this mode, underground operations will be limited.

Shift from normal flow to Filtration mode has been tested and it was demonstrated that a reverse pressure pulse was generated upon closure of the main exhaust fan inlet dampers. This reverse pressure pulse results in reverse flow temporarily in select portions of the underground system. Testing has further demonstrated that the reverse pressure/flow phenomena is greatly lessened if main fan coast down is allowed for a period of time prior to isolation. Modifications have been made that cause the main fan isolation dampers to close slowly, when the main exhaust fans are shut down, to minimize any pressure pulse back through the system.

In the filtration mode, the exhaust air will pass through two identical filter assemblies, with only one of the three Exhaust Filter Building filtration fans operating (all other fans are stopped). This system provides a means for removing the airborne particulates that may contain radioactive and hazardous waste contaminants in the reduced exhaust flow before the air is discharged through the exhaust stack to the atmosphere. The filtration mode is activated either manually or automatically if the radiation monitoring system detects abnormally high concentrations of airborne radioactive particulates. Shifting of the exhaust system to the filtration mode can be accomplished manually, either locally at the exhaust filtration building, or by the CMR operator. A high alarm condition from a Radiation Monitoring System active waste disposal room CAM, 75 CPM alpha, or 7,500 CPM beta/gamma, will cause an automatic shift of the mine exhaust air from unfiltered to filtered mode, System Design Description SDD-RM00.[4] The reduced exhaust flow is diverted to the HEPA filters by isolation and diversion dampers on the exhaust fans and duct work preventing unfiltered flow escaping to the atmosphere. The filtration mode is not initiated by the release of gases such as VOCs.

Provisions are included for detecting airborne radioactive contaminants in the waste disposal areas, in the waste shaft and station, and in the discharge to the surface exhaust vent.

Major Components and Operating Characteristics - The ventilation system consists of six centrifugal exhaust fans (three in the normal flow path and three in the filtration flow path), two identical HEPA filter assemblies arranged in parallel, isolation and back draft dampers, filter bypass arrangement, and associated ductwork. Operation of the underground ventilation system is detailed in the WIPP WP 04-VU series Facility Operations Procedures.[6]

The six fans are divided into two groups. One group consists of three fans, which are used during normal operation to provide an underground flow of 425,000 scfm (224 m^3/s), and are located near the exhaust shaft. One main fan can be operated to provide 260,000 scfm (123 m^3/s). The remaining three fans, rated at 60,000 scfm (28.3 m^3/s) each, are located at the Exhaust Filter Building, and are capable of being used during the filtered mode of operation. This mode of operation requires the use of only one of the three fans at any given time with all other fans stopped and isolated. Two of the three filter mode fans can also be operated (with the HEPA system bypassed) to provide other underground ventilation requirements, when needed.

Each filter assembly consists of two banks of prefilters and two banks of HEPA filters arranged in series; and, each assembly will handle 50 percent of the filtered mode airflow (30,000 cfm each [14.2 m^3/s]).

Any one of the three Exhaust Filter Building fans is capable of delivering 100 percent of the design flow rate with all filters at their maximum pressure drop. Fan failure is monitored by a flow sensing device on the fan's discharge side, and alarms in the CMR.

Safety Considerations and Controls - The operating status of the exhaust fans and the airborne contamination level of the effluent discharged are displayed in the CMR. Provides a means to switch to filtration.

An alarm for excessive pressure drop across the filters is actuated at a predetermined level. Filter differential pressure is displayed locally and in the CMR.

Instruments and system components are accessible for periodic testing and inspection during normal plant operation. Under normal operating conditions, the ventilation system functions continuously.

4.4.2.3.1 Natural Ventilation Pressure

The air flow in the underground is normally driven by the negative pressure induced by the exhaust fans. There can be a second pressure resulting from the difference in density between the air entering and leaving the repository which can influence airflow. This phenomenon is called the natural ventilation pressure (NVP). It is experienced on days when outside temperatures are either very hot or very cold.

Hot Weather NVP - During hot weather, the air going down to the underground is warmer and less dense (lighter) than the air returning from the underground. This lighter air has a natural tendency to resist being drawn down into the repository (hot air rises). Hence in hot weather there is a (negative) NVP which opposes the fan pressure. This reduces the flow down the AIS and SH shaft. It also reduces the differential pressures between the waste shaft station, waste disposal area, and the other areas. The air in the waste shaft will be cooler than that in the AIS and SH shaft, which further reduces the waste shaft station to W30 differential pressure. (See Figure 4.1-3 for U/G locations).

Under ordinary operating conditions, the pressure in W30 is higher (less negative) than that in the waste shaft station (S400). On very hot days (exceeding 100 degrees F [37.8 degrees C]) the reduction of this differential pressure caused by the negative NVP can result in the pressure in S400 being higher than in W30. Without corrective actions, this would allow airflow from the CA area into a non-CA area.

Cold Weather NVP - During cold weather, the air going down to the underground is colder and denser (heavier) than the air returning from the underground. This denser air has a natural tendency to sink down the AIS and SH shaft (cold air sinks). In cold weather there is a positive NVP which augments the fan pressure. This increases the airflow down the intake shafts, reduces the fan suction pressure (constant flow control) and increases the differential pressure between the waste shaft station, waste disposal area, and the other areas.

The WIPP mine ventilation system is designed for intake air to downcast in the AIS, SH shaft, and waste shaft. The system pressure required to induce those down drafts is supplied by the surface fans. On extreme cold weather days, a portion of the air entering the repository through the AIS and SH shaft may be the result of a positive NVP. This air is entering the repository without the aid of the mechanical fans. The fans in turn reduce their operating pressure because they are receiving a sufficient and constant volume of air. Upcasting of the air in the waste shaft can occur if the situation is not corrected.

The air feeding the waste shaft comes primarily from the auxiliary air intake tunnel, partly from leakage into the waste hoist tower, and partly from the Waste Handling Building. The result is that the air feeding the waste shaft tends to be warmer than the surface air feeding the AIS. The reduction in fan pressure, coupled with the warmer air in the waste shaft is only under alternate, reduced, and minimum ventilation modes.

Administrative action is required to adjust the underground ventilation configuration to avoid reverse flow in the waste shaft. There are several alternatives which can be performed concurrently to prevent or correct this problem should it occur. They include:

- Start second main exhaust fan (normal ventilation).
- Open the regulator to the waste shaft station.
- Cover the AIS and/or the SH shaft on the surface.
- Close the regulators to the mining, waste disposal and experimental areas.

A pressure chamber has been constructed on the west side of the waste shaft station to ensure that leakage from the CA side into the non-CA area does not occur. The pressure chamber is manually activated whenever waste handling is occurring in the waste shaft and/or waste shaft station, and differential pressure between S400 and W30 is low. The chamber is pressurized by six high pressure fans. The fans are operated in various combinations to provide the airflow necessary to maintain the pressure buffer. As a secondary backup system, pressure will be supplied by an actuated valve on a plant air pressurized line. The valve will be controlled by a Foxboro controller to regulate the flow of air into the chamber and maintain pressure differentials. The pressure inside the chamber is monitored to ensure that it is sufficient to prevent airflow reversal even if the differential pressure from S400 to W30 (which is also monitored) is in the wrong direction or positive NVP is sufficient to cause waste shaft reversal.

References for Section 4.4

1. DOE Order 6430.1A, General Design Criteria, April 1989 (For reference only, superceded by DOE O 420.1 and DOE O430.1A).

2. DOE Order 5400.5, Radiation Protection of the Public and the Environment, June 1990. (Latest is Change 2, January 7, 1993).

3. Energy Research and Development Administration, 76-21.

4. SDD-RM00, Radiation Monitoring System, Rev. 3, August 1997.

5. WIPP 04-ED series Facility Operations Procedures.

6. WP 04-VU, WIPP series Facility Operations Procedures.

7. ANSI N510, American National Standards Institute, Standard for Testing of Nuclear Air Cleaning Systems.

8. ASHRAE, Method of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter, 52-76.

9. 30 CFR 57, Safety and Health Standards - Underground Metal and Nonmetal Mines, 8th edition, 1994.

10. New Mexico Mine Safety Code for All Mines, 1990.

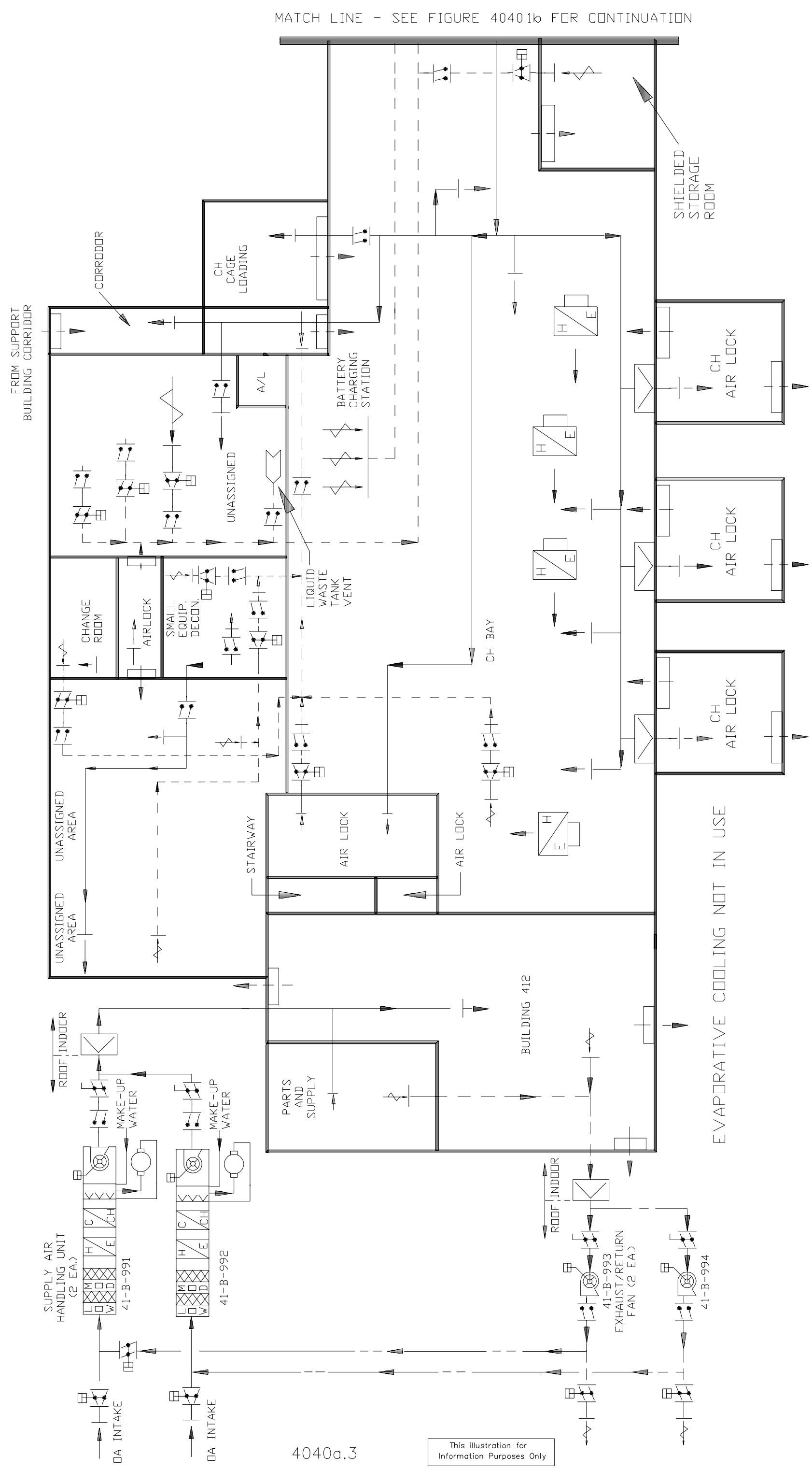


Figure 4.4-1a, WHB and TRUPACT Maintenance Facility

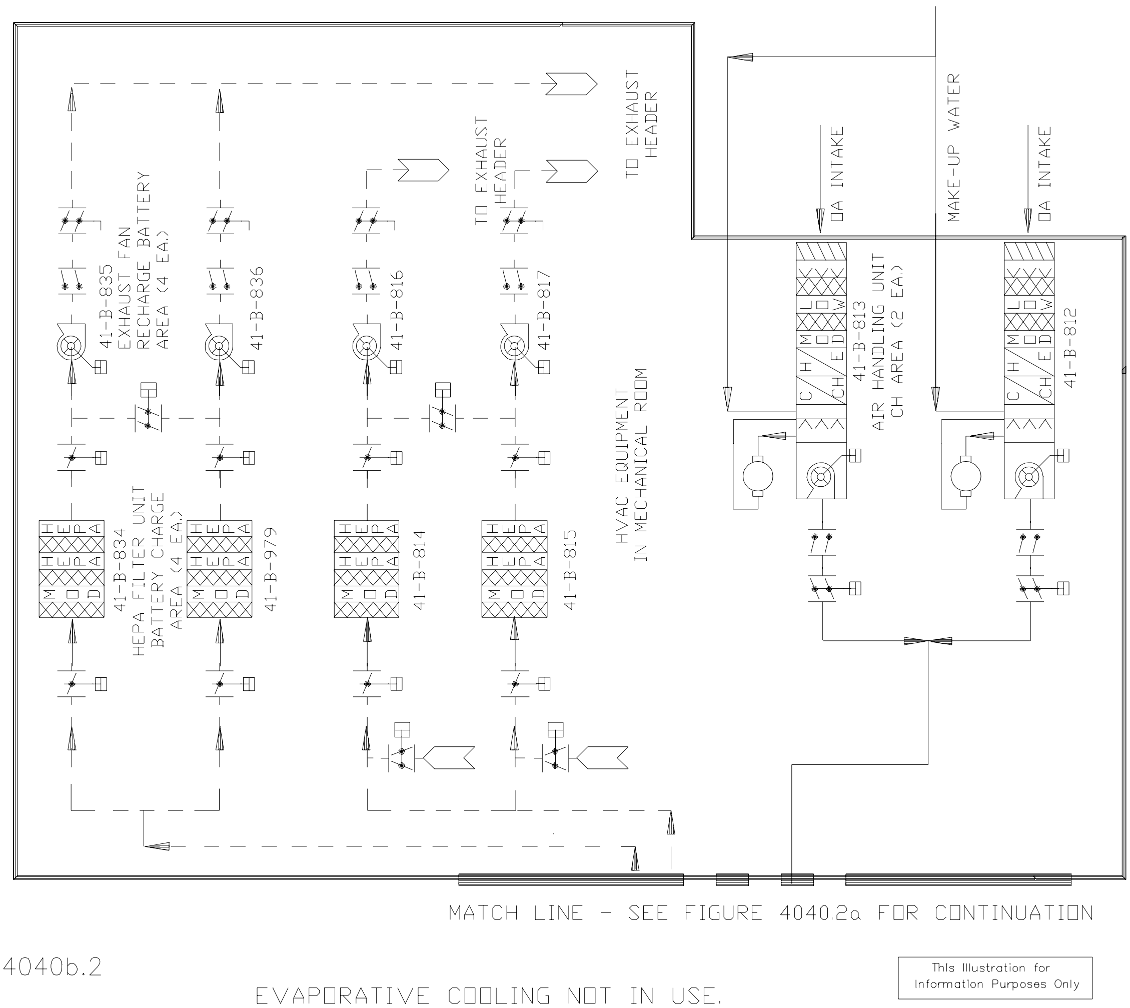


Figure 4.4-1b, Waste Handling Building

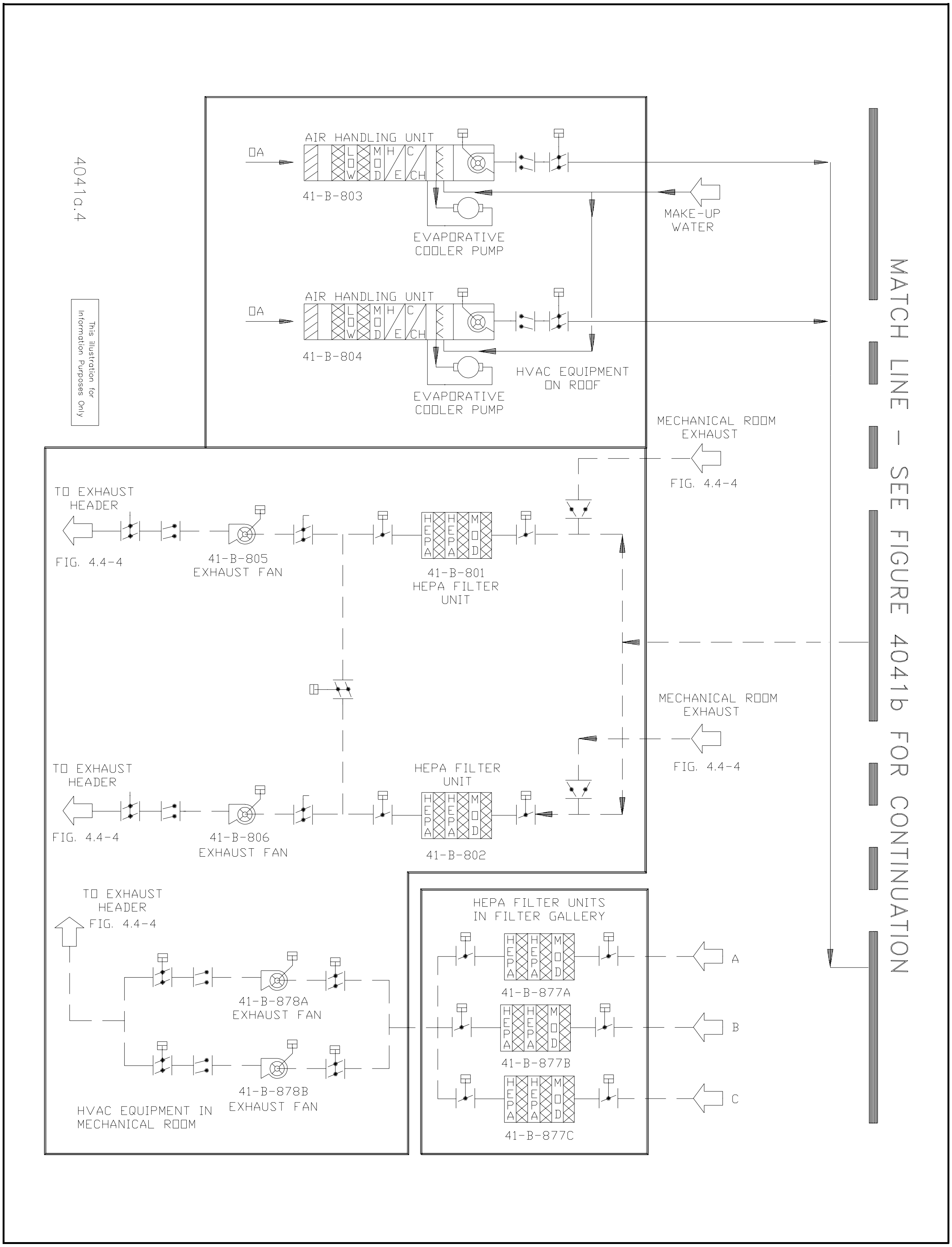


Figure 4.4-2a, WHB RH Handling HVAC Flow Diagram

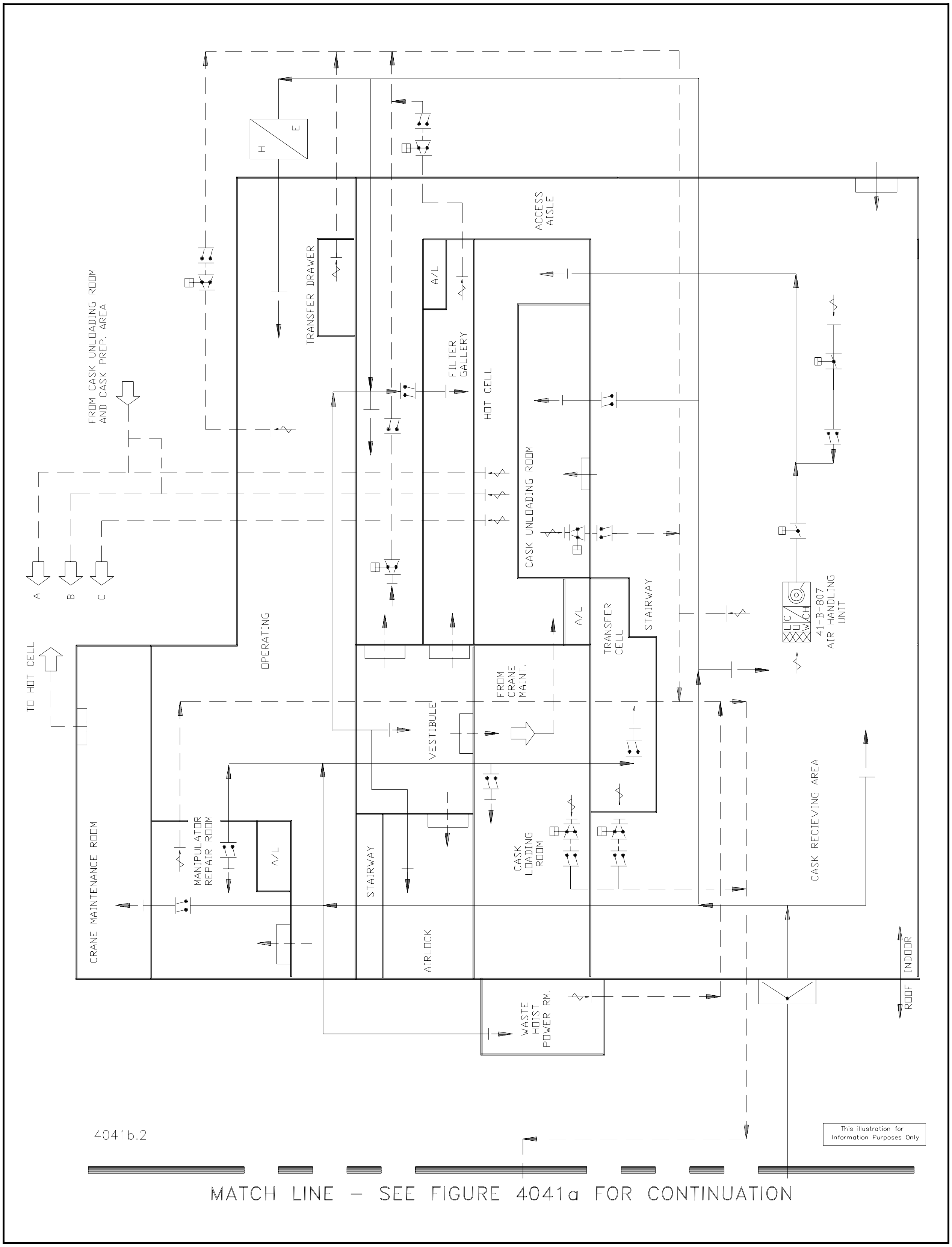


Figure 4.4-2b, WHB RH Handling HVAC Flow Diagram

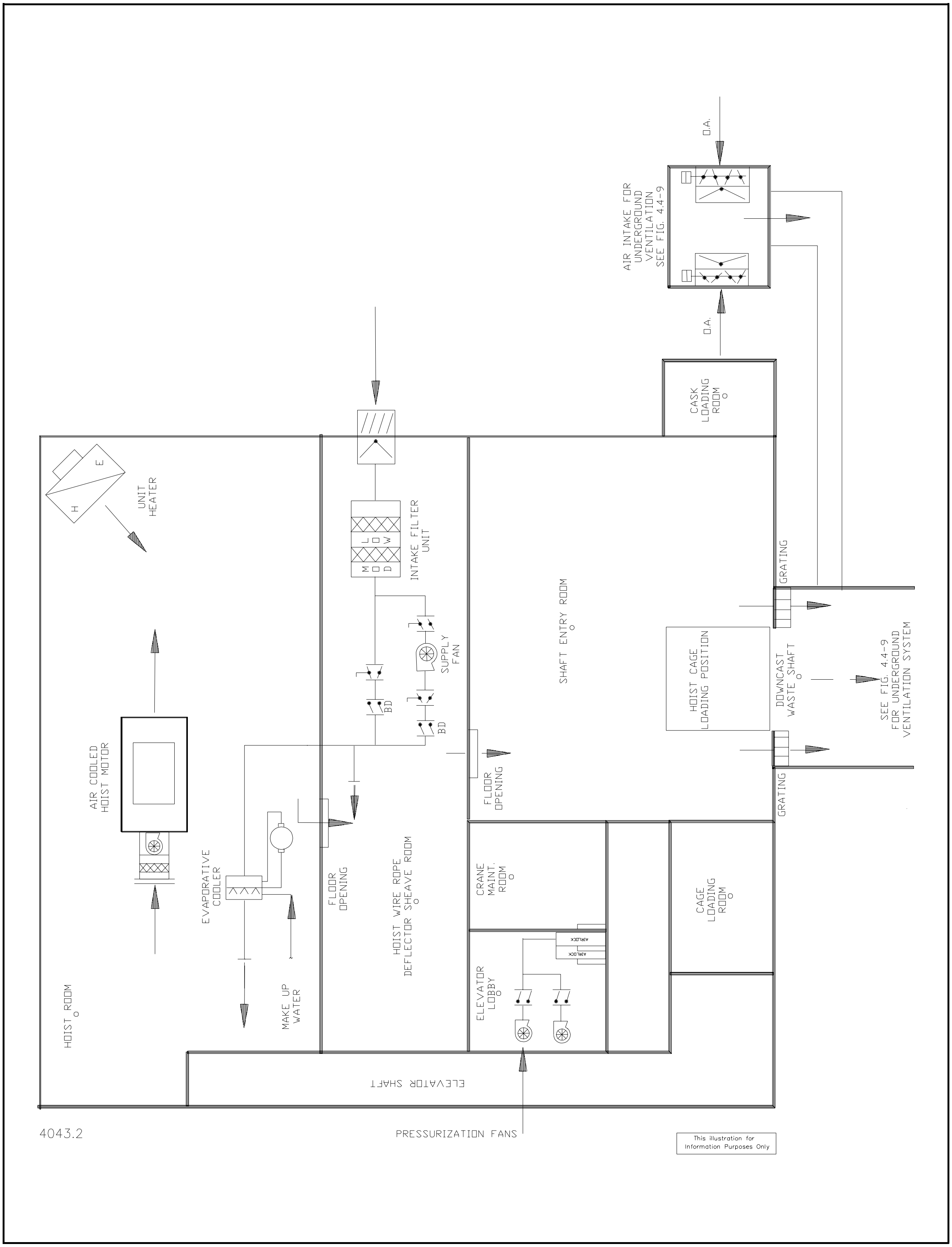


Figure 4.4-3, Waste Handling Shaft/Hoist Tower HVAC System Flow Diagram

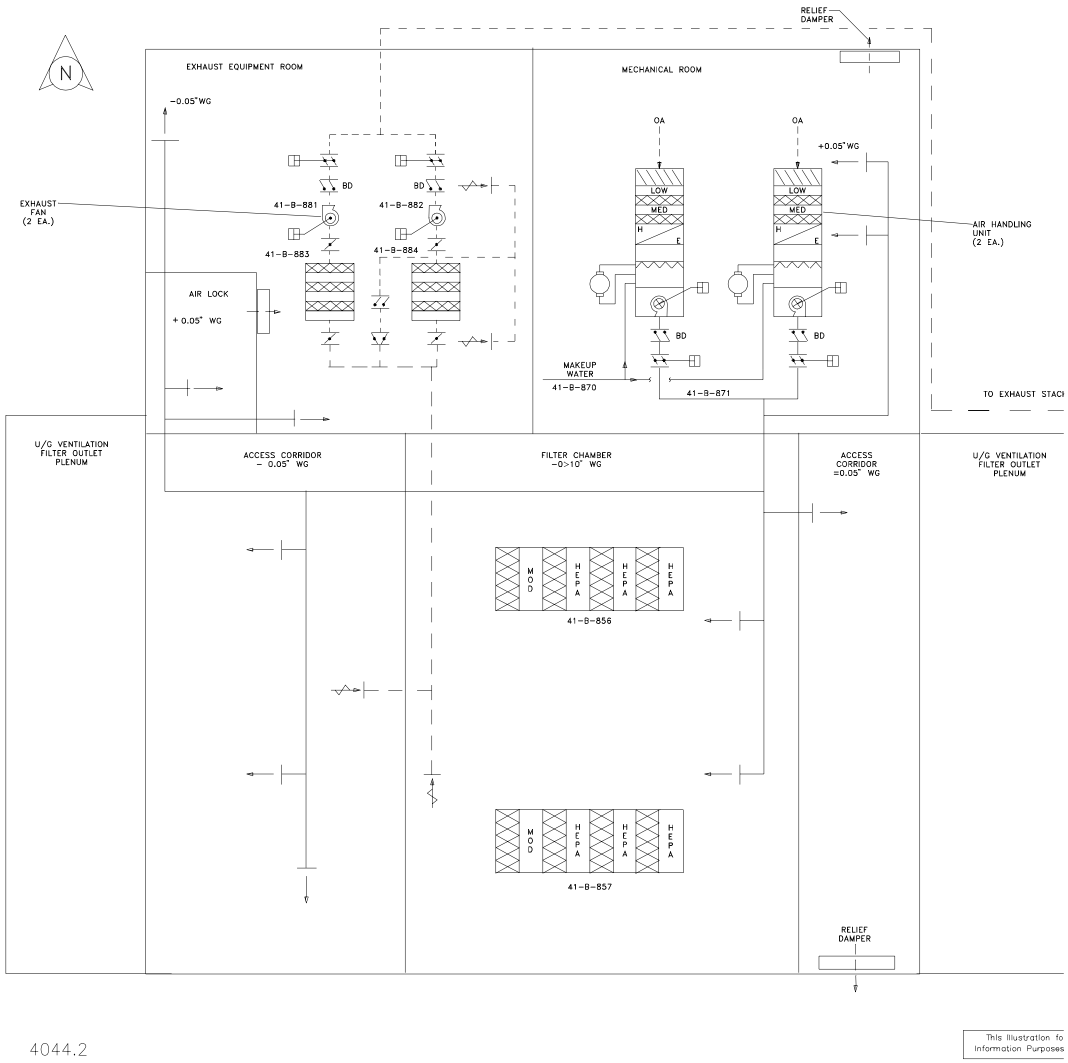


Figure 4.4-4, Exhaust Filter Building HVAC Flow Diagram

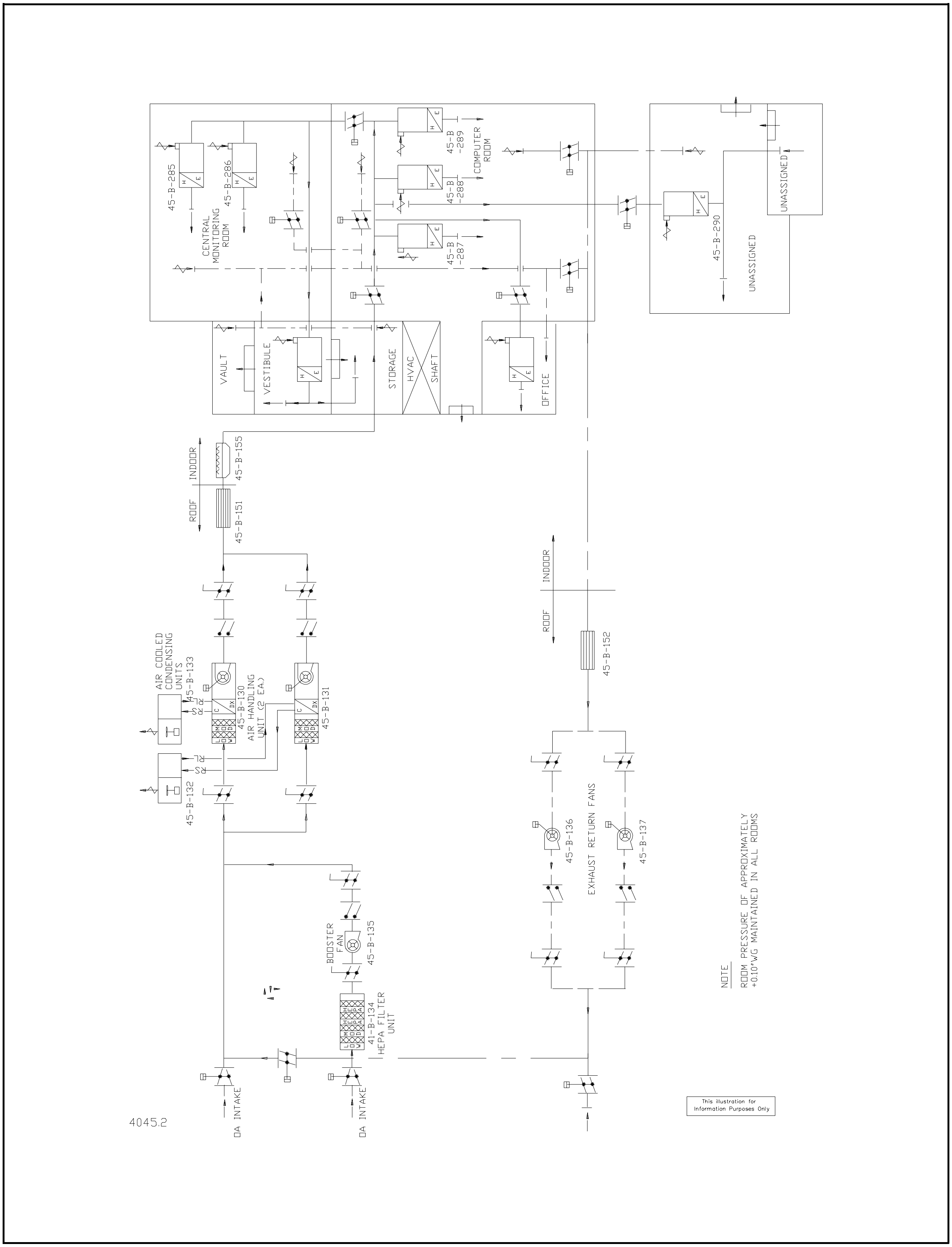


Figure 4.4-5, Support Building CMR Area HVAC Flow Diagram

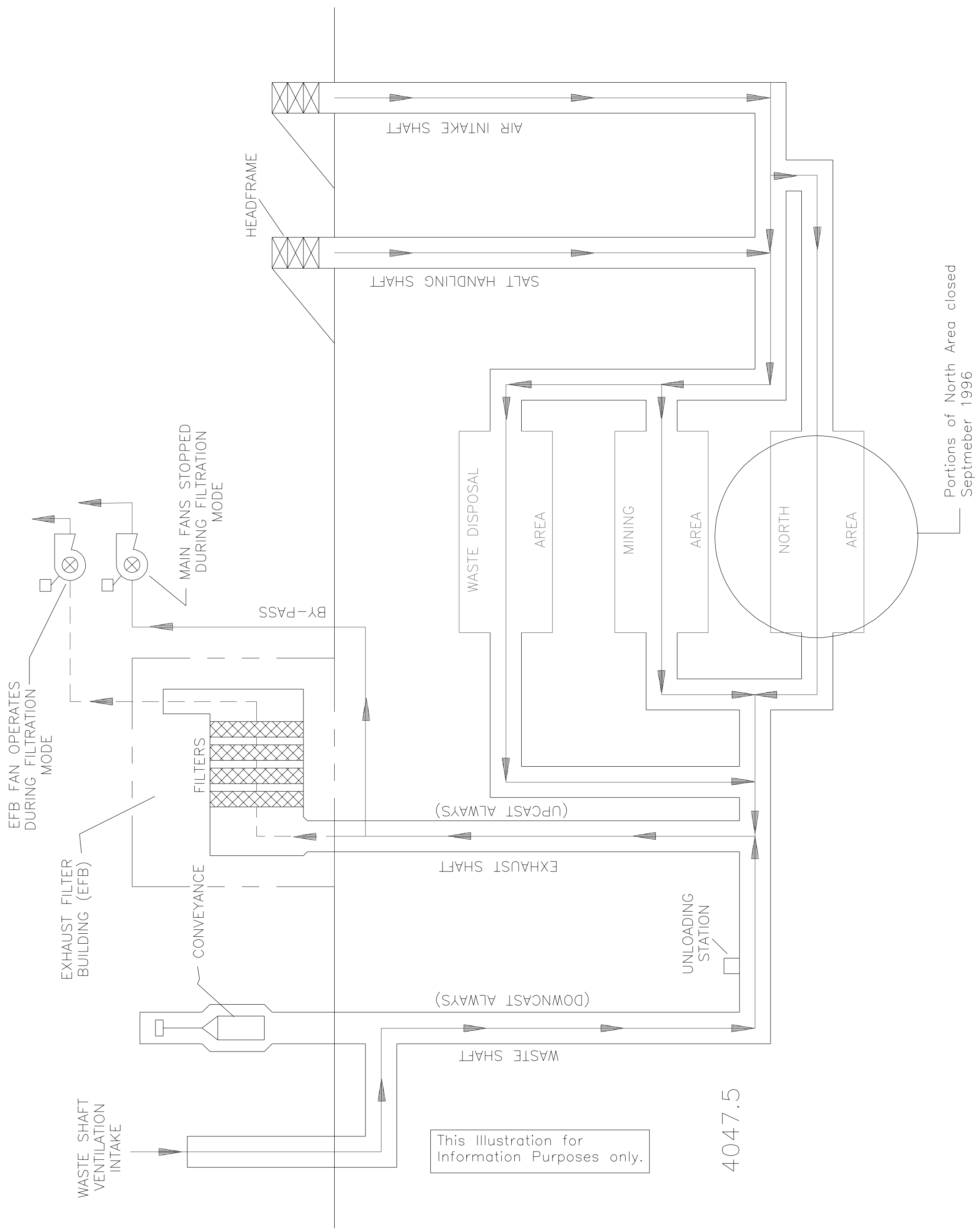


Figure 4.4-6, Underground Ventilation Air Flow Diagram

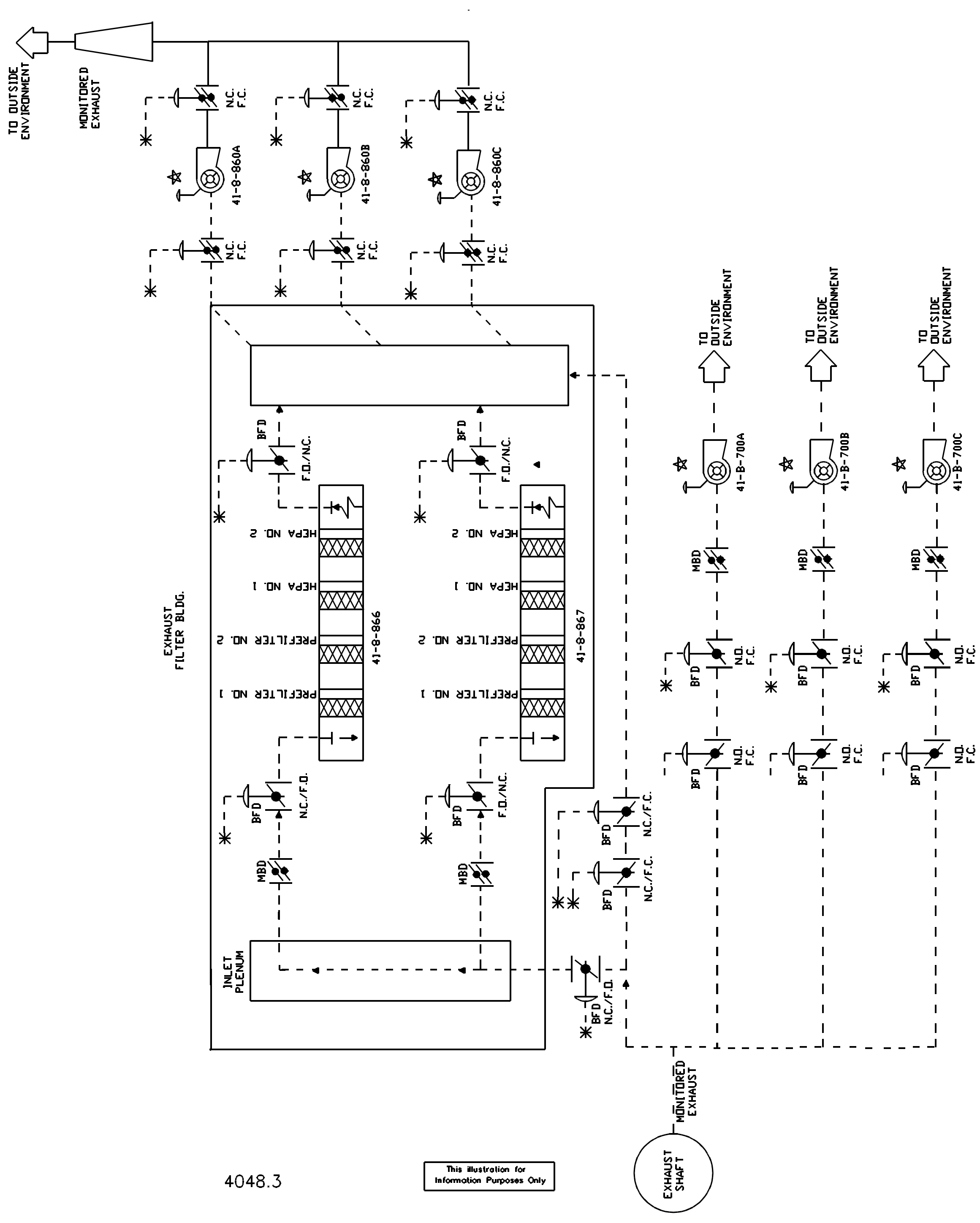


Figure 4.4-7, Main Fan and Exhaust Filter System Schematic

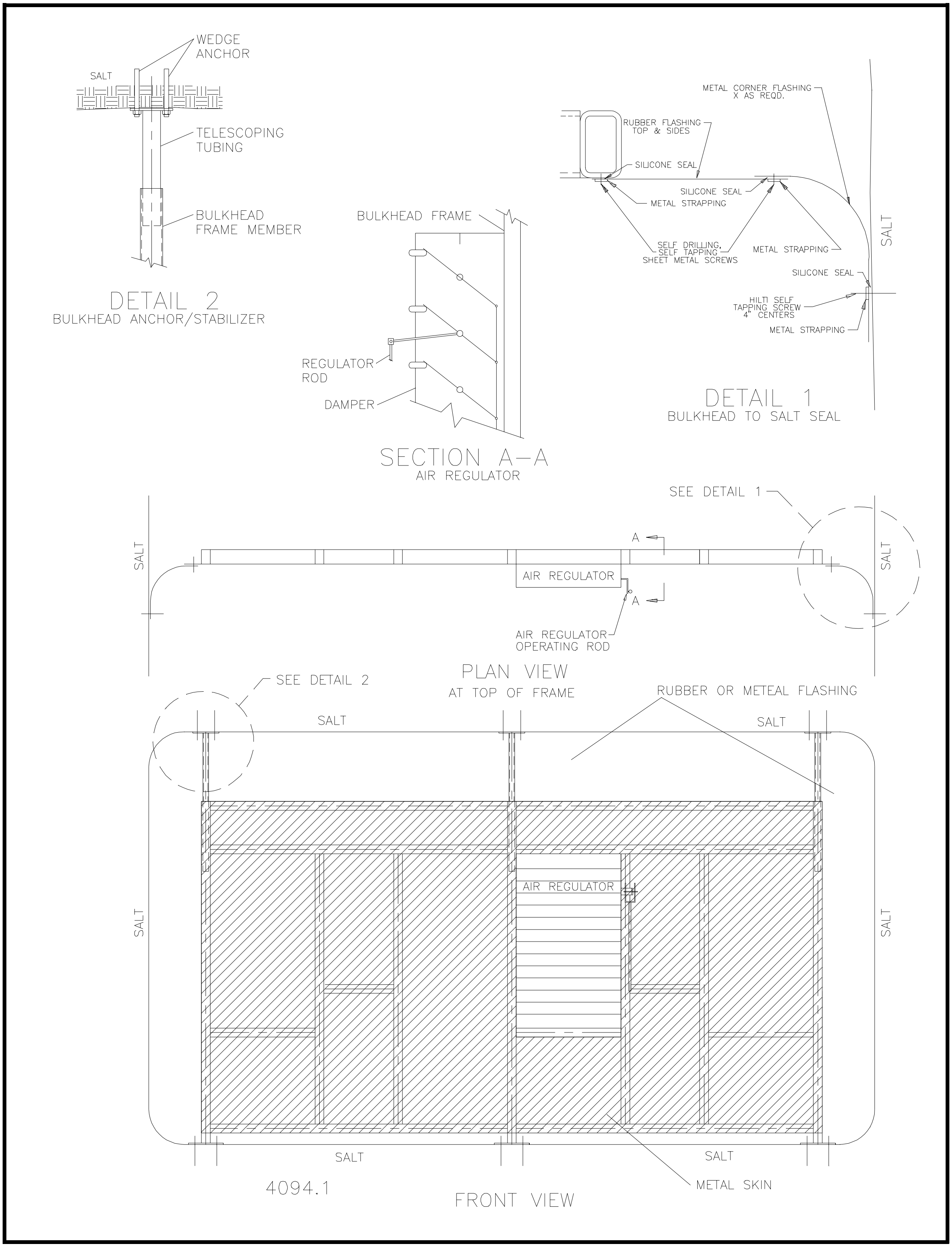


Figure 4.4-8, Typical Bulkhead Design and Components

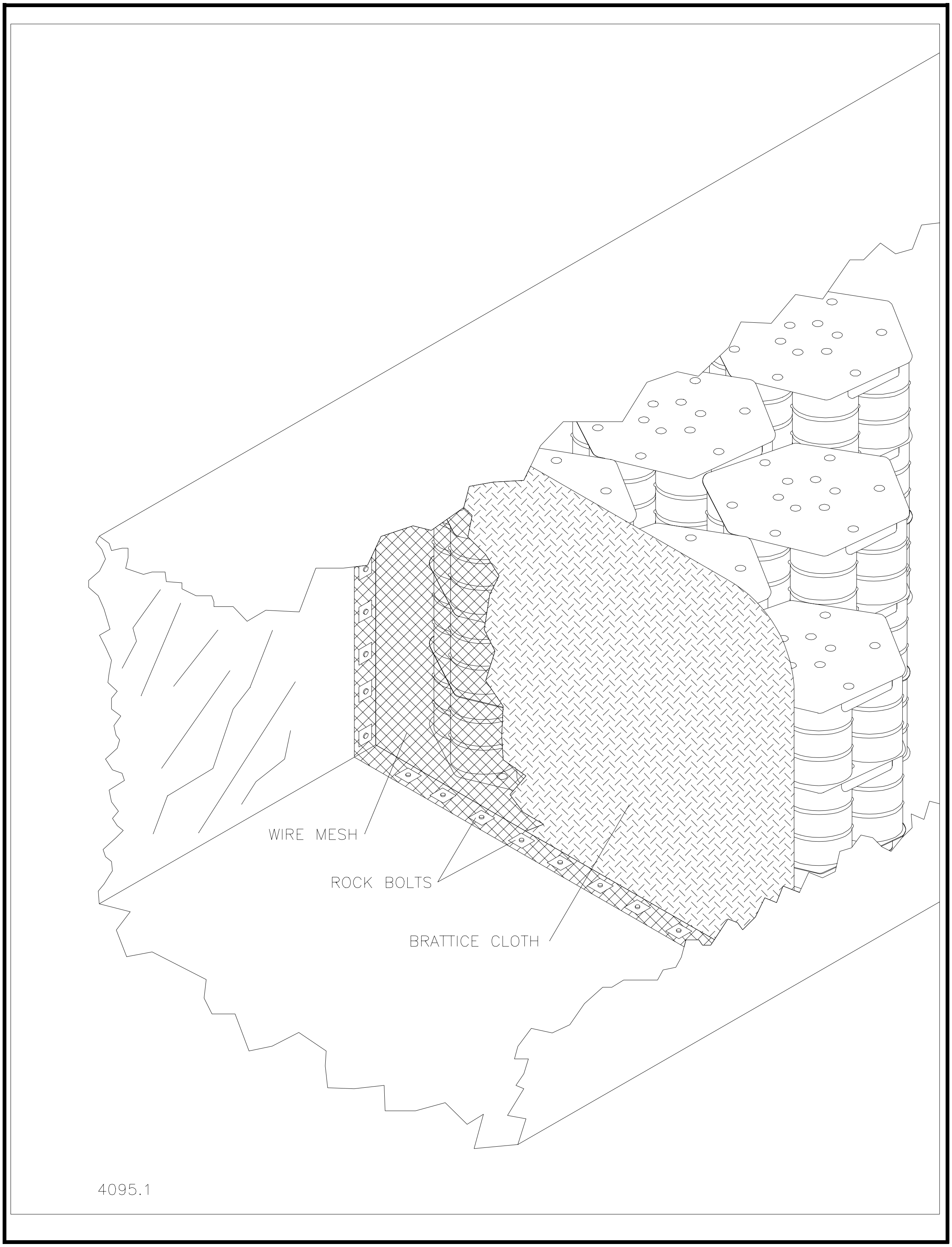


Figure 4.4-9, Typical Room Barricade

This page intentionally blank

4.5 Safety Support Systems

4.5.1 Fire Protection System

The WIPP fire protection system is designed to ensure personnel safety, mission continuity, and property conservation. Building designs incorporate features for fire prevention (e.g., control and extinguishment) Also, fire hazards are controlled throughout the WIPP. The plant design meets the "improved risk" level of protection defined in DOE 5480.7A[1] and satisfies the applicable sections of the National Fire Protection Association codes, DOE Orders, and federal codes to the extent described in WIPP-WID-96-2176, *WIPP Fire Hazard Analysis Report*.[2]

To meet these objectives, the WIPP facility design incorporates the following features:

- Most buildings and their support structures are protected by fixed, automatic fire suppression systems designed to the specific, individual hazards of each area.
- Noncombustible construction, fireproof masonry construction, and fire resistant materials are used whenever possible.
- Fire separations are installed where required because of different occupancies per the Uniform Building Code (UBC).
- In buildings where compartmentation is required, vertical openings are protected by enclosing stairways, elevators, pipeways, electrical penetrations, etc., to prevent fire from spreading to upper floors.

The exhaust ventilation systems which remove hot fire gases, toxic contaminants, explosive gases, and smoke are designed with a high fire integrity. The subsurface and surface structures are served by these systems.

The components of the electric service and distribution systems are listed by Underwriters' Laboratory, or approved by Factory Mutual Engineering Corporation, and are installed to minimize possible ignition of combustible material and maximize safety.

Adequate provisions for the safe exit of personnel are available for all potential fire occurrences with evacuation alarm signals provided throughout occupied areas.

Building evacuation plans help ensure the safe evacuation of building occupants during emergency conditions. The WIPP Emergency Management Program[3] contains the underground emergency procedures, the underground evacuation routes, and the designated assembly areas.

The WIPP Fire Protection System consists of four subsystems. They are:

- Fire Water Supply and Distribution System
- Fire Suppression System
- Fire Detection and Alarm System
- Radio Fire Alarm Reporter (RFAR) System

All fire protection systems are classified as Design Class IIIB.

4.5.1.1 System Descriptions

The WIPP facility fire protection systems service the WHB, the support structures, and the underground support areas.

4.5.1.1.1 Fire Water Supply and Distribution System

The Fire Water Supply and Distribution System consists of two fire pumps, a pressure maintenance (jockey) pump, and a compound loop yard distribution system. One fire pump is electric motor driven and the other pump is diesel engine driven. Both pumps are rated for 1,500 GPM (5678 LPM) at 125 psi (8.8 kg/cm^2). The system is required to provide fire water at a rate of 1,500 GPM (5678 LPM) for two hours (180,000 gallons [681,354 L]).

The Fire Water Supply System receives its normal water supply from one of two on-site 180,000 gallon (681,354 L) ground-level storage tanks, which are part of the Water Distribution System. The second tank supplies water to the Domestic/Utility Water System, which is a separate system from the Fire Water Supply System, and also reserves approximately 100,000 gallons (378,540 L) of water for use as fire water. Utilization of the water in the second tank by the Fire Water Supply System is achieved by the installation of a suction piping spoolpiece.

Operation of the two fire pumps and the jockey pump is controlled by changes in the distribution system pressure. The pumps are arranged for sequential operation. Under normal conditions, the jockey pump operates to maintain the designed system static pressure. Should there be a demand for fire water which exceeds the capacity of the jockey pump, system pressure will drop and the electric fire pump will start. If system pressure continues to drop, the diesel pump will start.

The yard distribution system consists of a compound loop arrangement serving all areas of the site. The system supplies fire water to all facilities containing a sprinkler system. In addition, the system supplies fire hydrants, which are located at approximately 300 ft (91 m) intervals throughout the site. The system contains numerous sectionalizing and control valves, which are locked, sealed, and visually checked monthly.

All major components of the Fire Water Supply and Distribution System are UL- listed and FM-approved.

4.5.1.1.2 Fire Suppression System/Fire Detection and Alarm System

The fire suppression system consists of several different fire extinguishing systems or equipment that service the surface buildings and facilities and for the underground areas. These may include any one or more of the following fire extinguishing capabilities: automatic wet pipe sprinkler system, standpipe and hose reels, automatic dry chemical extinguishing system, and portable fire extinguishers. The automatic wet pipe sprinkler system is the primary suppression system for fire protection at the WIPP. The fire detection and alarm system consists of multiple systems, each utilizing most or all of the following components: heat sensing fire detectors, smoke detectors, sprinkler system water flow alarm devices, manual fire alarm systems, control panels, audible warning devices, and visual warning devices. A complete description of the type of fire suppression system provided at each WIPP surface structure and the underground is provided in the *WIPP Fire Hazard Analysis*.[2]

4.5.1.1.3 Radio Fire Alarm Reporter System

The radio fire alarm reporter (RFAR) system provides notification of fire alarm and trouble signals to the CMR for structures not connected to the CMS local processing units and for structures which could have significant program or monetary impact. This system consists of radio transmitters that relay alarm and trouble signals via an FM signal to a central base station/receiver. The signal is displayed in the CMR.

4.5.1.1.4 Fire Protection System Design, Installation, Testing and Maintenance

The following NFPA[4] standards apply at the WIPP facility:

- The fire water supply and distribution system (pumps and hydrants) are designed, installed, tested, and maintained according to NFPA[4] 20, NFPA[4] 24, and NFPA[4] 25.
- The automatic wet pipe sprinkler systems are designed, installed, tested, and maintained in accordance with NFPA[4]13 and NFPA[4]25.
- The dry chemical fire suppression systems are designed, installed, tested and maintained in accordance with NFPA[4] 17.
- The fire detection and alarm systems are designed, installed, tested, and maintained in accordance with NFPA[4] 72.
- The radio fire alarm reporter system is designed, installed, tested, and maintained in accordance with NFPA[4] 72 and NFPA[4] 1221.

4.5.2 Plant Monitoring and Communications

The plant monitoring and communications systems include on-site and plant to off-site coverage. The systems are designed to provide immediate instructions to facility personnel to assure personnel and WIPP facility safety, WIPP facility security, and efficient WIPP facility operations under normal and emergency conditions.

Plant Monitoring and Communications includes the following systems:

- Central monitoring system
- Plant communications
  - Touch tone phones
  - Mine pager phones
  - Plant PA (including the Site Notification System) and alarm systems
  - Radio
  - CMS VAX Computer

4.5.2.1 Central Monitoring System

The CMR is the central location for the collection and monitoring of real time site data, automatically and manually, during normal and emergency conditions. The CMR was not intended to be designed or operated in a manner similar to the control room of a nuclear power plant. Most of the underground and surface data monitored in the CMR is gathered, processed, stored, logged, and displayed by the CMS, which collects the data continuously from approximately 1,500 remote sensors.

The CMS is a Design Class IIIA, computer-based monitoring and control system. It is used for real-time site data acquisition, display, storage, alarm and logging and for the control of site components. The CMS monitors the following systems:

- Radiation monitoring, with input from selected area radiation monitoring system (ARMS) detectors, selected continuous air monitoring systems (CAMS), radiation effluent monitoring systems (REMS).
- Electrical power status, including back-up diesel operation.
- Fire alarm system, including system status parameters.
- Ventilation system, including damper position, fan status, flow measurement, and filter differential pressure.
- Meteorological data, including wind speed and direction, temperature, and barometric pressure.
- Facility systems, including air compressors, vacuum pumps, and storage tank levels.

The CMR has three operator stations, including an engineer's station, which display alarms, status, trends, graphics, and interactive operations. The CMS electronic data storage devices are located in the computer room adjacent to the CMR. Operator's stations and an engineer's station are located in the CMR, and the backup operator's stations are located in the security control room, computer room, and underground operations connex (S-550).

The CMR has special features to allow its use during both normal and emergency conditions. These features include two-hour fire walls and redundant ventilation systems, including HEPA filtration of intake air to allow occupancy during radiological releases. The CMR sources of back-up AC electrical power include an uninterruptible power supply (UPS), with a minimum life expectancy of 30 minutes, and the diesel generator used to power priority loads (including the CMR) as discussed in Section 4.6.

4.5.2.2 Plant Communications

The dial phone system includes a private automatic branch exchange (PABX) network providing conventional on-site and off-site telephone services. Major uses of this subsystem include the reporting of occurrences (DOE Order 5000.3B)[5] and communications between the CMR and the following:

- Roving operators and instrumentation technicians.
- The Emergency Operations Center (EOC).
- Various departments such as Health Physics, Transportation, and Security.

The mine pager phones make up an independent, hard wired, battery-operated system for two-way communications between the surface and underground operations.

The plant public address (PA) and alarm systems provide for the initiation of surface and underground evacuation alarms and public address announcements from the CMR and local stations. The plant PA and alarm systems includes the site-wide PA and intercom installations, the Site Notification System for remote locations, and an additional underground evacuation alarm system. These alarms are supplied with backup power if the off-site power supply fails. The PA system master control console is located in the CMR, with paging stations located in the support building, waste handling building, water pumphouse, guard and security building, salt handling hoist house and head frame, exhaust filter building, safety and emergency services facility, engineering building, warehouse/shops building, and underground.

Radio includes two-way and paging on-site and off-site radio systems. These systems include base stations in the CMR, security control room, emergency operations center, and mobile and portable units.

4.5.2.3 Radiation Monitoring System

The Radiation Monitoring System includes five basic subsytems to ensure adequate information on plant radiation for protection of plant personnel and the surrounding environment under normal operation, off-normal events, and recovery from off-normal events. The subsystems are: Continuous Air Monitoring (CAM) System, Fixed Air Sampling (FAS) Systems, Area Radiation Monitoring (ARM) Systems, Radioactive Effluent Air Monitoring (REMS) Systems, and the Plant Vacuum (PV).

The five subsystems are coordinated into a single design package. Signals are provided to the CMR to provide continuous surveillance and display or log alarm status on the CRT or printer for selected CAM, REMS and ARM stationary monitors. Status of the PV system is also available at the CMR.

References for Section 4.5

1. DOE Order 5480.7A, Fire Protection, February 17, 1993.

2. WIPP-WID-96-2176, Rev. 1, *WIPP Fire Hazard Analysis Report*.

3. WP 12-9, WIPP Emergency Management Program, Rev. 11.

4. National Fire Protection Association.

5. DOE Order 5000.3B, Occurrence Reporting and Processing of Operations Information, February 22, 1993.

4.6 Utility and Auxiliary Systems

4.6.1 Electrical System

Unless otherwise indicated, all electrical system components are Design Class IIIB. The electrical system is designed to provide: normal and backup power to WIPP electrical equipment, grounding for electrically energized equipment and other plant structures, lightning protection for the plant, illumination for the plant surface facility, and for related underground operations.

Standard industrial electrical distribution equipment is used throughout. Equipment used includes medium voltage switchgear buses, medium voltage to low voltage step-down unit substations, motor control centers, small distribution transformers and panels, relay and protection circuitry, station batteries along with associated synchronous inverters, diesel generator sets, and the cabling, enclosures, and other structures required to locate and interconnect these items.

The electrical system is designed to supply power at the following nominal bus voltages:

- 13.8 kVac, nominal, 3-phase, 3-wire, 60-Hz - Power supply for the main plant substation, underground switching stations, and surface and underground unit substation transformers.
- 4.16 kVac, nominal, 3-phase, 3-wire, 60 Hz - Power supply for the main exhaust fan drive motors.
- 2.4 kVac, nominal, 3-phase, 3-wire, 60 Hz - Power supply for the drive motor for the M-G set, which provides the backup supply for the Salt Handling Shaft Drive Motor.
- 480/277 Vac, nominal, 3-phase, 4-wire, 60 Hz - Power supply for motor control centers, the AIS drive motor, solid state direct current converter systems for the SH and waste hoists, underground filtration fans, lighting and power distribution transformers.
- 120/208 Vac, nominal, 3-phase, 4-wire, 60 Hz - Power supply for control systems, instrumentation, lighting, communication, and small (fractional horsepower) motor-driven equipment.
- 120/208 Vac, nominal, 3-phase, 4 wire, 60 Hz - Uninterruptible power supply (UPS) for control and instrumentation which must be continuously energized under all plant operating modes.

4.6.1.1 Major Components and Operating Characteristics

There are three sources of power at the WIPP facility: normal power, backup power, and UPS.

4.6.1.1.1 Normal Power Source

The WIPP facility normal power is supplied by a public utility company, and is the preferred power source supplying power to the WIPP facility at all times.

The electrical utility company supplies electrical power from their 115 kV Potash /Kerrmac Junction open wire transmission line from the North and Whitten/Jal Substation open wire line from the South. The North line is about 9 miles long while the South line is about 19 miles long. The Potash Junction and Whitten Substations each have two feeders from multiple generating stations and loss of one generating source does not interrupt power to the WIPP facility.

The Utility substation at the WIPP facility is located East of the Property Protection Area. Area substations are located at the various surface facilities. Underground conduits, cable duct banks, and buried cables connect the Plant substation with the area substations.

4.6.1.1.2 Backup Power Source

In case of a loss of utility power, backup power to selected loads can be supplied by either of the two on-site Design Class IIIA 1,100 kW diesel generators. These generators provide reliable 480-V power, and are sized to feed the loads listed in Table 4.6-1. Backup power is fed through buses A and B (Figure 4.6-1). Each of the diesel generators can carry all preselected monitoring loads (see Section 4.6.1.1.3 for a discussion of essential loads) plus operation of the AIS hoist for personnel evacuation, and other selected backup loads in accordance with procedures in the WIPP WP 04-ED Facility Operations Procedures.[1]

Upon loss of normal power, the diesel(s) is started manually by the facility operator within 30 minutes using the electric starter/batteries. Only one diesel may be loaded at a time.[2] The starter system is a 24 V battery system with a 300 amp-hour capacity. The diesel generators may be started from the local control panel or from the CMR. Monitoring of the diesel generators and associated breakers is possible at the CMR, thus providing the ability to feed selected facility loads from the backup power source, in sequence, without exceeding generator capacity. The on-site total fuel storage capacity is sufficient for the operation of one engine generator at full load for one day, and additional fuel supplies are readily available within a few hours by tank truck allowing on-line refueling and continued operation.

The diesel generators and the generator load center are located outside between the Safety and Emergency Services Building and Exhaust Filter Building. A 480-V backup power indoor switchgear is located in the main electrical room in the Support Building. Area substations are located at various surface facilities.

Operation of backup power supplies and the selection of loads is addressed in the WIPP WP 04-ED Facility Operations Procedures.[1]

4.6.1.1.3 Uninterruptible Power Supply (Essential Loads)

The central UPS provides power to essential equipment (Table 4.6-2) located in the Support Building and the Waste Handling Building. The central UPS is located in the Support Building. In addition, individual UPSs provide transient-free power to strategically located LPUs for the radiation monitoring system on the surface, in selected areas in the exhaust shaft, and underground passages and waste disposal areas.

The purpose of the central UPS is to supply (120/208 Vac, 222 A) transient-free, reliable power to the essential loads listed in Table 4.6-2. This ensures continuous power to the radiation detection system for airborne contamination, LPUs, computer room, central monitoring room, and primary analytical chemistry laboratory instruments, even during the interval between the loss of off-site power and initiation of backup diesel generator power.

In case of loss of AC power input to the UPSs, the dedicated batteries can supply power to a fully loaded UPS for 30 minutes. The AC power input to the UPS will be restored within approximately 30 minutes via operator action.

All monitoring loads fed from the UPS system are shown on Westinghouse Drawing panel schedules for 41P-DP03/10, 41P-DP03/11, 45P-DP03/15, and 41P-DP03/17.[3] The connected load, as measured, is shown in Table 4.6-2.

4.6.1.1.4 Safety Considerations and Controls

Failure of the normal distribution system or any of its components will not affect safe conditions of the WIPP facilities. Upon loss of normal off-site power, the Exhaust Filter Building isolation valves fail to the filtration mode. The simplified single-line diagram for the normal and manually switched backup loads is shown in Figure 4.6-2a and Figure 4.6-2b (switching devices and equipment are symbolically represented).

4.6.2 Compressed Air

The compressed air system is Design Class IIIB except for the HEPA inlet filters for the backup compressors in the Support Building, which are Design Class II. The system is diverse in the types and sizes of compressors used, and redundancy is provided for the main plant air compressors, exhaust filter building, support building, salt hoist house, and the underground. All are electrically driven except for the diesel powered backup compressor in the underground.

The piping system consists of runs of 2, 4, and 6 in (5, 10, and 15 cm) pipe connecting the two compressor buildings to the waste handling building, support building, exhaust filter building, salt hoist house, and safety building. A pipe run down the waste shaft serves the underground. Each building and the underground can be isolated from the system.

There are two general types of compressors in use at the WIPP. The majority are reciprocating, but the primary main plant air compressors and the underground backup compressor are rotary screw type. All are either single- or two-stage units; the backup main plant air compressors and the backup units at the support building are the non-lubricated type for oil free output air.

The primary main plant air compressors are two single stage rotary screw units of 250 horsepower with a maximum capacity for each unit of 1,155 cfm (0.55 m^3/s) at a system pressure of 125 psi (8.8 kg/cm^2). Cooling for these compressors is accomplished with a fin and tube heat exchanger and cooling fan placed in the lubricating oil system.

The secondary main plant air compressors are two, two-stage, double acting reciprocating units of 200 horsepower and maximum capacity of 1,000 cfm (0.4 m^3/s) at 125 psi (8.8 kg/cm^2). These compressors are the only water cooled units on site, using a closed loop system, pumping a mixture of water and ethylene glycol antifreeze through a fin and tube heat exchanger with four electrically driven cooling fans.

A twin tower desiccant air dryer with prefilters and after filters is located just downstream of the compressors at each of the above installations to provide clean, moisture-free, compressed air dried to a dew point of 0 degrees F (-18 degrees C). A 1,000 gallon (3785 L) capacity air receiver is located just downstream of the dryer at each location and connected to the site piping system.

The backup compressors at the support building are aligned in parallel with the incoming plant air line. In the event of a loss of plant air, a check valve isolates the building from the plant air system, and the backup compressors start automatically as the building pressure drops to 100 psi.

The backup compressors at the support building utilize HEPA filters for their inlet air rather than the less efficient type found on the other units. In the event of a high radiation alarm from Station C, the HVAC system supplying the CMR is automatically shifted to a HEPA filtered supply air. At the same time, a signal is sent to close a solenoid valve isolating the building from the plant air system. The HVAC dampers and controls will now be operated by HEPA filtered air provided by the backup compressors to preclude contamination of the CMR air supply.

The support building, waste handling building, and exhaust filter building employ desiccant air dryers similar to the large units installed at the main compressor buildings but much smaller. These dryers provide additional filtering of the air and lower the dew point to -40 degrees F (-40 degrees C). The Plant Air System ends at these dryers and the Instrument Air System begins. Instrument quality air is then used to operate dampers and control systems for the underground ventilation system and HVAC systems in the above mentioned buildings.

The salt hoist house has a backup installation similar to those described above but using a refrigerated air dryer instead of the desiccant type. This unit provides air for operation of the hoist brakes in the event of a loss of plant air.

The maintenance shop, AIS hoist house, warehouse, and engineering building each have a stand alone compressor installation for vehicle maintenance, hoist operation, HVAC system operation, and other utility purposes. These buildings are not supplied by the plant air system.

Compressed gases sub-systems are installed in three site locations. The dosimetry laboratory uses nitrogen in processing the thermo-luminescent detectors. The counting laboratories use P-10, hydrogen, and liquid nitrogen in various analytical procedures. Mine Rescue uses high-pressure oxygen to refill breathing pack bottles. The commercial gas bottles are installed with safety binding and supply manifolds. Rescue uses compressed air for Scott Air Packs.

Inlet Air Filters (45-K-100A and B)

The compressed air supplied to the CMR in the Support Building must be free of radioactive particulates, and since these compressors only operate when the plant air supply fails or when radiation has been detected, HEPA filters are used as the inlet filters for these compressors. One HEPA filter supplies two compressors -- one compressor on each receiver; a second filter supplies the other two compressors. These filters preclude the entry of airborne radioactive particulates into the compressed air stream.

4.6.3 Water Distribution System

The Water Distribution System is designed to receive water from a commercial water department, transport the water to the WIPP Site, provide storage for the required reserve of fire water, chlorinate and store domestic water, and distribute domestic water for use by personnel, processes, HVAC and irrigation.

4.6.4 Sewage Treatment System

The sewage treatment facility collects and treats sanitary waste and nonradioactive liquids from the surface. Provisions also exist for the facility to receive non-hazardous effluents typically resulting from observation wells and the de-watering of mine shafts.

References for Section 4.6

1. WP 04-ED, WIPP series Facility Operations Procedures.

2. Air Quality Permit No. 310-M-2.

3. Main UPS System Panel Schedules 41P-DP03/10, 41P-DP03/11, 45P-DP03/15, 45P-DP03/17.

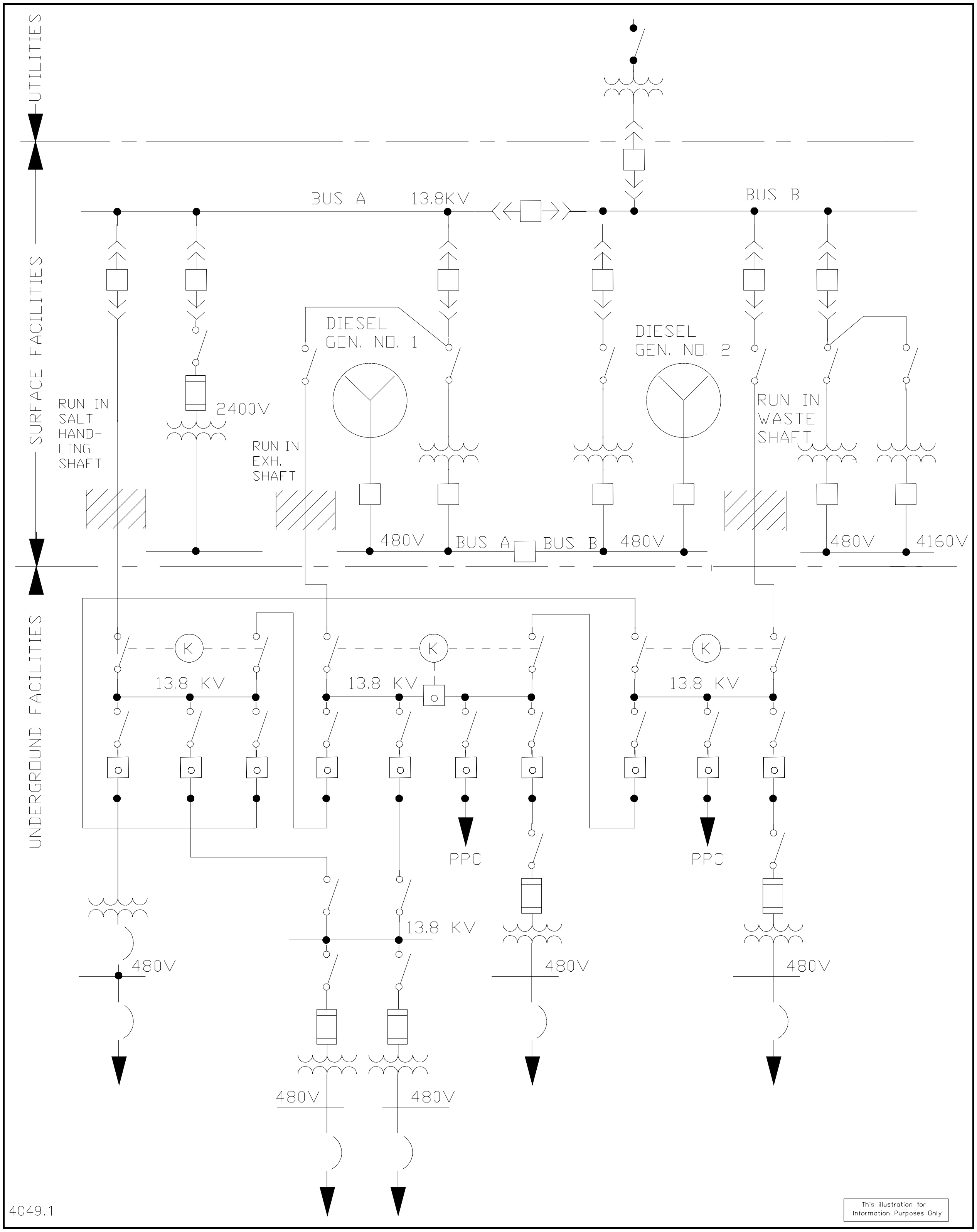


Figure 4.6-1, Electrical Distribution System

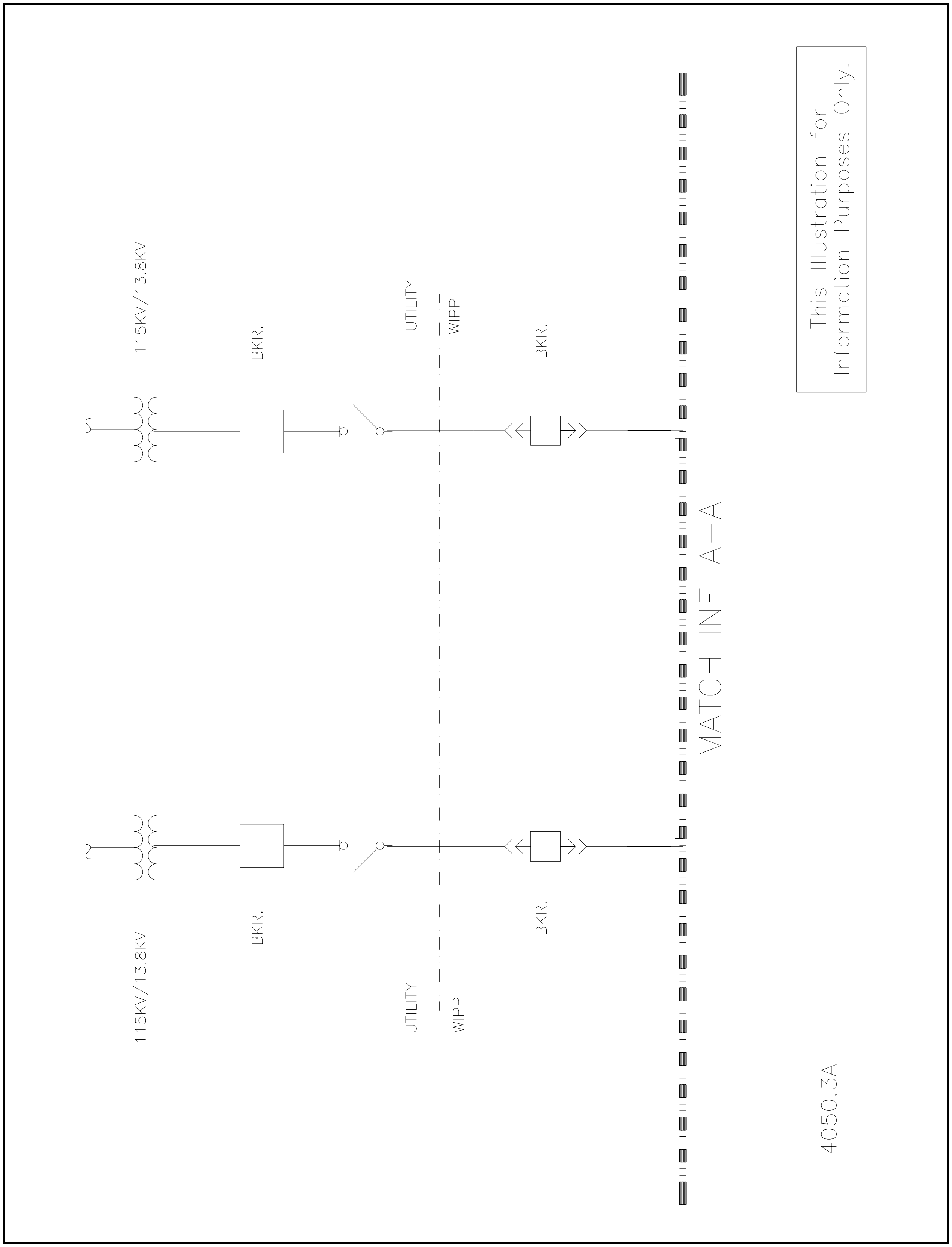


Figure 4.6-2a, 13.8 kV Power Distribution System Single Line Diagram

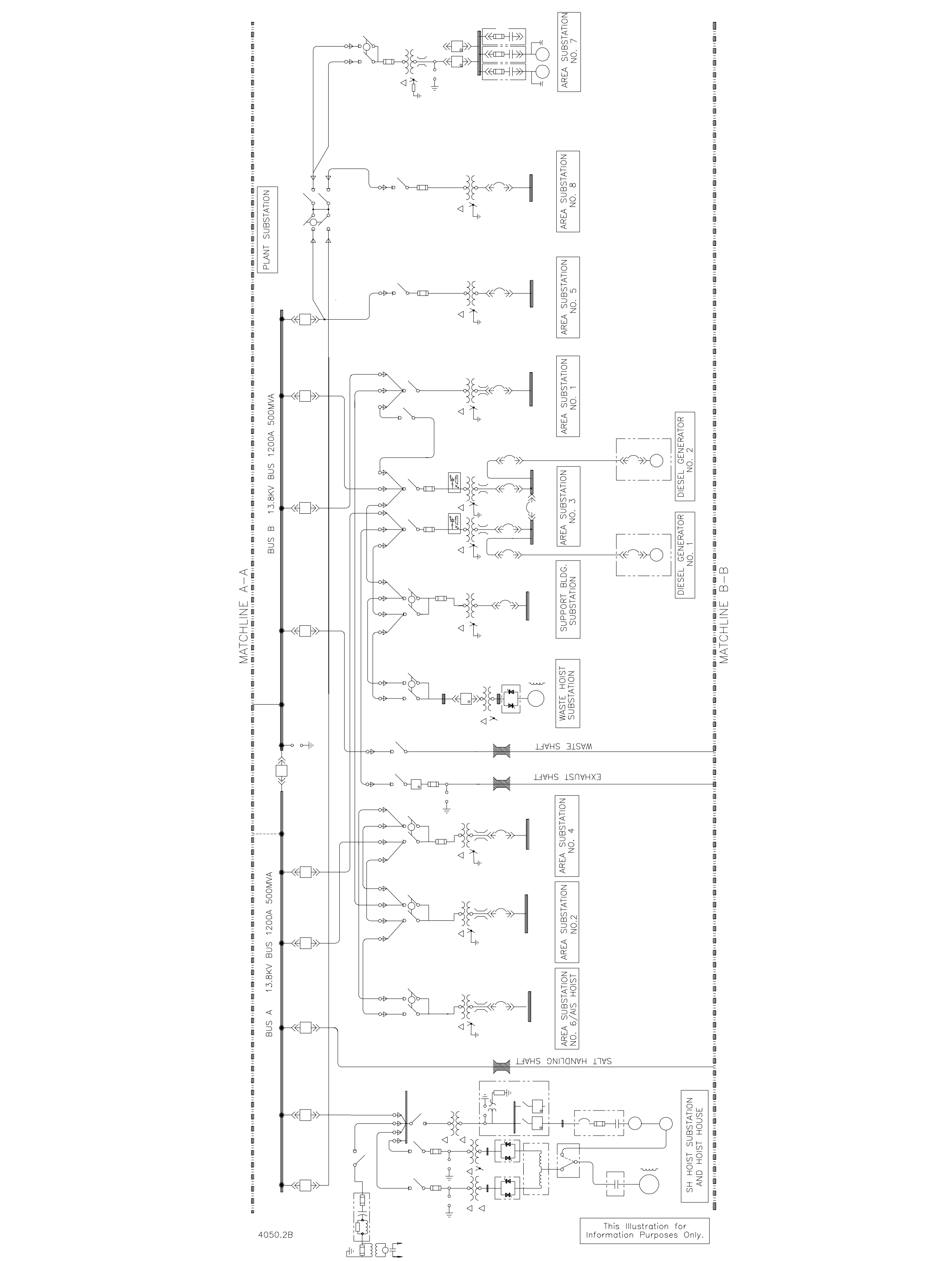


Figure 4.6-2b, 13.8 kV Power Distribution System Single Line Diagram

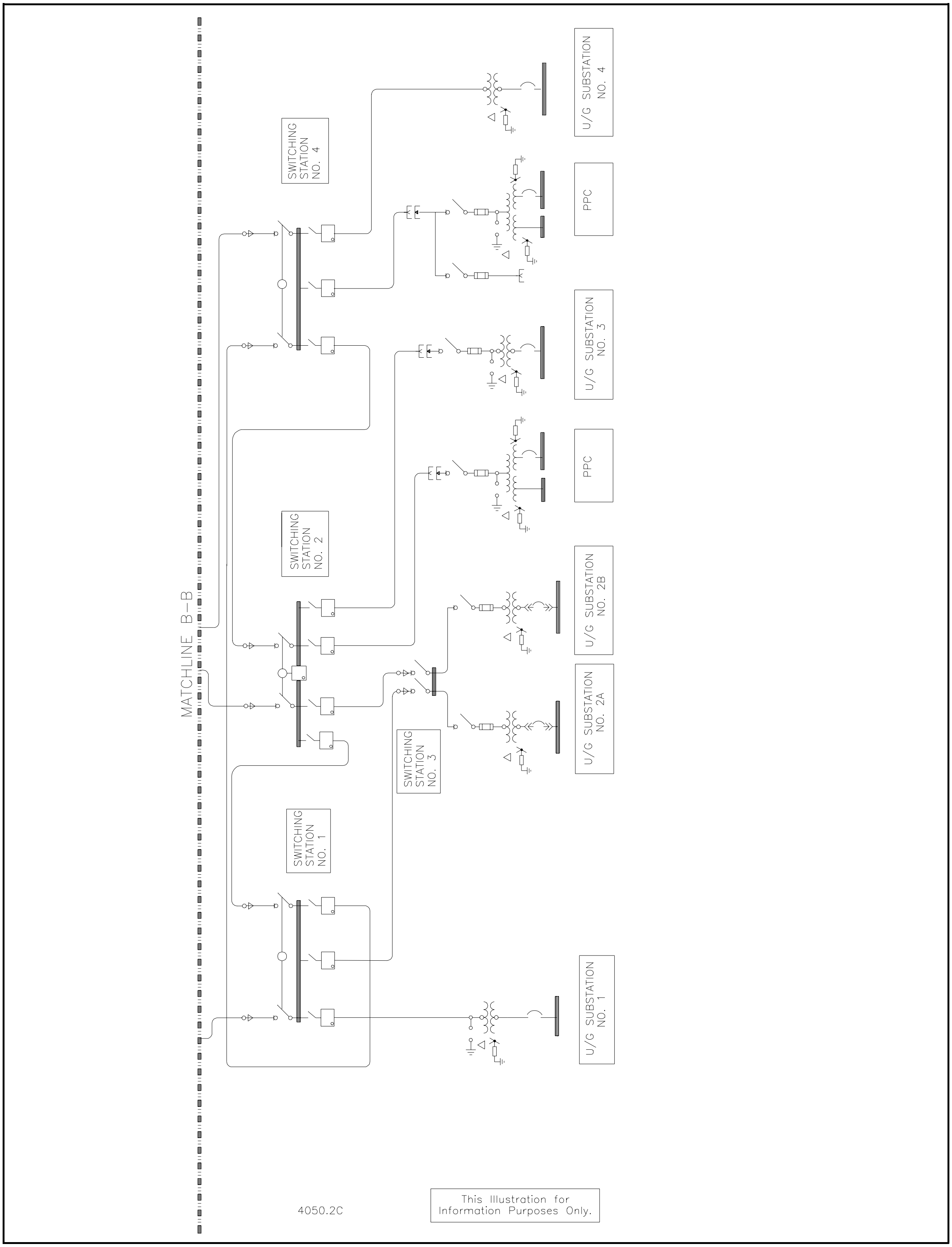


Figure 4.6-2c, 13.8 kV Power Distribution System Single Line Diagram

Table 4.6-1, Diesel Generator Load

Manually Switched Backup		
Loads	**kW**	**Remarks**
Uninterruptible Power System* Central Monitoring System* WHB Continuous Air Monitors*	72	
Central Monitoring Room HVAC System Utilities	20	
Fire Protection Systems in the Waste Handling Building Support Building	30	Battery power is provided in fire protection system until the diesel generator is started and loaded.
Fire Pump	160	
Communications Systems	16	
Guard & Security Building	35	
Air Intake Shaft Hoist (If necessary for U/G evacuation)*	330	The diesel generators load is reduced to 900 kW prior to operating the AIS hoist.
WHB Lighting	45	
WHB Cranes	80	After the diesel generator is started cranes are energized as required to land their loads.
WHB Vacuum Pumps	50	
Main Air Compressors (1-200 hp)*	160	
U/G Exhaust Fans (1-235 hp)*	188	
Waste Handling Building Fans*	100	
U/G Sandia other Experimental Loads	400	
Safety & Emergency Services Building (EOC)*	10	
* Priority Back-up loads. Other loads picked up depending on actual kW loading of diesel or by load shedding.		

Table 4.6-2, UPS Loads

LOAD ON CENTRAL UPS	
• Radiological Monitoring System (ARM & CAM), • Central Monitoring System - CMS equipment in the Support Bldg. and in Waste Handling Bldg, • Communication System in Waste Handling and Support Bldg, • Seismic Trip in Waste Handling Bldg. • Network computers and equipment in the Support Bldg. Computer Room. Total Connected Load Running Load	88 kW 30 kW
Loads on Individual UPS Units	
• CMS equipment in facilities other than Waste Handling and Support Buildings. • Selected Surface and Underground Radiological Monitoring Units, • Emergency Operations Center and Safety and Emergency Services Facility Guard and Security Building, • Safety Communication and Alarm System in facilities other then Waste Handling and Support Buildings. Total Independent Backup System Load	66 kVA

This page intentionally blank

4.7 Radioactive Waste (Radwaste) and Hazardous Waste Management

Since the WIPP facility operational philosophy is to remain radiologically clean, decontamination operations following detection of contamination may generate some radioactive waste. The plant-derived waste could originate in both the surface and underground facilities. Because derived wastes can contain only those materials present in the waste from which they were derived, no additional characterization of the derived waste is proposed for disposal purposes. Characterization of derived waste will primarily be based on process knowledge. High activity waste is not expected to be generated during any normal operating sequences.

4.7.1 Liquid Radwaste System

Water used as a fire suppressant is the largest potential source of liquid radwaste. Another source would be any liquid used for decontamination. The fire potential in waste handling areas is remote, and contaminated water from fire fighting is not expected. All suspect liquids are collected, sampled and analyzed for radioactivity, and if the liquid exceeds the uncontrolled release limit of Order DOE 5400.5,[1] it is collected and made acceptable for disposal in the WIPP.

All non-fire water liquid radwaste is collected in portable tanks or drums, and handled in accordance with procedures in the WP 05-WH1036, Site-Derived Mixed Waste Handling,[2] and the RCRA Compliance Manual.[3]

4.7.2 Solid Radwaste System

The solid radwaste system provides for the collection and packaging of site-derived solid radwaste. It is anticipated that all site-derived waste will be contact handled, due to its low activity and the nature of the potential for sources of site-derived solid waste at the WIPP facility.

The maximum estimated solid radwaste volumes derived at the WIPP facility are listed below.

Source	Estimated Annual Volume cubic feet	(cubic meters)
Health Physics Laboratory	4	(0.11)
Solid Waste	205	(5.81)
Decontamination efforts	200	(5.66)
Sweeping	8	(0.23)
TOTAL	417	(11.8)

These maximum solid radwaste volumes are extremely conservative and actual volumes are expected to be much less. Solid radwaste is collected in standard Type A containers with filter vents, and accounted for in the WWIS.

4.7.3 Hazardous Waste System

Nonradioactive hazardous waste generated on-site typically includes absorbed liquids from spills and routine usage of maintenance products, including oils, coolants, and solvents. Safe storage of these materials and associated hazards are administered by the Site Generated Non-Radioactive Hazardous Waste Management,[4] and the Industrial Safety Program,[5] and the WIPP Emergency Management Program.[6]

A Hazardous Waste/Material Storage Facility is provided for storage of various types of incoming and outgoing hazardous materials prior to shipment to a Treatment Storage and Disposal Facility, and is shown in Figure 4.1-2a.

References for Section 4.7

1. DOE Order 5400.5, Radiation Protection of the Public and the Environment, January 7, 1993.

2. WP 05-WH1036, Site-Generated Mixed Waste Handling.

3. WP 02-RC.03, Resource Conservation and Recovery Act (RCRA) Compliance Manual.

4. WP 02-RC.01, Site Generated Non-Radioactive Hazardous Waste Management.

5. WP 12-IS.01, Industrial Safety Program.

6. WP 12-9, WIPP Emergency Management Program.

This page intentionally blank

4.8 Human Factors Engineering Considerations

This section summarizes the systematic inquiry of the importance to safety of reliable, correct, and effective human-machine interactions, considering the mission of the WIPP facility and the physical nature of the radioactive wastes that it will receive. The specific human errors that can contribute to accidental releases of hazardous materials are discussed in Chapter 5 as an integral part of each hypothesized accident. Based on the analysis of those accidents and the discussion below, it can be concluded that the WIPP waste acceptance criteria for transuranic wastes, facility design, and operational controls provide high confidence that all potential releases can be contained with passive safety features that eliminate the need for human actions requiring sophisticated human-machine interfaces.

To provide additional support for the conclusion that no detailed human factor evaluation of human-machine interfaces is required, a scoping assessment of the effectiveness of the human-machine interfaces that support important design functions of the Table 4.1-1 Design Class II and IIIA systems is summarized in Table 4.8-1. [It can be seen that most of the Design Class II and IIIA WIPP systems and equipment do not require human actions to initiate or sustain their function relative to the release of radiological or nonradiological waste materials.] In most cases these functions are accomplished with automatic passive mechanisms designed to provide containment for the waste materials.

Functions allocated to automatic passive mechanisms or automatic active systems may be influenced by human error during maintenance. However, using the graded approach, human-machine interfaces for maintenance activities at WIPP are judged to be adequate because they are deliberate, and there is ample opportunity to discover errors and correct them with no adverse safety consequences. The policy outlined in WP 10-2, Maintenance Operations Instruction Manual,[1] states that maintenance shall have a high degree of integration with other activities and shall have minimal impact on operations. Maintenance on specific systems is listed on the Plan of the Week, which Operations management must approve. A Plan of the Day meeting further ensures that coordination will be maintained. Finally, the facility is designed to provide adequate space and a favorable environment in which to accomplish maintenance activities.

The ability of the staff to accomplish their responsibilities in potential accident environments is addressed in Section 8.5. As discussed in the justification for the graded approach below, the limited magnitude of the hazard and the lack of dispersal driving forces provide very high confidence that the staffing and training presented in those sections will enable the staff to perform their responsibilities in potential accident environments.

The above graded approach to human factors engineering considerations is justified by the evaluation of the design and operation of the WIPP against three criteria given in Paragraph 8a of DOE Order 5480.23:[2]

- **Criteria (a) _Magnitude of Hazard.** The magnitude of hazardous materials that can be involved in an accident leading to a release is very limited. The radioactive material is delivered to the site in sealed containers; and, the waste handling operations are designed to maintain that integrity throughout the entire process required to safely emplace those containers in the site's underground waste disposal rooms. Inventory limits on individual containers ensure that heat generated by radioactive decay can be easily dissipated by passive mechanisms. Finally, only a limited number of waste containers have the possibility of being breached as a result of any one accident initiating event. As a result, the consequences of unmitigated releases from all accidents hypothesized in Chapter 5, including those initiated by human error, do not produce significant offsite health consequences.

- **Criteria (b) — Complexity of the Facility and/or Systems Being Relied on to Maintain an Acceptable Level of Risk.** The facility has no complex system requirements to maintain an acceptable level of risk. The facility is designed to minimize the presence and impact of other energy sources that could provide the heat or driving force to disperse hazardous materials. When something unusual happens during normal operations, such as support systems becoming unavailable, **waste handling can be simply stopped and personnel evacuated until an acceptable operating condition is reestablished**.

  Should an initiating event occur that breaches the waste containers, **the plant design permits the immediate cessation of activity and isolation of the area where the breach occurs**. Once isolation is achieved, there is no driving force within the waste or waste handling area that could result in a release of the waste material. Consequently, sufficient time is available to thoroughly plan and prepare for the remediation process prior to initiating decontamination and recovery actions.

- **Criteria (c) — Stage of Life Cycle.** Human factors considered here is limited to that time necessary to properly emplace the transuranic waste designated for disposal at WIPP. The operations will be straightforward, proceduralized, and consistent. Moreover, operations will be continued for only the period of time needed to complete the disposal process.

  Once a panel is filled and sealed off, the natural properties of the salt and the location of the mine combine to provide passive isolation of the waste from the environment. The potential for human intrusion after the facility closure is beyond the scope of the human factors evaluation considered here.

References for Section 4.8

1. WP 10-2, Maintenance Operations Instruction Manual.

2. DOE Order 5480.23, Nuclear Safety Analysis Report, 8-10-94.

Table 4.8-1, Human Factors Evaluation Requirements of Design Class II/IIIA SSCs

Table 4.1-1 Description			Functional Allocation	Human Errors Impacting Safety Function (Excluding Design, Maintenance, and Testing) and Consequence.	Human Factors Screening Results
System/Component	Design Class	Design Class Function			
COMPRESSED AIR SYSTEM (SDD-CAOO)					
High Efficiency Particulate Air (HEPA) filters for Support Building compressors	II	Control of radioactive effluent from entering the compressed air system	Passive Mechanisms	None	Adequate
PLANT BUILDINGS, FACILITIES, AND MISCELLANEOUS EQUIPMENT (SDD-CFOO)					
Waste Handling Building structure and structural components including tornado doors (Bldg. 411)	II	Provide physical confinement	Passive Mechanisms	None	Adequate
Station A Effluent Monitoring Instrument Shed (Bldg 364)	II	Design Class Interface. (Houses Station A)	Passive Mechanisms	None	Adequate
Effluent Monitoring Rooms A and B (Building 413A and 413B)	II	Design Class Interface. (Houses Local Processing Units (LPU)s collecting data from Stations A and B)	Passive Mechanisms	None	Adequate
Station B Effluent Monitoring Instrument Shed (Bldg 365)	IIIA	Design Class Interface. (Houses monitoring equipment for Exhaust Filter Building duct)	Passive Mechanisms	None	Adequate
Support Building (Bldg 451)	IIIA	Design Class Interface. (Houses Central Monitoring Room (CMR))	Passive Mechanisms	None	Adequate
Exhaust Filter Building (Bldg 413)	IIIA	Design Class Interface. (Houses Exhaust Filtration System)	Passive Mechanisms	None	Adequate
EFB HEPA Filter Units & Isolation Dampers	II	Failure could prevent mitigation	Passive Mechanisms	None	Adequate

Table 4.8-1, Human Factors Evaluation Requirements of Design Class II/IIIA SSCs Page 2 of 7

Table 4.1-1 Description			Functional Allocation	Human Errors Impacting Safety Function (Excluding Design, Maintenance, and Testing) and Consequence.	Human Factors Screening Results
System/Component	**Design Class**	**Design Class Function**			
EFB Exhaust System	IIIA	Failure could prevent mitigation	Passive Mechanisms	None	Adequate
Building 412 (Originally TRUPACT Maintenance Facility)	IIIA	Design Class Interface. (Structural interface with WHB)	Passive Mechanisms	None	Adequate
PLANT MONITORING AND COMMUNICATION SYSTEM (SDD-CMOO)					
Central Monitoring System	IIIA	Monitors important facility parameters	Automatic with alarms and readout in CMR.	CMRO fails to monitor and back up automatic functions. No human mitigation of ongoing scenario	Adequate
ELECTRICAL SYSTEM (SDD-EDOO {Surface and Underground})					
Diesel Generator and associated equipment	IIIA	Provides backup power to Design Class II and IIIA items	Active - Manual startup and loading, either locally or from the CMR, within 30 minutes to prevent loss of UPS.	None. Loss of active ventilation allows only very minor leakage of airborne radioactive materials loss of ΔP. 30 minutes is sufficient time for suspension of underground activities and evacuation of personnel to surface to comply with mine safety requirements.	Adequate
ENVIRONMENTAL MONITORING SYSTEM (SDD-EM00)					
Volatile Organic Compound (VOC) Monitoring Equipment and sub-systems	IIIA	Monitors release of VOCs	N/A	No safety function - Periodic sampling for confirmatory monitoring in accordance with RCRA	Adequate
HEATING, VENTILATION, AND AIR CONDITIONING (HVAC) SYSTEM (SDD-HV00)					

Table 4.8-1, Human Factors Evaluation Requirements of Design Class II/IIIA SSCs Page 3 of 7

Table 4.1-1 Description			Functional Allocation	Human Errors Impacting Safety Function (Excluding Design, Maintenance, and Testing) and Consequence.	Human Factors Screening Results
System/Component	Design Class	Design Class Function			
Exhaust Filtration System	II	Design Class Interface. (Control of radioactive effluent)	Passive mechanisms.	None. Filters required to be online during waste handling.	Adequate
HEPA Filters	II	Control of radioactive effluent	Passive Mechanisms	None. Filters required to be online during waste handling.	Adequate
Tornado Dampers	II	Control of radioactive effluent	Automatic	None	Adequate
Exhaust Systems HV01 (Bldg 411, CH HVAC), HV02, (Bldg 411, RH HVAC), and HV04 (Station A and Bldg 413, Exhaust Filter Building HVAC)	IIIA	Design Class Interface. (Provide filtration and maintain differential pressure)	Passive Mechanisms	None. Systems required to be online during waste handling.	Adequate
HVAC for the CMR	IIIA	Design Class Interface. (Maintains acceptable CMR environment)	Automatic	None	Adequate
RADIATION MONITORING SYSTEM (SDD-RM00)					
Stations A3, B2, and C (including UPSs)	II	Monitors radioactive effluents	Automatic with alarms and readout in CMR.	CMRO fails to verify operation and notify plant personnel. FSM fails to initiate facility emergency plans. No human mitigation of ongoing scenario.	Adequate
The remainder of the RMS SSCs (except PV00 equipment which is IIIB) are Design Class IIIA	IIIA	Monitors radioactive effluents	Automatic with alarms and readout in CMR.	CMRO fails to verify operation and notify plant personnel. FSM fails to initiate facility emergency plans. No human mitigation of ongoing scenario.	Adequate
UNDERGROUND HOIST SYSTEM (SDD-UH00)					
Waste Hoist and Equipment	IIIA	Failure could cause radioactive material release	Automatic (See WIPP/WID-96-2178 Rev. 0)	None	Adequate

Table 4.8-1, Human Factors Evaluation Requirements of Design Class II/IIIA SSCs

Table 4.1-1 Description			Functional Allocation	Human Errors Impacting Safety Function (Excluding Design, Maintenance, and Testing) and Consequence.	Human Factors Screening Results
System/Component	Design Class	Design Class Function			
UNDERGROUND VENTILATION SYSTEM (SDD-VU00)					
Exhaust duct elbow at the top of the Exhaust Shaft	II	Design Class Interface. (Channels exhaust air to the EFB)	Passive Mechanisms	None	Adequate
HEPA Filters and Isolation Dampers	II	Control of radioactive effluent	Passive Mechanisms	None	Adequate
Exhaust Fans for the filtration mode	II	Design Class Interface. (Channels exhaust air through the EFB)	Passive Mechanisms	None	Adequate
Exhaust System Instruments and Hardware	IIIA	Design Class Interface. (Supports Exhaust Filtration System)	Passive Mechanisms	None	Adequate
(6) High Pressure Fans for Bulkhead 309 (Pressure Chamber)	IIIA	Maintain buffer zone between RMA and non-RMA	Passive Mechanisms	None	Adequate
WASTE HANDLING EQUIPMENT (SDD-WH00)					
6-ton TRUDOCK cranes	IIIA	Failure could cause radioactive materials release	Active - Manual in use	Failure could lead to initiating event for CH Accident Release	See SAR CH 5
Adjustable Center-of-Gravity Lift Fixtures (ACGLF's)	IIIA	Failure could cause radioactive materials release	Active - Manual in use	Failure could lead to initiating event for CH Accident Release	See SAR CH 5
TRUPACT-II tools	IIIA	Failure could cause radioactive materials release	Active - Manual in use	Failure could lead to initiating event for CH Accident Release	See SAR CH 5
Leak check tools for TRUPACT-II	IIIA	Failure could cause radioactive materials release	Active - Manual in use	Failure could lead to initiating event for CH Accident Release	See SAR CH 5

Table 4.8-1, Human Factors Evaluation Requirements of Design Class II/IIIA SSCs Page 5 of 7

Table 4.1-1 Description			Functional Allocation	Human Errors Impacting Safety Function (Excluding Design, Maintenance, and Testing) and Consequence.	Human Factors Screening Results
System/Component	Design Class	Design Class Function			
TRUPACT-II Lift Fixture (Non ACGLF)	IIIA	Failure could cause radioactive materials release	Active - Manual in use	Failure could lead to initiating event for CH Accident Release	See SAR CH 5
Strongback Lifting Fixture (CH)	IIIA	Failure could cause radioactive materials release	Active - Manual in use	Failure could lead to initiating event for CH Accident Release	See SAR CH 5
SWB Lift Fixture Adapter	IIIA	Failure could cause radioactive materials release	Active - Manual in use	Failure could lead to initiating event for CH Accident Release	See SAR CH 5
TDOP Lift Fixture Adaptor	IIIA	Failure could cause radioactive materials release	Active - Manual in use	Failure could lead to initiating event for CH Accident Release	See SAR CH 5
SWB Forklift Lift Fixture	IIIA	Failure could cause radioactive materials release	Active - Manual in use	Failure could lead to initiating event for CH Accident Release	See SAR CH 5
TRUDOCK Vent Hood System	IIIA	Failure could prevent mitigation	Active - Manual in use	Failure could lead to loss of mitigation	See SAR CH 5
Facility Cask	II	Provides permanent shielding	Passive Mechanisms	None	Adequate
Telescoping Port Shield	II	Provides permanent shielding	Passive Mechanisms	None	Adequate
Shield Bell	II	Provides permanent shielding	Passive Mechanisms	None	Adequate
Shield Valve	II	Provides permanent shielding	Passive Mechanisms	None	Adequate
Hot Cell Viewing Windows	II	Provides permanent shielding	Passive Mechanisms	None	Adequate
Transfer Drawer	II	Design Class Interface. (Provides permanent shielding)	Active - In use manual	Failure could lead to initiating event for RH Accident Release	To be evaluated during RH analysis

Table 4.8-1, Human Factors Evaluation Requirements of Design Class II/IIIA SSCs **Page 6 of 7**

Table 4.1-1 Description			Functional Allocation	Human Errors Impacting Safety Function (Excluding Design, Maintenance, and Testing) and Consequence.	Human Factors Screening Results
System/Component	Design Class	Design Class Function			
140/25 ton crane	IIIA	Failure could cause radioactive materials release	Active - In use manual	Failure could lead to initiating event for RH Accident Release	To be evaluated during RH analysis
Cask Lifting Yoke	IIIA	Failure could cause radioactive materials release	Active - In use manual	Failure could lead to initiating event for RH Accident Release	To be evaluated during RH analysis
Facility Cask Loading Room Hoist	IIIA	Failure could cause radioactive materials release	Passive Mechanisms	None	Adequate
Facility Grapples	IIIA	Failure could cause radioactive materials release	Active - In use manual	Failure could lead to initiating event for RH Accident Release	To be evaluated during RH analysis

Table 4.8-1, Human Factors Evaluation Requirements of Design Class II/IIIA SSCs **Page 7 of 7**

Table 4.1-1 Description			Functional Allocation	Human Errors Impacting Safety Function (Excluding Design, Maintenance, and Testing) and Consequence.	Human Factors Screening Results
System/Component	Design Class	Design Class Function			
The Horizontal Emplacement and Retrieval Equipment (HERE)	IIIA	Failure could cause radioactive material release	Active - In use manual	Failure could lead to initiating event for RH Accident Release	To be evaluated during RH analysis
Hot Cell 15-ton Bridge Crane	IIIA	Failure could cause radioactive materials release	Active - In use manual	Failure could lead to initiating event for RH Accident Release	To be evaluated during RH analysis
Bridge Mounted Manipulator PAR 6000	IIIA	Failure could cause radioactive materials release	Active - In use manual	Failure could lead to initiating event for RH Accident Release	To be evaluated during RH analysis
Master-Slave Manipulator	IIIA	Failure could cause radioactive materials release	Active - In use manual	Failure could lead to initiating event for RH Accident Release	To be evaluated during RH analysis
Overpack Welder Equipment	IIIA	Failure could cause radioactive materials release	Active - In use manual	Failure could lead to initiating event for RH Accident Release	To be evaluated during RH analysis
Grapple Rotating Block	IIIA	Failure could cause radioactive materials release	Active - In use manual	Failure could lead to initiating event for RH Accident Release	To be evaluated during RH analysis
Canister Shuttle Car	IIIA	Failure could cause radioactive materials release	Active - In use manual	Failure could lead to initiating event for RH Accident Release	To be evaluated during RH analysis

HAZARD AND ACCIDENT ANALYSIS
TABLE OF CONTENTS

SECTION TITLE PAGE NO.

HAZARD AND ACCIDENT ANALYSIS
TABLE OF CONTENTS

SECTION **TITLE** **PAGE NO.**

HAZARD AND ACCIDENT ANALYSIS
LIST OF FIGURES

FIGURES	TITLE	PAGE NO.

HAZARD AND ACCIDENT ANALYSIS
LIST OF TABLES

TABLE **TITLE** **PAGE NO.**

HAZARD AND ACCIDENT ANALYSIS

This chapter: (1) systematically identifies the potential hazards resulting from Waste Isolation Pilot Plant (WIPP) disposal-phase handling and emplacement normal operations, and (2) assesses those hazards to evaluate abnormal, internal operational, external, and natural phenomena events that could develop into accidents. The hazard analysis: (1) considers the complete spectrum of accidents that may occur and qualitatively analyzes the accident annual occurrence frequency, and the resultant potential consequences to the public, workers, facility operations, and the environment; (2) identifies and assesses associated preventative and mitigative features for defense-in-depth; and (3) identifies a subset of accidents to be quantitatively evaluated in the accident analysis. The accident analysis evaluates these accidents against risk evaluation guidelines to verify the adequacy of the preventative and mitigative systems.

The methodology and requirements of DOE Order 5480.23,[1] and its implementing standards DOE-STD-1027-92[2] and DOE-STD-3009-94[3] were utilized in the development of this chapter. The potential hazards associated with the long-term waste isolation phase are addressed in the WIPP performance assessment submitted to EPA in October, 1996. The performance assessment is summarized in Section 5.5.

This chapter only addresses contact handled (CH) transuranic (TRU) waste handling and emplacement operations described in Chapter 4. Future updates of this chapter (currently scheduled for FY-1999) will include a hazard and accident analysis of remote handled (RH) TRU waste handling and emplacement operations.

5.1 Contact Handled (CH) Transuranic (TRU) Hazard Analysis

The CH TRU hazard analysis involved a multi-step process which included (1) identification of the potential hazards associated with WIPP operations, (2) characterization of the waste expected at the WIPP, (3) a hazard evaluation in the form of a Hazard and Operability Study[4] (HAZOP) for the CH TRU waste handling and emplacement process, (4) the identification of potential accidents requiring quantitative accident analysis, (5) development of the WIPP defense-in-depth philosophy, and (6) an evaluation of worker protection from those accidents identified in the qualitative hazards analysis.

The hazard analysis in this section includes a thorough review of existing documentation [Final Environmental Impact Statement (FEIS),[5] Final Supplement Environmental Impact Statement (SEIS),[6] WIPP Fire Hazards and Risk Analysis,[7] and Failure Modes and Effects Analyses (FMEA)] to ensure hazards were thoroughly evaluated.

5.1.1 Hazard Identification

A hazard is defined as a material, energy source, or operation that has a potential for causing injury or illness in humans, or damage to a facility or the environment, without regard for the frequency or credibility of accident scenarios or consequence mitigation.[3] Hazards associated with normal WIPP operations include mining dangers, high voltage, compressed gases, confined spaces, radiological and nonradiological hazardous materials, non-ionizing radiation, high noise levels, mechanical and moving equipment dangers, working at heights, construction, and material handling dangers. Operations at the WIPP do not involve high temperature and pressure systems, rotating machinery, electromagnetic fields, or use of toxic materials in large quantities.

Routine occupational hazards are clearly regulated by DOE-Prescribed Occupational Safety and Health Act (OSHA) and by Mine Safety and Health Act (MSHA) standards. Programs for protecting WIPP workers from routine occupational hazards are discussed in Chapter 8.

As part of normal operations activities at the WIPP, the waste containers (having met the WIPP Waste Acceptance Criteria[8] (WAC)) are closely inspected and surveyed for radiation, contamination, and damage before transfer to the underground repository. Most significantly, the cleanliness of containers is required to not be in excess of the DOE's free release limits (20 disintegrations per minute [dpm](0.3 Bq)) alpha per 15.5 in^2 (100 cm^2), or 200 dpm (3 Bq) beta/gamma per 15.5 in^2 (100 cm^2) prior to shipment from the generator sites. (See Section 7 for the basis for radiological and hazardous material protection limits.) WIPP normal operations do not entail any planned or expected releases of airborne radioactive materials which may present an internal occupational radiological hazard to workers, or present a hazard from the airborne pathway to the offsite public. Therefore, the radiological hazards for normal operations are limited to worker occupational external radiation exposure from the waste containers. Nonradiological hazards to the public and worker during normal operations may result from small releases of Volatile Organic Compounds (VOCs) from waste containers. Protection of the public and the worker from hazards involved with radiological and nonradiological materials during normal WIPP operations are further discussed in detail in Chapter 7. Therefore, for the purposes of establishing an inventory of radiological and nonradiological material, only that material contained in the waste drums is considered.

Operational, natural phenomena (such as earthquakes and tornadoes), and external hazards (such as aircraft crashes) are considered further in this chapter when they are identified as an initiating event leading to an uncontrolled abnormal or accidental release of waste container radiological or nonradiological materials.

For all conceivable operations and activities during the operational disposal-phase, few credible mechanisms can be identified that could lead to accidental releases of waste container radiological and nonradiological materials. The CH waste containers are designed and fabricated in accordance with stringent regulatory requirements. The integrity of the waste containers is ensured during the design life in relation to the time interval of the disposal-phase. While accidents or incidents could occur to individual waste containers, the structural capabilities of the containers as designed can sustain anticipated waste container drops from waste handling equipment. In addition, as discussed above, WIPP operations do not entail any dispersal energies from high pressure, high temperature, or high energy systems that could result in breach of waste container integrity.

Additionally, it should be noted that the hazards identified as a result of WIPP operations, in relation to most high or moderate hazard nuclear facilities, do not require safe shutdown of the facility in a specific manner in terms of time and technical conditions. The WIPP facility and operations either individually, or collectively, can be shutdown or stopped at any time.

Inventory of Hazardous Materials

The hazard identification process resulted in identifying process operation locations within the Waste Handling Building (WHB) and the underground disposal horizon for which an inventory of radiological material could be identified. The anticipated inventory was determined based on material form, location, and quantity associated with the process of receipt, handling, and disposal of CH TRU waste.

These process operation locations include:

1. Waste Handling Building (CH Bay)

   - CH Bay
   - Shielded Holding Area
   - Conveyance Loading Room

2. Underground Horizon

   - Waste Shaft Station
   - Disposal Panel

Table 5.1-1 summarizes the maximum CH TRU waste container inventory by facility process location. The radiological and nonradiological waste container contents are characterized in Section 5.1.2. The bounding radiological and nonradiological hazardous material inventory for each process location may be obtained by multiplying the number of waste containers by the maximum waste container contents derived in Section 5.1.2.

5.1.2 CH Waste Characterization

This section describes the methodology used in the development of waste container contents (radioactive/chemical content) to be disposed of at the WIPP. A description of waste containers, types, volumes, radioactive and nonradioactive constituents, and discussions on content development are included for use in the hazards and accident analysis.

Waste container types considered for this analysis are standard DOT Type A 55-gallon (208 L) drums (or equivalent) or standard waste boxes (SWBs), ten drum overpacks (TDOP), 85-gallon (321 L) overpacks, and pipe containers in 55-gallon (208 L) drums (pipe overpack payload containers). The design of these containers is discussed in detail in Section 4.2.

5.1.2.1 CH TRU Wastes

As defined in Public Law 102-579, WIPP Land Withdrawal Act,[9] the term "transuranic waste" means waste containing more than 100 nanocuries of alpha-emitting transuranic isotopes per gram of waste, with half lives greater than 20 years, except for: a) high-level radioactive waste; b) waste that the Secretary has determined, with the concurrence of the Administrator, does not need the degree of isolation required by the disposal regulations; or c) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with part 61 of title 10, Code of Federal Regulations.

TRU waste is classified as either CH or RH, depending on the external dose rate at the waste container surface. CH TRU wastes are packaged with an external surface dose rate of up to 200 millirem per hour. CH TRU waste decays principally by alpha emission, with some beta, gamma, and neutron emissions. Alpha emitting radionuclides result in no external radiation exposure to humans, but are hazardous if inhaled or ingested. Since beta emissions, like alpha, have limited penetrating energy, adequate personnel protection is provided by the waste container. Gamma and neutron radiation are more penetrating, and require shielding for safe management and storage. CH TRU waste contains predominantly alpha-emitting radioisotopes, and closed containers provide protection from inhalation or ingestion.

5.1.2.1.1 CH TRU Radionuclide Inventory

The WIPP TRU Waste Baseline Inventory Report[10] (BIR), Revision 3, provides estimated volumes of CH TRU waste to be supplied by the 19 DOE waste generator and/or storage sites, including small quantity sites. Historically, ten generator/storage sites had been listed as sources of TRU waste for disposal at WIPP. Activities associated with the Federal Facilities Compliance Act[11] (FFCA) resulted in the identification of nine additional sites that routinely engage in TRU waste activities. The wastes from these additional sites are included in the totals in the BIR. The radionuclide inventory by final waste form, stored waste volume, and waste site, as derived from a June 1996 query of Revision 3 of the BIR database, is shown in Table A-1 of Appendix A. Table A-1 is a summary of data reported by the generator sites for 569 individual waste streams shown in Table A-2, which organizes the waste streams by final waste form and radionuclide concentration, expressed in terms of PE-Ci/equivalent 55- gallon drums (0.208 m^3) (See Appendix B for a discussion on the PE-Ci concept). Waste form definitions are discussed in more detail in Section 5.1.2.2.

The right side of Table A-1 shows the volume percent (and range of average radionuclide concentration in PE-Ci/drum) of each final waste form that fall into a combination of two categories: (1) not to be processed/repackaged before WIPP disposal, and (2) to be processed/repackaged before WIPP disposal. Three bins are used to represent the distribution of radionuclide concentrations among the waste streams.

- The highest bin gives the volume percent consisting of waste streams whose average PE-Ci content is greater than 20 PE-Ci/drum equivalent. This value was selected because it is a factor of four below the 80 PE-Ci value (derived below) selected for bounding consequence calculations, but also above drums that will be loaded primarily with Pu-239.

- The lowest bin upper cutoff was selected at 8 PE-Ci to provide an indication of the volume percentage of waste that would produce a consequence at least a factor of ten below the bounding consequences calculated for this SAR.

- The middle bin may be considered to generally correspond to the volume percentage of drums that may approach the WAC nuclear criticality loading limits (200 fissile gram equivalents (FGE)) imposed for waste consisting of primarily Pu-239 operations material.

It should be noted that waste planned for processing/repackaging before shipment to the WIPP is reported for its current storage configuration, so the radionuclide concentrations associated with them may change prior to receipt at the WIPP, especially if the higher concentration waste streams consist of Pu-239, which is limited to 200 fissile-grams (16.8 PE-Ci) per 55-gallon (208 L) drum.

Table A-3 in Appendix A shows the individual waste streams listed by declining average waste stream radionuclide concentration. This table also shows the Ci/drum concentration of the major isotopes that contribute to the PE-Ci content in each waste stream. As can be seen from Table A-3, the radionuclide composition of CH TRU waste varies widely among the DOE waste generator facilities in terms of waste form or waste stream, TRU radionuclide composition, and waste volume.

Additionally, the radioisotopes found in waste containers are the result of various plutonium "processes" with very specific "mixes" or radionuclide distributions, which also varies widely among the waste generator facilities as shown in Table A-3. The Pu-mixes and the associated isotopic weight distributions used for this analysis are identified in DOE/WIPP 91-058, Radionuclide Inventory for the Waste Isolation Pilot Plant.[12] Although the inventory data in DOE/WIPP 91-058 is outdated, the document is used solely to provide the approximate isotopic weight distributions for all of the Pu-mixes. Appendix H of the BIR also provides isotopic mixes and distributions for Idaho National Engineering and Environmental Laboratory (INEEL) and Los Alamos National Laboratory (LANL) waste. Waste received at WIPP will include waste contaminated with the Pu-51 through Pu-83 mixes which include Pu-239 (weapons grade, fuel grade, reactor grade), and Pu-238 (heat source) operations mixes. Based on the BIR and DOE/WIPP 91-058, the isotopic composition (in weight %) of CH TRU waste from weapons grade Pu-239 operations waste is approximately 93% Pu-239, 6% Pu-240, and less than 0.01% total Pu-238, Pu-241, and Pu-242. For heat source Pu-238 operations, the approximate numbers are: 80% Pu-238, up to 20% Pu-239, and less than 3% total Pu-240, Pu-241, and Pu-242.

5.1.2.1.2 Waste Container Radionuclide Inventory for Safety Analysis Calculations

Background

Past WIPP safety analyses have established a waste container radionuclide inventory (CI) for use in accident analysis calculations based: (1) strictly on the weapons grade mix (Pu-52 distribution), or (2) based on an average or representative waste container content. Additionally, an arbitrarily chosen radionuclide inventory of 1000 PE-Ci was previously used for bounding accident analysis consequence calculations, and established as the WIPP WAC[8] Pu-239 Equivalent Activity Operations and Safety limit.

Past safety analysis consequence calculations were performed predicated on the WIPP WAC Operations and Safety requirement that waste materials be immobilized if $>1\%$ by weight is particulate material $<$ 10 microns in diameter, or if $>$ 15 % by weight is particulate material$<$ 200 microns in diameter. However, deletion of this constraint is desirable due to the risk and cost in characterizing the size distribution of deposited radionuclide surface contamination on combustible and noncombustible solids. This SAR has evaluated a reasonable range of CIs for "untreated" (not solidified, vitrified, or overpacked) CH TRU waste. Based on a maximum reasonable CI, used in conservative safety analysis with updated airborne release and respirable fractions and the radionuclide limitations for untreated waste derived below, the potential dose consequences due to inhalation by immediate workers, the noninvolved worker, and the maximally exposed individual (MEI) from operational accidents whose frequencies greater than 1E-06/yr are within the risk evaluation guidelines established in Section 5.2.4. As a result, immobilization is no longer required.

In conjunction with this goal, the establishment of the radionuclide CI for use in accident analysis calculations must also involve: (1) an evaluation of existing safety analysis orders and guidance documents to establish the appropriate level of conservatism for the CI for safety analysis calculations; (2) consideration of the projected waste inventory in Appendix A, and the desire to encompass as much of the Pu-239 and Pu-238 operations waste as possible with the least design or operational impacts to both the waste generator and the WIPP; and (3) evaluation of the existing WAC transportation constraints (nuclear criticality (Pu-239 FGE) and Thermal Power ($<$ 40 watts per TRUPACT-II) criteria). The adequacy of the WIPP facility design, and operational administrative controls (the maximum CI derived below, and elimination of the immobilization requirement as a WAC criterion) is evaluated, based on the accident results in Section 5.2, in detail in Section 5.2.4.

As shown in Table A-4 of Appendix A, each Pu-mix is scaled to the WAC[8] nuclear criticality limit of 200 fissile-gram equivalents (FGE) for 55-gallon (208 L) drums, and 325 FGE for SWBs, using the isotopic weight distributions in DOE/WIPP 91-058,[12] and converted to Plutonium-239 Equivalent Curies (PE-Ci) (see Appendix B for a discussion of the PE-Ci concept). The scaled drum PE-Ci values range from 16.8 PE-Ci for the Pu-52 mix, to 47.2 PE-Ci for the Pu-57 mix, and 9,070.0 PE-Ci for the Pu-83 mix; the values for the scaled SWB range from 27.4 PE-Ci for the Pu-52 mix, to 76.7 PE-Ci for the Pu-57 mix, and 14,739.0 PE-Ci for the Pu-83 mix.

The WIPP WAC Thermal Power transportation requirements, limit the decay heat from all CH-TRU waste to 40 watts per TRUPACT-II. Using the Pu-239 "weapons-grade" distribution in Table A-4 of Appendix A, calculations indicate that the 40 watt limit equates to a maximum total possible PE-Ci for a TRUPACT-II shipment of Pu-239 waste of approximately 1,430 PE-Ci. However, based on the above discussions, for the predominant Pu-239 weapons grade operations waste, the most restrictive of the applicable WIPP WAC criteria is the nuclear criticality criterion, which restricts a single drum to 200 FGE (16.8 PE-Ci), and 325 FGE for SWBs (27.4 PE-Ci), and 325 FGE/TRUPACT-II (27.4 PE-Ci).

Using the Pu-238 "heat source" distribution in Table A-4 of Appendix A, calculations indicate that the 40 watt limit equates to a maximum total possible PE-Ci for a TRUPACT-II shipment of Pu-238 waste of approximately 1,117 PE-Ci. For the less predominant Pu-238 heat source operations waste, the most restrictive of the applicable WIPP WAC criteria is the thermal power criterion, which restricts the total PE-Ci for a TRUPACT-II shipment of Pu-238 waste to approximately 1,117 PE-Ci, much less than the theoretically possible 9,070 PE-Ci (200 FGE) in a single drum. These values are considered below in conjunction with the data in Appendix A for determining a maximum CI.

Approach for Developing the Waste Container Radionuclide Inventory for Safety Analysis Calculations

DOE-STD-3009-94[3] and its draft appendix state that the accident analysis source term material at risk (MAR) should "represent a reasonable maximum for a given process or activity, as opposed to artificial maximums unrepresentative of actual conditions." Additionally, Section A.3.1 of the draft appendix to DOE-STD-3009-94, states that documentation may be used to "back off" of bounding estimates of the MAR.

TRUPACT-II shipments to the WIPP are assumed to be comprised of 14 Type A 55-gallon (208L) drums (or equivalent), two TRUPACT-II SWBs, or one-ten drum overpack (TDOP), as these are currently the only payload containers authorized for unloading at the WIPP by the WAC. The use of a pipe overpack in a 55-gallon (208 L) drum for high concentration TRU waste will provide double containment of that waste. Furthermore, the 1/4" thick stainless steel pipe container that will be placed in the 55-gallon (208 L) drum is judged to be strong enough to permit the overpacked configuration to survive all postulated accidents without a release.

Accident scenarios may involve damage to one, some, or all of the waste containers within the TRUPACT-II. Since the MAR for an accident scenario is a function of the number of waste containers assumed damaged in the scenario and their individual radionuclide CI (MAR = CI * (number of containers damaged)), deriving a reasonable maximum for MAR must also involve deriving a reasonable maximum for CI, as well as for the distribution of PE-Ci contents in the individual waste containers assumed to be involved or damaged.

Based on the data in Appendix A, it is considered "realistic" that the MAR (total of the distribution of PE-Ci contents in the waste containers assumed to be involved or damaged in an accident scenario) is such that each waste container is at or below the average CI derived below. As shown in Table A-3, approximately 86 percent of the volume for all waste forms, including the predominant heterogeneous, uncategorized metal, and combustible waste forms average less than 8 PE-Ci, and 70 percent average less than 3.0 PE-Ci.

Consistent with DOE-STD-3009-94, based on the data in Appendix A, for accident scenarios analyzed in Section 5.2 which involve multiple waste containers, it is conservatively assumed that a "reasonable maximum" MAR (total of the distribution of PE-Ci contents in the waste containers assumed to be involved or damaged in an accident scenario) is such that (1) one waste container contains the maximum radionuclide inventory, and (2) the remaining waste containers contain an average radionuclide inventory, both of which are derived below. For accident scenarios which involve single waste containers, it is conservatively assumed that the waste container contains the maximum radionuclide inventory. Table A-5 of Appendix A, which accomplishes a binomial sampling analysis of the waste drum population, demonstrates that the probability that mixtures of drums exceeding the MAR used above being involved in accidents is very low. Therefore, it may be conservatively concluded that the above assumptions produce reasonable maximum MAR.

It is considered "bounding" that the total of the distribution of PE-Ci contents in the waste containers assumed to be involved or damaged in an accident scenario is at the maximum allowable PE-Ci of 27.4 PE-Ci (325 FGE TRUPACT-II limit) for weapons grade waste, or 1,117 PE-Ci (TRUPACT-II Thermal Power 40-watt limit) for heat source waste.

Average Waste Container Radionuclide Inventory for Safety Analysis Calculations

Section 5.1.2.1.1 has established the variability in the average waste container inventory among the DOE waste generator facilities in terms of waste form or waste stream, and TRU radionuclide composition or Pu process mix. As shown in Table A-3, the waste stream dependent average waste container inventory varies from approximately 1,600 PE-Ci/drum to less than 1 PE-Ci/drum. A "reasonable maximum" average radionuclide inventory of 8 PE-Ci (Table A-1 lowest bin upper cutoff) is established. As shown in Table A-3, 86 percent of the volume for all waste forms have radionuclide concentrations below 8 PE-Ci/drum, including the predominant heterogeneous, uncategorized metal, and combustible waste forms. Additionally, as shown in Table A-2, 96 percent of the volume of uncategorized metals (chosen in Section 5.2.1.1 as the waste form for waste container breach/impact analyses) have radionuclide concentrations below 8 PE-Ci/drum.

It is judged that the waste stream averaged radionuclide concentrations are a good indication of the radionuclide content in individual drums. First, there are 569 individual waste streams, and many sites have multiple waste streams assigned to the same final waste form. A waste stream is defined by the WAC as "material generated from a single process or activity that is similar in material, physical form, isotopic makeup, and hazardous constituents." While it is possible to have variability in the content of individual drums, it should be noted that the heavily loaded drums must be only a small fraction of the total number of drums in a waste stream. For example, a drum that has 5 times the average PE-Ci/drum would require 5 drums having 20% of the average to offset that one heavily loaded drum. As a result, consequence calculations, for multiple drum accidents, assuming that one waste container contains the maximum radionuclide inventory, and the remaining waste containers contain a "reasonable maximum" average radionuclide inventory is reasonable.

Maximum Waste Container Radionuclide Inventory for Safety Analysis Calculations

The maximum CI that complies with DOE-STD-3009-94 guidance on the level of conservatism for the accident analysis source term MAR is established by: (1) enveloping and allowing for disposal at WIPP as much of the stored Table A-3 waste streams contaminated from Pu-239 operations, and high curie content Pu-238 operations waste; and (2) considering the above discussion relating to the WIPP WAC nuclear criticality criterion.

The "reasonable maximum" drum CI for use in accident consequence analysis was established in a previous revision of the SAR by: (1) multiplying the Pu-52 mix scaled 16.8 PE-Ci by a factor of five, and rounded down to 80 PE-Ci for conservatism to encompass the 200 FGE scaled radionuclide content of waste streams contaminated by Pu-239 operations mixes; and (2) evaluating the appropriateness of 80 PE-Ci based on the data provided in Appendix A. The SWB radionuclide inventory is established by multiplying the Pu-52 mix scaled value of 27.4 by a factor of five, and rounding down to 130 PE-Ci. The discussion below confirms that these TRU loadings are a reasonable maximum for use in accident consequence analysis.

As shown in Table A-3 of Appendix A, the maximum radionuclide drum CI of 80 PE-Ci will encompass and allow for disposal a majority (over 99 percent) of the waste volume contaminated from Pu-239 and Pu-238 operations. It is acknowledged that some percentage of the system waste volume will exceed the 80 and 130 PE-Ci values. However, as shown in Table A-3, approximately 27 of the 569 waste streams (less than 5 percent) fall into this category. Within those 27 waste streams, there are 541 equivalent 55-gallon (208 L) drums, or 0.2 percent of the 281,410 total system stored equivalent drums. Of the 27 waste streams, 20 of those waste streams (474 drums) will be processed/repackaged prior to shipment to WIPP.

The maximum container loads of 80 PE-Ci (drums) or 130 PE-Ci (SWBs) used to formulate the MAR are the maximum "untreated" TRU waste container content that may be shipped to the WIPP. As a defense-in-depth approach to prevent potential unacceptable dose consequences to the MEI, noninvolved worker, and immediate worker (the primary receptor of concern for evaluation of the adequacy of the immobilization criterion) from high PE-Ci untreated waste, the WAC requires that waste containers exceeding the 80 PE-Ci (drums) or 130 PE-Ci (SWBs) values must be overpacked (drum within a SWB or TDOP), or solidified, or vitrified (thus immobilized) prior to acceptance at WIPP. Solidification and vitrification both greatly inhibit the release of the waste form should a container be breached during an accident. Overpacking provides an additional barrier that will greatly reduce the frequency of breach during accidents. These two factors, combined with the low percentage of high TRU waste volume that currently exists in the inventory, are judged to make the risks associated with high PE-Ci waste forms small compared to those estimated for the "reasonable maximum" MAR.

As discussed above, the WIPP WAC Thermal Power TRUPACT-II requirement limits the maximum total PE-Ci for a TRUPACT-II shipment of Pu-238 waste to approximately 1,117 PE-Ci. Therefore, the WAC Pu-239 Equivalent Activity Operations and Safety maximum allowable waste container radionuclide inventory of 1,100 PE-Ci for overpacked and 1,800 PE-Ci for solidified/vitrified waste is established.

The adequacy of these assumptions and the WIPP CH TRU facility design basis are evaluated in detail based on the accident results in Section 5.2.4. Receipt of waste for disposal at WIPP that does not meet the applicable Operations and Safety Requirements of the WIPP WAC will first require the performance of an Unreviewed Safety Question Determination (USQD) in accordance with the requirements of DOE Order 5480.21, Unreviewed Safety Questions.[13]

5.1.2.2 TRU Mixed Waste

Hazardous waste, as defined in 40 CFR 261, Subparts C and D,[14] often occurs as co-contaminants with TRU waste from defense-related operations, resulting in "TRU mixed waste." The BIR[10] estimates the quantities of Resource Conservation and Recovery Act (RCRA) regulated TRU waste to be shipped from each generator site. The most common hazardous constituents in the TRU mixed waste consist of the following:

Metals

Some of the TRU mixed waste to be emplaced in the WIPP facility contains metals for which toxicity characteristics were established (EPA hazardous waste codes D004 through D011). These materials are known to be present based on acceptable knowledge of waste-generating processes and various analytical results used to verify acceptable knowledge. Cadmium, chromium, lead, mercury, selenium, and silver are present in discarded tools and equipment, solidified sludges, cemented laboratory liquids, and waste from decontamination and decommissioning activities. A large percentage of the waste consists of lead-lined glove boxes, leaded rubber gloves and aprons, lead bricks and piping, lead tape, and other lead items. Lead, because of its radiation-shielding applications, is the most prevalent toxicity-characteristic metal present.

Halogenated Volatile Organic Compounds

Some of the mixed waste to be emplaced in the WIPP facility contains spent halogenated organic solvents (EPA hazardous waste numbers F001 through F005). The presence of these compounds is confirmed by analytical results from headspace gas sampling of TRU mixed waste. Tetrachloroethylene; trichloroethylene; methylene chloride; carbon tetrachloride; 1,1,1-trichloroethane; and 1,1,2-trichloro-1,2,2-trifluoroethane (EPA hazardous waste codes F001 and F002) are the most prevalent halogenated organic compounds identified in TRU mixed waste that may be managed at the WIPP facility during the Disposal Phase. These compounds are commonly used to clean metal surfaces prior to plating, polishing, or fabrication; to dissolve other compounds; or as coolants. Because they are highly volatile, only very small amounts typically remain on equipment after cleaning, or in the case of treated wastewaters, in the sludges after clarification and flocculation.

Nonhalogenated Volatile Organic Compounds

Xylene, methanol, and n-butanol are the most prevalent nonhalogenated VOCs in TRU mixed waste that may be managed at the WIPP facility during the Disposal Phase. These compounds occur in TRU mixed waste materials in much smaller quantities than halogenated VOCs. Like the halogenated VOCs, they are used as degreasers and solvents, and are similarly volatile. The same analytical methods that are used for halogenated VOCs are used to detect the presence of nonhalogenated VOCs.

TRU mixed waste generated at DOE sites results from specific processes and activities that are well-defined and well-controlled, enabling the DOE to characterize waste streams on the basis of knowledge of the process and the raw materials used. Examples of the major types of operations that generate TRU mixed waste include:

- Production of Nuclear Products—Production of nuclear products includes reactor operation, radionuclide separation/finishing, and weapons fabrication and manufacturing. The majority of the TRU mixed waste was generated by weapons fabrication and radionuclide separation/finishing processes. More specifically, wastes consist of residues from chemical processes, air and liquid filtration, casting, machining, cleaning, product quality sampling, analytical activities, and maintenance and refurbishment of equipment and facilities.

- Plutonium Recovery—Plutonium recovery wastes are residues from the recovery of valuable plutonium-contaminated molds, metals, glass, plastics, rags, salts used in electrorefining, precipitates, firebrick, soot, and filters.

- Research and Development (R&D)—R&D projects include a variety of hot cell or glove box activities that often simulate full-scale operations described above, producing similar TRU mixed wastes. Other types of R&D projects include metallurgical research, actinide separations, process demonstrations, and chemical and physical properties determinations.

- Decontamination and Decommissioning—Facilities and equipment that are no longer needed or usable are decontaminated and decommissioned, resulting in TRU mixed wastes consisting of scrap materials, cleaning agents, tools, piping, filters, Plexiglas™, glove boxes, concrete rubble, asphalt, cinder blocks, and other building materials. This is expected to be the largest category by volume of TRU mixed waste to be generated in the future.

Hazardous Constituents

Hazardous constituents in TRU mixed wastes to be shipped to the WIPP may exist in both the gaseous and solid states within the waste containers. For potential accident scenarios involving the breach of waste containers, knowledge of the hazardous materials in the gaseous state is necessary. Information on headspace gas concentrations is taken from the DOE/WIPP-91-005, Waste Isolation Pilot Plant RCRA Part B Permit Application,[16] for use in analyzing potential waste container breach/puncture scenarios. (Headspace is the void surrounding the waste). Analytical data on the concentrations of 29 VOCs in the headspace gases has been calculated and is summarized in the RCRA Part B Permit Application, Table D9-7.[16] The most prevalent VOCs observed in the headspace gases are methylene chloride and carbon tetrachloride. Additionally, methylene chloride and carbon tetrachloride, as well as chloroform are considered potential carcinogens. A comparison of the headspace weighted averages (ppmv) with the chemical OSHA permissible exposure limit time weighted average (PEL-TWA)(see section 3.3.5) indicates that the headspace weighted averages of carbon tetrachloride, chloroform, and 1,1,2,2-tetrachloroethane initially exceed the PEL-TWA, and require further analyses of the potential exposures during accident conditions. Therefore, methylene chloride, carbon tetrachloride, and chloroform (due to prevalence and as carcinogens), and 1,1,2,2-tetrachloroethane (due to prevalence) are selected for consideration for accidental releases involving the release of headspace gases (Table 5.1-2).

Fire scenarios require knowledge of the hazardous materials in the solid/liquid state. The BIR,[10] indicates that the largest volume of existing TRU mixed waste is from the Idaho National Engineering and Environmental Laboratory (INEEL). As such, the INEEL Hazardous Stored TRU Waste Source Term for the Radioactive Waste Management Complex Transuranic Storage Area[15] is used to develop the total waste container nonradioactive hazardous material inventory (Table 5.1-3).

The waste that will come to WIPP will be addressed by programs at the TRU waste generator sites that implement WIPP requirements. These programs will include the requirements of the Waste Analysis Plan (WAP) found in the WIPP RCRA Part B Application, Chapter C.[16] The WAP defines the required waste characterization activities to be performed by the TRU waste generator sites. Every container of waste that will be shipped to WIPP will also meet the certification requirements contained in the WIPP WAC.[8] These criteria ensure that the waste is compatible with the transportation, management, and long-term disposal requirements for the WIPP and that have been characterized to meet regulatory requirements.

The WAC requires the generator to prepare a waste certification program that lists the methods and techniques used for determining compliance with the WAC and associated quality assurance/quality control (QA/QC) criteria. The WAC contains all of the health and safety based limits that the waste must meet for acceptance by WIPP. Also, the WAC contains transportation related limits based on the Certificate of Compliance for the TRUPACT-II (Nuclear Regulatory Commission) and for hazardous waste (EPA).

Waste Acceptance

Waste acceptance refers to the process whereby a final determination is made, on a container-by-container basis, that waste can be managed at the WIPP in a manner that is protective of human health and the environment, and is in compliance with the regulations. Waste that is finally accepted for disposal at the WIPP will have undergone the screening scrutiny that is required by the WIPP programmatic documents. This means that waste must meet the requirements of the WIPP WAC,[8] WIPP RCRA Part B, Chapter C (WAP),[16] and the data quality objectives of the QAPP.[17] These programmatic documents require that data collected regarding the waste be verified at the point of generation, by the generating site project office, and then again by WIPP. The WAC establishes minimum criteria that the waste must meet, and limits that cannot be exceeded in order to maintain health and safety parameters.

The following waste is unacceptable for management at the WIPP facility:

- Ignitable, reactive, and corrosive waste
- Liquid wastes, (all waste must meet the WAC criteria regarding residual liquid content)
- Compressed gases
- Incompatible waste, (waste must be compatible with backfill, seal and panel closure materials, container, cask, and TRUPACT-II materials as well as with other waste)
- Headspace-gas VOC concentrations resulting in average annual emissions not protective of human health and the environment
- Wastes with EPA codes not listed on RCRA Part A permit application, which is Chapter A of the RCRA Part B permit application[16]
- Waste with equal to or more than 50 parts per million (ppm) (50 milligrams per liter [L]) polychlorinated biphenyls (PCB)

The WIPP facility will not accept waste that exhibits the characteristics of ignitability, reactivity, or corrosivity. The DOE ensures through administrative and operational procedures at the generator sites that TRU mixed waste received at the WIPP facility does not exhibit these characteristics. These characteristics are generally associated with liquid wastes or specific waste forms that may react violently. The WAP and the WAC, therefore, prohibit liquid waste, explosives, compressed gases, oxidizers, and pyrophorics. The absence of these wastes is confirmed by RTR, visual examination, and headspace analysis, as discussed previously. The prohibition of these materials is key to limiting the hazards associated with WIPP CH TRU waste handling activities.

The TRU mixed waste received at the WIPP facility will not be aqueous or liquid, will not contain WAC-prohibited materials, and will be capable of being handled at standard temperatures and pressures without reaction to oxygen or water. The WAC specifies that liquid waste is not acceptable at the WIPP. The WIPP facility will not accept containers holding waste that would be considered a liquid waste. Every container holding waste shall contain less than 0.53 gallons (2 L) of liquid for a 55-gal drum (208L), or 2.1 gallons (8 L) for a SWB. Each container must contain as little residual liquid as is reasonably achievable, and all internal containers (e.g., bottles and cans) must contain less than one inch (2.54 cm) of liquid at the bottom of the container.

Additionally, TRU mixed waste cannot contain explosives, compressed gases, oxidizers, or nonradionuclide pyrophoric materials. (Waste generators have submitted information on waste streams based on known waste generation processes that indicate certain waste streams may have the potential for reactivity, ignitability, or corrosivity.) These characteristics must be eliminated prior to waste acceptance for disposal at the WIPP.

The WIPP will manage TRU mixed waste in a manner that mitigates the buildup of explosive or flammable gases within the waste. Containers are vented through individual particulate filters, allowing any gases that are generated by radiolytic and microbial processes within a waste container to escape; to prevent over pressurization.

The WIPP facility is designed to manage only compatible waste. Therefore, a compatibility analysis was performed to identify potential incompatibilities for all defense generated TRU mixed waste reported in the BIR.[10] Wastes were screened for incompatibilities based on their chemical content and physical waste form. The compatibility analysis also took into account waste compatibility with various aspects of the repository such as shaft, seal, and panel closure materials, backfill, and fire suppressant materials.

To ensure the integrity of the WIPP facility, waste streams identified to contain incompatible materials or materials incompatible with waste containers cannot be shipped to WIPP unless they are treated to remove the incompatibility. Only those waste streams that are compatible, or have been treated to remove incompatibilities, will be shipped to WIPP.

The DOE will only allow generators to ship those waste streams with EPA Hazardous Waste Codes listed on Part A of the RCRA Permit, which is Chapter A of the RCRA Part B Permit.[16] Characterization of all waste streams will be performed as required by the WAP. If during the characterization process, new hazardous waste codes are identified, those wastes cannot be accepted for disposal at the WIPP facility until a permit modification has been submitted and approved. Similar waste streams at other generator sites will be examined more closely to ensure that the newly identified code does not apply. If other waste streams also require a new hazardous waste code, shipment of these waste streams will also cease until a permit modification has been submitted and approved. Approval will be based on the physical and chemical properties of the waste.

Transformer oils containing PCBs have been identified in a limited number of waste streams included in the Waste Matrix Code corresponding to organic sludges. Because the WIPP facility is not seeking permission to manage PCB waste, these waste streams are required to be screened to assure PCB levels are below 50 ppm.

The WAC requires the following information about the waste to be shipped to WIPP: radionuclide identification and quantities; RTR confirmation of the waste form, identification, and indication that no excluded items have been detected; identification of the RCRA constituents identified from headspace gas analysis; totals analysis of homogeneous waste. The WAC also requests other information that is required for transportation, safe handling, and disposal of the waste.

5.1.3 CH Hazard Categorization

The hazard categorization for the CH TRU Waste Handling Process was developed based on the methodology and requirements in DOE-STD-1027-92, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports.[2] The Standard requires that a nonreactor nuclear facility be placed in a hazard category based on the unmitigated release of material from the facility. The material then is compared against Threshold Quantities (TQs) identified in Attachment 1 of the Standard.

The maximum drum radionuclide inventory developed in Section 5.1.2, susceptible to an unmitigated accidental release is 80 PE-Ci. Since this quantity exceeds the Hazard Category 3 threshold of 56 Ci for Pu-239 (Attachment 1 of Standard), the WIPP is classified overall as a Hazard Category 2 facility.

5.1.4 Hazard Evaluation

The WIPP CH TRU handling process was qualitatively evaluated using a HAZOP (Summarized in Appendix C).[4] This systematic approach to hazard analysis was conducted by a leader knowledgeable in the HAZOP methodology, and consisted of personnel from various disciplines familiar with the design and operation of the WIPP (HAZOP Team). The HAZOP Team identified deviations from the intended design and operation of the waste handling system that could: (1) result in process slowdown or shutdown, (2) result in worker injury or fatality, and (3) result in the release of waste container radiological and nonradiological materials.

The HAZOP Team assigned a qualitative consequence and frequency ranking for each deviation as discussed below. A hazard evaluation ranking mechanism utilized the frequency and the most significant consequences to separate the low risk hazards from high risk hazards that may warrant additional quantitative analysis. Based on this ranking approach a basic set of accidents was chosen for further quantitative assessment in Section 5.2 to: (1) verify and document the basis for the qualitative frequency and consequence assignments in the HAZOP, and (2) identify the need for Design Class I (safety-class) structures, systems, or components (SSCs) and Technical Safety Requirements (TSRs).

The HAZOP replaces previous hazards analyses in existing documentation including the Final Environmental Impact Statement (FEIS),[5] Final Supplement Environmental Impact Statement (SEIS),[6] WIPP Fire Hazards and Risk Analysis,[7] and Failure Modes and Effects Analyses (FMEAs), for the purposes of identifying initiating events for quantitative accident analysis in Section 5.2. However, these documents were reviewed in preparation of this section, to ensure that all hazards associated with CH TRU waste handling were identified in the HAZOP.

Since the performance of the HAZOP, an update of the WIPP Fire Hazards Analysis[32] has been performed to meet the requirements of DOE Order 5480.7A.[18] The updated Fire Hazards Analysis presents considerable evidence that supports the previous evaluation that the frequency of room or structural fire, as an accident in the Waste Handling Building (WHB) resulting in a direct release of radioactive material from the waste containers engulfed in the fire, is beyond extremely unlikely. The low frequency of this scenario is due primarily to the very low amounts of combustibles in waste handling areas, and lack of favorable propagation factors in the WHB. The most likely ignition source for fires in this area, are electrical fires involving transmission equipment, electric motors, appliances, and process equipment (including waste hoist motor and controls, 6-ton bridge crane motor, and electrical waste handling equipment motors). Fire detection and suppression systems are not required to prevent or mitigate room or structural fires leading to the accidental release of radioactive material. However, the updated fire hazards analysis indicates that the existing WHB fire detection and suppression systems are adequate to meet the requirements of DOE Order 5480.7A.

Because of proximity of the WIPP Support Building and the TRUPACT Maintenance Facility (TMF) to the WHB, the 1997 update of the FHA investigated the likelihood of fire propagating from either of these two buildings to the WHB with the potential to fully engulf the WHB, resulting in the collapse of the roof of the Contact Handling Bay (CH Bay) over the stored waste drums, resulting in an uncontrolled release of hazardous materials to the environment. The analysis determined that the frequency that a significant fire in either the Support Building or TRUPACT Maintenance Facility will propagate to the CH Bay of the Waste Handling Building and cause structural failure over the waste storage area is beyond extremely unlikely (less than 1E-6 per year). When the entire sequence of events required to produce structural failure is quantified, the likelihood of a structural collapse is about 2E-12/year for fires originating in the Support Building, and about 2E-10/year for fires originating in the TRUPACT Maintenance Facility. When no credit is taken for the fire suppression system, a fire that could result in an uncontrolled release of hazardous materials from a structural failure over the waste storage area, or from direct radiation is beyond extremely unlikely (less than 1E-6 per year).

The HAZOP evaluates the WHB waste handling equipment fires, and fires associated with diesel waste handling equipment in the underground as low frequency, low consequence events. Such fires may lead directly to waste handling equipment failure, or small fires impacting waste containers, both of which may lead to a release of radionuclides. The update FHA investigated the increased potential for fires resulting from the introduction of the additional fuel and ignition source of the diesel powered vehicle into the waste panels. The analysis found that the frequency of waste container breach due to a forklift-induced fire is less than 1E-6 per year, or beyond extremely unlikely. As a result of the FHA evaluation, it was determined that the use of diesel driven forklifts to place waste containers and MgO sacks in the underground will have negligible impact of safety. The updated FHA, and the HAZOP, both conclude that adequate equipment and manual fire suppression is available to prevent or mitigate these potential low risk fires.

The bounding amount of combustible material, as well as the presence of an ignition source, for the quantitative evaluation of a sustained fire scenario in both the WHB and the underground, is within the waste container. Such sustained internal waste container fires are assumed unmitigated by manual or automatic fire suppression systems. Additionally, spontaneous ignition within a waste container is considered of special interest due to the Waste Acceptance Criteria administrative controls that act to prevent such accidents. As such, spontaneous ignition within a waste container, evaluated qualitatively as extremely unlikely by the HAZOP Team, is evaluated quantitatively in Section 5.2.

PLG-1167,[33] Analysis of Roof Falls and Methane Gas Explosions in Closed Rooms and Panels investigated the possibility of a combustible gas explosion in a closed panel. Combustible gases, consisting primarily of methane, can be generated within waste drums containing organic materials. These gases can be released to the underground horizon through activated carbon venting plugs provided in each waste container. In unventilated areas, these gases may build up over a period of time, leading to a concern about the potential for an explosive mixture to form. The Panel Closure System has been designed to remain intact during such an event. PLG-1167,[33] examined the uncertainties in the generation of methane gas using recent information that indicate that concentrations will not reach potentially explosive concentrations during the time frame that an individual panel will remain open to ventilation. In addition, it concludes that the Panel Closure System design is adequate to address the range of conditions that might be expected within the sealed panel over the operational lifetime of the WIPP facility. The results show that for the worst case assumptions regarding the parameters of interest, the explosion pressure never exceeds the interface stress, and the gases from the explosion pressures would be contained. Therefore, it may be concluded that the likelihood of a breach of the Panel Closure System due to a methane explosion is beyond extremely unlikely.

5.1.4.1 HAZOP Methodology

The HAZOP technique, based on a creative systematic interaction of a multi-disciplinary team, evaluated the significance of deviations from the normal waste handling process. The HAZOP Team consisted of experienced personnel from Facility Operations, Maintenance Operations, (including previously qualified waste handlers experienced in TRUPACT and drum handling activities), industrial and nuclear safety, engineering, and regulatory compliance.

The HAZOP process started with the receipt of a CH TRU waste transporter at the front gate and ended with CH TRU waste being disposed of in the underground. HAZOP nodes (process steps) were selected to define the movement of CH TRU waste through the facility. Deviations were postulated for each node, and once the deviation was confirmed to be plausible, the HAZOP Team determined the possible causes for the deviation. The resulting potential consequences were explored without taking into consideration any mitigating features.

An evaluation was made to determine if mitigating safeguards were in place to alleviate the consequences. Some of the potential deviation consequences or concerns identified by the HAZOP Team are:

- Worker injury or fatality,
- Process slowdown or shutdown,
- Internal and external conditions may result in breach/rupture of waste containers resulting in the airborne release of radiological and/or nonradiological hazardous materials (loss of primary confinement),
- External waste container surface contamination and need for decontamination,
- Worker and public exposure to radiation and airborne radiological and nonradiological hazardous materials,
- Potential for receipt of damaged waste containers and need for overpack operations.

The HAZOP deviation ranking process used a two-number system, consisting of a qualitative consequence classification (Table 5.1-4) and a qualitative frequency (Table 5.1-5) classification. The qualitative consequence classification was ranked without consideration for mitigation. The qualitative frequency was ranked taking into consideration the probability of failure of identified safeguards and mitigation for that deviation. The HAZOP Team concluded that:

- Safeguards currently exist at the WIPP to prevent or reduce the frequency of such deviations from occurring. Identified safeguards include facility and equipment design, procedures, training, preventative maintenance and inspection, and administrative controls including the WIPP WAC[8] (see Table 5.1-7 and Appendix C).

- Mitigation exists to reduce the consequences of any postulated deviation to acceptable levels. Identified mitigation includes confinement/ventilation systems and associated HEPA filtration systems (see Table 5.1-7, and Appendix C).

As qualitatively concluded from this HAZOP, the design of the WIPP CH TRU Waste Handling System is sufficient to ensure the safety of the public, workers, and the environment. The HAZOP Team identified no substantial recommendations for the WIPP management to consider to reduce the severity or frequency of any of the postulated deviations.

5.1.4.2 Selection of CH Potential Accidents

The HAZOP[4] provided a list of deviations that were qualitatively ranked by relative consequence and frequency using the 'total rank' consequence criteria of Table 5.1-4, and the frequency criteria of Table 5.1-5. This resulted in the 'total rank' recorded in Appendix C. As stated in the HAZOP[4], the consequence ranking (total ranking) of each deviation included both the resultant consequence to the worker and the radiological and nonradiological consequence to the offsite public. In most deviations, the possibility of worker fatality resulted in the assignment of the highest possible consequence ranking of four. The total rank results in Appendix C are used for the evaluation of worker protection from accidents in Section 5.1.7.

In order to select potential CH accidents for quantitative accident analysis, the total list of hazards was narrowed to focus on risk posed by the accidental release of radiological and nonradiological hazardous material, by using the 'hazard rank' consequence criteria Table 5.1-6. This eliminated occupational deviations exclusive of the hazardous materials involved, providing a subset 'hazard rank' (also recorded in Appendix C).

In order to determine the risk associated with each deviation, the relative frequency and hazard consequence ranking (hazard rank) were combined. The deviations were then categorized as acceptable, moderate, or high risk based on the Relative Frequency and Consequence Ranking Matrix (Figure 5.1-1). Those deviations with a frequency and consequence combination that is in the matrix area of acceptable risk were excluded from further consideration for quantitative evaluation, with the exceptions of the waste hoist drop (CH5), earthquake (CH6), and aircraft crash (CH8). The waste hoist drop (CH5) was also selected for its significant interest to external organizations, as well as the earthquake (CH6) as a natural event, and the aircraft crash (CH8) as an external event as required by DOE-STD-3009-94.[3]

Table 5.1-7 lists the deviations whose combined 'hazard rank' were identified to be of moderate or high risk. The list of deviations in Table 5.1-7 is used for the selection of accidents for quantitative analysis in Section 5.2.

5.1.5 Prevention of Inadvertent Nuclear Criticality

The intent of a criticality safety program is to prevent the accumulation of fissile and fissionable material and neutron moderating or reflecting materials in quantities and configurations that could result in an accidental nuclear criticality.

To ensure adequate margins of criticality safety for adherence to DOE Order 5480.5,[19] the WIPP facility was designed so that during each operation involving fissile material K_{eff} does not exceed a value of 0.95 (at the 95 percent confidence level) for the most reactive set of conditions considered credibly possible. The calculation of K_{eff} includes the effect of neutron interaction and reflection between fissile elements and dimensional variations resulting from fabrication tolerances and changes due to corrosion and mechanical distortion. As discussed below, these calculations indicate the combination of conditions enabling the K_{eff} limit of 0.95 to be exceeded for the CH waste forms handled at the WIPP facility is incredible.

5.1.5.1 WIPP Nuclear Criticality Safety Program Elements

The WIPP nuclear criticality program elements consist of mass limits control, TRU waste disposal configuration control, and analytical verification of subcriticality.

Mass Limits Control

The WIPP WAC[8] limits the fissile or fissionable radionuclide content of CH TRU waste, including allowance for measurement errors, to 200 Fissile-Gram Equivalent (FGE) for a 55-gallon (208 L) drum and 325 FGE for a SWB. Further, the WAC limits the TRUPACT II payload, including error allowance, to 325 grams of FGE total. Overpack containers are limited by the FGE limit on the containers they overpack.

TRU Waste Disposal Configuration Control

In addition to the mass limits control, geometry controls are required for the emplacement and/or in-transit handling disposal configurations. Drum arrays shall not exceed three drums high, and may be infinite in both horizontal directions. With the current plutonium loading limits, the axial height of the WIPP disposal array is limited by the maximum height of 55 gallon drums, not SWBs or overpack containers.

CH TRU Nuclear Criticality Safety Analysis

In compliance with DOE Order 5480.5,[19] a criticality analysis[20] was performed to ensure that no credible criticality accident could occur at the WIPP. The analysis was based on the mass limit control and geometry control discussed above, with additional conservative assumptions in terms of; isotopic content, density and configuration modeling, moderation, and reflection. Further, for the CH waste analysis, it was assumed that the waste package storage array is infinite in both horizontal directions.

The results of the WIPP CH TRU criticality analysis[20] indicate that, for each of the conditions analyzed, the calculated effective multiplication factor, K_{eff}, is less than 0.95 including uncertainties at 95 percent probability at 95 percent confidence level. Accordingly, no credible criticality hazard exists at the WIPP for CH TRU operations.

DOE Order 5480.24[21] requires additional analysis of nuclear criticality safety. The WIPP CH TRU criticality analysis[20] was examined for compliance with the order and all the applicable requirements for the order performance of criticality analysis were complied with within the analysis.

5.1.5.2 Compliance with Mandatory ANSI/ANS Standards

The existing WIPP nuclear criticality safety program elements were reviewed to ensure compliance with the six mandatory American Nuclear Society ANSI/ANS nuclear criticality safety standards as the Order requires. The six mandatory standards are: ANSI/ANS-8.1,[22] 8.3,[23] 8.5,[24] 8.7,[25] 8.15,[26] and 8.19.[27]

The WIPP nuclear criticality safety program elements are found to be in compliance with the requirements of ANSI/ANS-8.1, Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors,[22] and ANSI/ANS-8.15, Nuclear Criticality Control of Special Actinide Elements,[26] in regard to: mass control, geometry control, and performance of criticality analyses.

The criticality-related administrative control provisions were determined to be in compliance with ANSI/ANS-8.19, Administrative Practices for Nuclear Criticality Safety.[27]

Since it has been established by analyses[20] that a criticality accident is beyond extremely unlikely (frequency $\leq$ 1 E-06/yr) at the WIPP, ANSI/ANS-8.3,[23] a Criticality Accident Alarm System, is not applicable as called for in the Order.

The two facility-specific standards, ANSI/ANS-8.5, Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material,[24] and ANSI/ANS-8.7, Guide for Nuclear Criticality Safety in the Storage of Fissile Materials,[25] are not applicable to the WIPP.

The existing WIPP nuclear criticality safety program elements are therefore in compliance with the Order-required mandatory criticality safety standards.

5.1.6 Defense-in-Depth

A defense-in-depth philosophy is employed in WIPP's approach to enhancing the safety of the facility in conjunction with its design and operations. The WIPP defense-in-depth safety approach provides layers of defense: (1) against release of radiological and nonradiological hazardous waste container materials and the resultant consequences to the public and the environment, and (2) for protection of the worker against accidents. The WIPP approach provides three layers of defense against releases. Each successive layer provides an additional measure of the combined defense strategy.

The ultimate safety objective of the first, or primary layer of WIPP defense-in-depth is **accident prevention**. The reduction of risk (as the product of frequency and consequence) to both workers and the public from WIPP CH TRU waste handling and emplacement operations is primarily achieved by reducing the frequency of occurrence of postulated abnormal events or accidents. The conservative design of the facility's structures, systems, and components (SSCs), with operations conducted by trained/qualified personnel, to the standards set forth in approved procedures, provides the first layer. Specific preventative measures are identified in Appendix C for each postulated deviation as identified in the HAZOP,[4] and in Table 5.1-7 for each deviation considered for quantitative accident analysis.

The occurrence frequency for each postulated deviation as identified in the HAZOP,[4] and in Table 5.1-7 for each deviation considered for quantitative accident analysis, is primarily derived from process inherent events, equipment failure, and human error. To reduce the frequency of equipment failure, the facility design, fabrication, and construction were undertaken in accordance with applicable codes and standards, based on the design classification of SSCs established in Chapter 4. Extensive pre-operational tests were conducted to verify that SSCs perform their design function. This is followed up presently by in-service and pre-operational checks and inspections, and preventive maintenance and quality assurance programs. The WIPP employs configuration management change control and modification retest to ensure quality throughout facility life. For hazards associated with underground operations, a substantial array of ground control planning and practices, support systems, instrumentation, monitoring, and evaluation exist to reduce the frequency of potential underground accidents. Technical Safety Requirement (TSR) Administrative Controls (ACs) are derived in Chapter 6 and required in the WIPP TSR Document (Attachment 1 to the SAR) to ensure that the high level of design is maintained throughout the facility lifetime.

Additionally, as identified in the HAZOP, accident prevention for process inherent events such as spontaneous ignition, is achieved administratively through the WAC[8] (as discussed in detail in Section 5.1.2.2) which restricts waste elements (such as the presence of pyrophorics) which may be initiating events for accidents. In addition, the following provide administrative controls to prevent the risk from postulated accidents from being unacceptable: (1) WAC limits on the radionuclide and fissile content of each waste container, (2) waste container integrity provisions ensure the robustness reflected in the waste container accident release analyses, and (3) criticality safety is a designed in-storage and handling configuration that ensures (in conjunction with waste characteristics) that active criticality control is not required.

Prevention of human error as an initiating event is achieved by the extensive training and qualification programs, operational procedures, and conduct of operations programs. TSR ACs are derived in Chapter 6 and required in the WIPP TSR Document (Attachment 1 to the SAR) to ensure that these programs are maintained, and operations continue to be conducted with highly qualified and trained personnel using current approved procedures.

The second layer of defense-in-depth provides protection against anticipated and unlikely operational events that might occur in spite of the protection afforded by the first layer of defense. The second defense layer is characterized by detection and protection systems, and controls that: (1) indicate component, system, or process performance degradation created by compromises of the first layer, and (2) provide adequate mitigation and accommodation of the consequences of those operational accidents which may occur.

Specific mitigative features are identified in Appendix C for each postulated deviation as identified in the HAZOP,[4] and in Table 5.1-7 for each deviation considered for quantitative accident analysis. In general, the WHB and underground radiation and effluent monitoring systems and HEPA filtration systems, and the WIPP emergency management program[30] provide this layer of defense-in-depth. In addition, the WIPP Human Factors Evaluation,[31] determined that well established policies and procedures are in place ensuring normal and emergency procedures are implemented, adequate directions have been provided to shift personnel concerning actions to be taken in a potential accident environment, and adequate procedures are available for follow up response. TSR ACs are derived in Chapter 6 and required in the WIPP TSR Document (Attachment 1 to the SAR) supporting the second level of defense-in-depth. Programs supporting defense-in-depth as required by the TSRs, are discussed in detail in Chapters 7, 8, and 9.

The third layer of defense-in-depth supplements the first two layers by providing protection against extremely unlikely operational, natural phenomenon, and external events. These events represent extreme cases of failures and are analyzed in Section 5.2.3 using conservative assumptions and calculations to assess the radiological and nonradiological effects of such accidents on the MEI, noninvolved worker, and immediate worker to verify that a conservative design bases has been established. These accidents include sustained waste container internal fire, waste hoist failure, and roof fall in the underground.

5.1.7 Protection of Immediate Workers from Accidents

The HAZOP[4] for the CH TRU Waste Handling System identified a number of waste handling process hazards that could potentially lead to events resulting in immediate worker injury or fatality, or exposure to radiological and nonradiological hazardous materials. The Total Rank (or risk) for each postulated deviation as identified in Appendix C, is the qualitative product of the frequency of the event and the potential consequences. As shown in Appendix C, the consequences of the postulated deviations were dominated by the assumption that a worker fatality may result without safeguards in place, regardless of dose or dosage received.

Consistent with: (1) Paragraph 6 of Attachment 1 of DOE Order 5480.22, Technical Safety Requirements;[28] (2) the defense-in-depth philosophy discussed in Section 5.1.6; and (3) the philosophy of Process Safety Management (PSM), as published in 29 CFR 1910.119, Process Safety Management of Highly Hazardous Chemicals,[29] reduction of the risk to workers from accidents is accomplished at the WIPP primarily by identifying controls to **prevent the event from happening**. (note: Compliance with 29 CFR 1910.119 is not required by WIPP. However, the WIPP philosophy of reduction of accident risk discussed in this section, is consistent with this standard.) As stated in paragraph 6 of Attachment 1 of DOE Order 5480.22, "The TSRs are not based upon maintaining worker exposures below some acceptable level following an uncontrolled release of hazardous material or inadvertent criticality; rather the risk to workers is reduced through the reduction of the frequency and potential impact of such events."

Consistent with this statement, in conjunction with the defense-in-depth philosophy described in the previous section, total risk is evaluated by: (1) performing engineering analyses in the form of event tree/fault tree analysis to identify systems, structures, components, processes, or controls that contribute most to the accident phenomena frequency for the purposes of verifying their adequacy or identifying improvements to reduce the accident frequency and therefore risk, and (2) evaluating human error as an initiating event.

As discussed in Section 5.1.4.1, the HAZOP Team identified a significant number of existing preventative safeguards that lower the frequency of occurrence of each deviation, substantially reducing the risk of injury or fatality to workers. The HAZOP Team concluded, consistent with the first layer of defense-in-depth, safeguards currently exist at the WIPP to prevent or reduce the frequency of such deviations from occurring. Identified preventative safeguards as shown in Appendix C, and Table 5.1-7 generally include the following:

- Facility and equipment design, application of appropriate design classification and applicable design codes and standards,

- Programs relating to configuration and document control, quality assurance, and preventative maintenance and inspection,

- Administrative controls including the WIPP WAC,[8] waste handling procedures and training, and the WIPP Emergency Management Program[30] and associated procedures.

Due to the importance of these preventative features in WIPP defense-in-depth and worker protection from accidents, TSR ACs are derived in Chapter 6, and required in the WIPP TSR Document (Attachment 1 to the SAR).

Section 5.2.3 evaluates the accident dose consequences to immediate workers from operational waste container handling accidents whose frequency is greater than 1E-06/yr, and may be initiated by waste handling equipment failure or directly through human error by a worker performing a waste handling operation. These accidents include crane failure, and waste container drops or puncture in the Waste Handling Building and the underground. The immediate worker is that individual directly involved with the waste handling operation for which the accident is postulated. This evaluation will ensure that the maximum allowable radionuclide inventory, in conjunction with the other layers of defense-in-depth, will preclude worker exposure from being unacceptable. A detailed summary of the evaluation of the WAC maximum allowable radionuclide inventory is provided in Section 1.3.2.4. Releases from such accidents are conservatively assumed to be instantaneous, and, although procedures dictate that workers exit the area immediately, such accidents present an immediate risk due to the inhalation of airborne radionuclides to the worker performing the waste handling operation.

To evaluate the risk to immediate workers from extremely unlikely operational accidents such as roof fall in the underground and waste hoist failure, the direction of resources in this SAR is more focused on the evaluation of system/facility reliability (accident prevention) than on an in-depth evaluation of radiological consequences to an immediate worker and post accident mitigative systems and controls. This evaluation is conducted in the event tree/fault tree analysis in Appendix D, and the accident scenario and evaluation of design adequacy descriptions for each applicable accident in Section 5.2.3. The risk to workers from extremely unlikely process inherent events such as spontaneous ignition, is a result of the failure of the WIPP WAC to restrict waste elements (such as the presence of pyrophorics) that may cause the initiating event. Again, the direction of resources is focused on the evaluation of the adequacy of the WAC certification process to prevent this type of accident, than on the evaluation of a survivable, specified radiological consequence for which mitigative SSCs or administrative controls may be derived. This evaluation is conducted in the event tree/fault tree analysis in Appendix D, and discussed in Section 5.1.2, and the accident scenario descriptions for CH1 and CH7 in Section 5.2.3.

In addition to these fault tree analyses, human error as an initiating event has been evaluated in the WIPP Human Factors Evaluation.[31]

As derived from the WIPP HAZOP, the risk to immediate workers from severe natural phenomenon (design basis earthquake and/or tornado), is dominated by worker fatality due to the energetic phenomenon during the event, as opposed to a specified radiological dose for which additional mitigative SSCs or administrative controls may be derived. This SAR is focused more on the evaluation of the existing facility design when subjected to the severe natural phenomenon (to reduce the likelihood of worker fatality, as well as breach of waste containers), rather than on the evaluation of radiological consequences to an immediate worker. This evaluation is conducted in the accident scenario and evaluation of design adequacy descriptions for each applicable accident in Section 5.2.3.

5.1.8 Defense-in-Depth Structures, Systems, and Components (SSCs)

As discussed in Sections 5.1.6 and 5.1.7, specific preventative and mitigative SSCs are listed in Appendix C for each postulated deviation as identified in the HAZOP,[4] and in Table 5.1-7 for each deviation considered for quantitative accident analysis. Specific SSCs that fulfill a defense-in-depth function, or considered essential for waste handling, storage and/or disposal operations are as follows: (1) Waste Handling Building (WHB) Heating, Ventilation and Air Conditioning (HVAC) (excluding RH area ventilation unless the RH area is used for CH storage or handling), and Underground Ventilation and Filtration System (UVFS) (including underground shift to filtration); (2) Waste Hoist Equipment (including Brake System); (3) Waste Handling Equipment (including the TRUDOCK Bridge Crane, forklifts, transporters, etc., as required), (4) WHB structure including tornado doors, (5) Central Monitoring System (to support underground shift to filtration only); and (6) Radiation Monitoring System, active waste disposal room exit alpha CAM (for underground shift to filtration).

Section 5.2.4.1, Evaluation of the Design Basis, discusses in detail: (1) the evaluation of safety significant SSCs, and (2) the applicability of functional and performance requirements (system evaluation) and controls (TSRs). Detailed design descriptions for the above SSCs may be found in Chapter 4 and the applicable Systems Design Descriptions.

References for Section 5.1

1. DOE Order 5480.23, Nuclear Safety Analysis Reports, April 1992.

2. DOE-STD-1027-92, Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports, 1992.

3. DOE-STD-3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports, July 1994.

4. WCAP 14312, Hazard and Operability Study for CH TRU Waste Handling System, Waste Isolation Pilot Plant, Westinghouse Waste Isolation Division, April, 1995.

5. DOE/EIS-0026, Final Environmental Impact Statement, Waste Isolation Pilot Plant, 2 Vols, U.S. Department of Energy, Carlsbad, N.M., 1980.

6. DOE/EIS-0026-FS, Final Supplement Environmental Impact Statement, Waste Isolation Pilot Plant, U.S. Department of Energy, Carlsbad, N.M., 1990.

7. DOE/WIPP 91-031, WIPP Fire Hazards and Risk Analysis, May 1991.

8. WIPP-DOE-069, Rev. 5, TRU Waste Acceptance Criteria for the Waste Isolation Pilot Plant, April 1996.

9. Public Law 102-579, WIPP Land Withdrawal Act, October 30, 1992.

10. DOE/CAO-95-1121, U.S. Department of Energy Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report (BIR), Revision 3, December 1995.

11. Public Law 102-386, Federal Facility Compliance Act, U.S. Congress, 1992.

12. DOE/WIPP 91-058, Radionuclide Inventory for the Waste Isolation Pilot Plant, Rev. 0.

13. DOE Order 5480.21, Unreviewed Safety Questions, December 1991.

14. CFR (Code of Federal Regulations) 40, Part 261, Identification and Listing of Hazardous Waste.

15. ENV-003, Hazardous Stored TRU Waste Source Terms for the RWMC's TSA, 1990.

16. DOE/WIPP-91-005, Waste Isolation Pilot Plant RCRA Part B Permit Application, Revision 6, U.S. Department of Energy, Carlsbad, N.M. .

17. CAO-94-1010, Revision 0, Transuranic Waste Characterization Quality Assurance Program Plan, U.S. Department of Energy, Carlsbad, N.M., 1995.

18. DOE Order 5480.7A, Fire Protection, 02/17/93, U.S. Department of Energy, Washington, DC 20585.

19. DOE Order 5480.5, Safety of Nuclear Facilities, September 23, 1986.

20. WIPP Nuclear Criticality Safety Evaluation, July 1998.

21. DOE Order 5480.24, Nuclear Criticality Safety, August 12, 1992.

22. ANSI/ANS-8.1, Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors.

23. ANSI/ANS-8.3, Criticality Accident Alarm System.

24. ANSI/ANS-8.5, Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material.

25. ANSI/ANS-8.7, Guide for Nuclear Criticality Safety in the Storage of Fissile Materials.

26. ANSI/ANS-8.15, Nuclear Criticality Control of Special Actinide Elements.

27. ANSI/ANS-8.19, Administrative Practices for Nuclear Criticality Safety.

28. DOE Order 5480.22, Technical Safety Requirements, Change 1, September 15, 1992.

29. 29 CFR 1910.119, Process Safety Management of Highly Hazardous Chemicals.

30. WP 12-9, WIPP Emergency Management Program

31. PLG-1004, Waste Isolation Pilot Plant Human Factors Evaluation, July, 1994.

32. DOE-WID-96-2176, Revision 2, WIPP Fire Hazards Analysis Report, August, 1998.

33. PLG-1167, Analysis of Roof Falls and Methane Gas Explosions in Closed Rooms and Panels

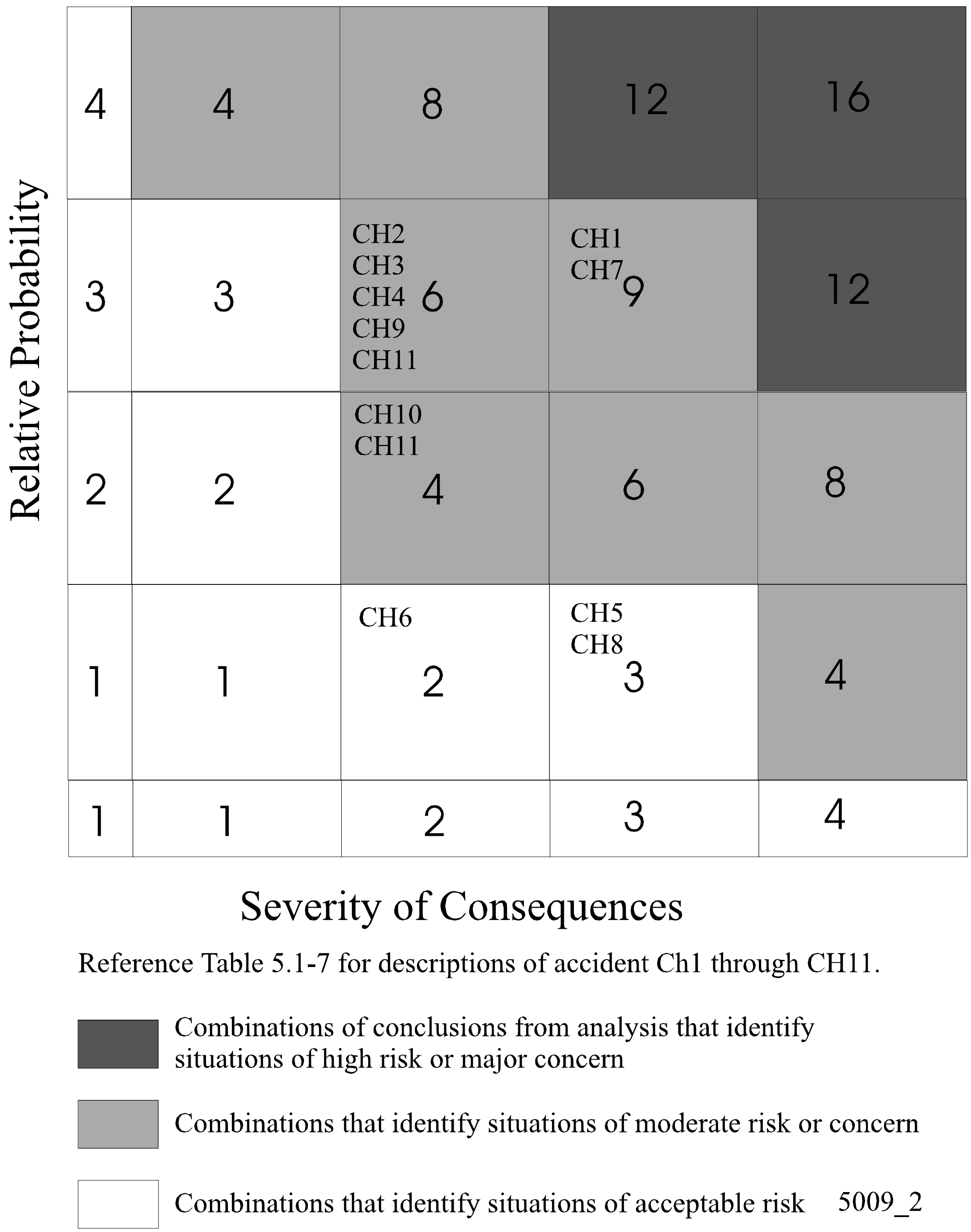


Figure 5.1-1, Relative Frequency and Consequence Ranking Matrix for Hazard Evaluation

Table 5.1-1, Maximum Hazardous Material Inventory by Facility Location

Hazard Type	Material Form	Location (Facility Process)	Inventory Number of Drums	or SWBs	Basis for Number of Drums/SWBs
WASTE HANDLING BUILDING					
Radioactive/ Nonradioactive Material	CH TRU Waste	CH Bay	196	28	7 Facility Pallets
				1	Derived Waste Storage - 1 SWB
		Shielded Holding	28	4	1 facility pallet
		Conveyance Loading Room	28	4	1 facility pallet
UNDERGROUND HORIZON					
Radioactive/ Non radioactive Material	CH TRU Waste	Waste Shaft Station	28	4	1 facility pallet
		Disposal panel	81,000	11,580	Total waste capacity/panel divided by waste container volume

Table 5.1-2, VOC Concentrations

Chemical	Weighted[1] Average (ppmv/mole gas)	Mole Fraction (1.0E-06 mole VOC/ppmv)	Moles gas/drum (moles gas)[4]	Molecular Weight (g/mole)	Unit Conversion 0.0022 lb/g (1.0E+03mg/g)	Drum Inventory[2] lb (mg)	SWB Inventory[3] lb (mg)
Methylene Chloride	368.5	1.0E-06	6.56	84.9	2.2E-03 (1.0E+03)	4.5E-04 (205.2)	1.81E-03 (820.9)
Chloroform	25.3	1.0E-06	6.56	119.4	2.2E-03 (1.0E+03)	4.36E-05 (19.8)	1.74E-04 (79.3)
1,1,2,2-Tetrachloroethane	9.4	1.0E-06	6.56	167.9	2.2E-03 (1.0E+03)	2.29E-05 (10.4)	9.11E-05 (41.4)
Carbon Tetrachloride	375.5	1.0E-06	6.56	153.8	2.2E-03 (1.0E+03)	8.36E-04 (378.9)	3.33E-03 (1,515.4)

Notes:

1. Data from DOE/CAO-96-2160, WIPP No Migration Variance Petition, June 1996 .

2. Drum Inventory = weighted average (ppmv VOC/mole gas) x mole fraction (1E-06 mole VOC/ppmv VOC) x moles gas/drum (6.56 moles gas at STP/drum) x molecular weight (g/mole VOC) x (2.2E-03 lb/g)

3. SWB Inventory =(4 drum equivalents) x (Drum Inventory)

4. Assumption: 70% void space in TRU waste drums
   55 gallons/drum at STP: air =0.01076 lbs/gallon; molecular weight air = 0.06372 lbs/mole
   Air moles/l = (0.01076 lbs/gallon)/(0.06372 lbs/mole) = 0.1703 mole/gallon
   Moles gas /drum = (0.70)(55 gallons/drum)(0.1703 mole/gallon) = 6.56 moles/drum

Table 5.1-3, Hazardous Material Concentrations Used in Fire Scenarios (CH1 and CH7)

Chemical	Average[1] Weight Fraction	Inventory - lbs (mg)[2] (Based on 243 lbs/drum)
Asbestos	2.7E-03	0.66 (3.0E+05)
Beryllium	2.1E-04	0.051 (2.3E+04)
Cadmium	3.0E-06	7.3E-04 (3.3E+02)
Lead	8.3E-03	2.00 (9.1E+05)
Butyl Alcohol	3.0E-03	0.73 (3.3E+05)
Carbon Tetrachloride	6.3E-03	1.52 (6.9E+05)
Mercury	3.5E-03	0.86 (3.9E+05)
Methyl Alcohol	8.0E-06	1.9E-03 (8.8E+02)
Methylene Chloride	4.0E-04	0.10 (4.4E+04)
Polychlorinated Biphenyl (PCB)	8.5E-03	1.98 (9.0E+05)
Trichlorethylene	3.9E-03	0.95 (4.3E+05)

Notes:

1. Data from Reference 15, Table 1. Data listed is average weight fraction of each hazardous material of the total drum weight. Sum will not add to unity, as other nonhazardous materials are within each drum.

2. Drum Inventory = (Weight Fraction) x (243 lbs/drum) [x (453.592 g/lb) x (1E+03 mg/g)]

Table 5.1-4, Total Rank Qualitative Consequence Classification Table

Consequence Category	Description
1	May cause facility worker injury as a result of an industrial accident or acute exposure from radiological or toxicological material with no lost time. Negligible offsite impact to people or environs. May result in facility contamination with no significant disruption of facility operation.
2	May cause facility worker injury as a result of an industrial accident or acute exposure from radiological or toxicological material with lost time and with no disability. Negligible offsite impact to people or environs. May result in facility contamination, or facility damage with minor disruption of facility operation.
3	May cause severe facility worker injury with disability. Minor offsite impact to people or environs. May result in facility contamination, or facility damage with major disruption of facility operation.
4	May cause deaths to facility workers. Considerable offsite impact to people and environs. Offsite contamination requiring cleanup, or facility destruction.

Table 5.1-5, Qualitative Relative Frequency Classification Table

Relative Frequency Category	Estimated Annual Frequency of Occurrence	Description
1 Beyond Extremely Unlikely	$10^{-6} \geq f$	All accidents not included in other categories. Frequency of less than once in a million years.
2 (Extremely Unlikely)	$10^{-4} \geq f > 10^{-6}$	Accidents that will probably not occur during the life cycle of the facility. This class includes the design basis accidents. Frequency between one in 10,000 years and once in 1,000,000 years.
3 (Unlikely)	$10^{-2} \geq f > 10^{-4}$	Accidents that are not anticipated to occur during the lifetime of the facility. Natural phenomena of this class include: Uniform Building code-level earthquake, 100-year flood, maximum wind gust, etc. Frequency between one in 100 years and once in 10,000 operating years.
4 (Anticipated)	$10^{-1} \geq f > 10^{-2}$	Incidents that may occur several times during the lifetime of the facility (incidents that commonly occur). Frequency is between one in 10 years and one in 100 operating years.

Table 5.1-6, Hazard Rank Qualitative Consequence Classification Table

Consequence Category	Description
1	May cause facility worker injury as an acute exposure from radiological or toxicological material with no lost time. Negligible offsite impact to people or environs. May result in facility contamination with no significant disruption of facility operation.
2	May cause facility worker injury as an acute exposure from radiological or toxicological material with lost time and with no disability. Negligible offsite impact to people or environs. May result in facility contamination, or facility damage with minor disruption of facility operation.
3	Minor offsite impact to people or environs. May result in facility contamination, or facility damage with major disruption of facility operation.
4	Considerable offsite impact to people and environs. Offsite contamination requiring cleanup, or facility destruction.

Table 5.1-7, HAZOP Accident Scenario Ranking Page 1 of 3

Accident	Scenario	# Node	Deviation	Consequence	Qualitative Consequence Ranking (Table 5.1-6)	Qualitative Frequency Ranking (Table 5.1-5)	Risk	Prevention/Mitigation
CH1	Fire/spontaneous ignition	07 TRUPACT II internal condition	Fire in TRUPACT II	Minor radioactive materials released	3	3	9	Prevention: Type A container, Waste container integrity, QA, Reinstall ICV lid, Building Construction, Stable drum history, TRUPACT II integrity, Vented drums, WAC criteria. Mitigation: Reinstall ICV lid, WHB HEPA filtration and fire suppression systems, Emergency response plan and teams.
CH2	Crane failure/breach	08 Transfer of payload from TRUDOCK to facility pallet	Failure of lifting equipment	Negligible radioactive materials released	2	3	6	Prevention: Type A container, Crane fail safe design, QA, Operator training & qualification, PM program, Procedures, Stretch wrapping, WAC criteria, Hoisting & rigging practices, two operators, pre-op checks, waste container integrity. Mitigation: Building Exhaust HEPA filtered, Emergency response plan and teams.
CH2	Crane failure/breach	08 Transfer of payload from TRUDOCK to facility pallet	Failure to secure load	Negligible radioactive materials released	2	3	6	Prevention: Type A container, Fail safe design, QA, Operator training & qualification, Preoperational checks on equipment, PM program, Procedures, Stretch wrapping, WAC criteria, Hoisting & rigging practices, Two operators, Waste container integrity. Mitigation: Building Exhaust HEPA filtered, Emergency Response Plan and teams .
CH3	Fork lift mishap/puncture	09 Transfer facility pallet to conveyance car	Fork lift improper engagement of load	Negligible radioactive materials released	2	3	6	Prevention: Forklift design, QA, Adequate lighting, Operator training & qualification, Pre-op checks, PM program, Procedures, Spotters, WAC criteria, Type A container, Drum integrity, Waste container integrity. Mitigation: Building Exhaust HEPA filtered, Emergency response plan and teams.
CH4	Fork lift mishap/breach	09 Transfer facility pallet to conveyance car	Moving accident	Negligible radioactive materials released	2	3	6	Prevention: Type A container, Operator training & qualification, PM program, Stretch wrapping, Spotters, Tie-down strapping, WAC criteria, Procedures, Pre-op checks, QA, Drum integrity, Waste container integrity. Mitigation: Building Exhaust HEPA Filtered, Emergency Response Plan and Teams.

Table 5.1-7, HAZOP Accident Scenario Ranking Page 2 of 3

Accident	Scenario	# Node	Deviation	Consequence	Qualitative Consequence Ranking (Table 5.1-6)	Qualitative Frequency Ranking (Table 5.1-5)	Risk	Prevention/Mitigation
CH4	Fork lift mishap/breach	09 Transfer facility pallet to conveyance car	Mislocation on the conveyance car	Negligible radioactive materials released	**2**	**3**	**6**	Prevention: Type A container, QA, Air lock doors interlocked, Local alarms, Operator training & qualification, Restricted access, Robust doors & walls, Stretch wrapping, Spotters, WAC criteria, Procedures, Tie-down strapping, Waste container integrity, PM program, Pre-op checks. Mitigation: HEPA filtration, Emergency response plan and teams.
CH4	Car/breach	10 Transfer conveyance car load onto the waste cage	Moving accident	Negligible radioactive materials released	**2**	**3**	**6**	Prevention: Type A container, QA, Operator training & qualification, Procedures, Stretch wrapping, Spotters, Strapped containers, WAC criteria, Waste container integrity, PM program, Pre-op checks. Mitigation: HEPA filtration, Emergency response plan and teams.
CH5	Hoist failure/breach	11 Waste hoist	Waste hoist drop	Minor radioactive materials released	**3**	**1**	**3**	Prevention: Brake testing, Cable NDT exams, Acoustics exam for failed parts, Control system has elevation check mechanisms, Four independent valve failures required to fail brakes, Brakes checked with full power, Catch gear, Cage fails up, Maintenance procedures & program, Mine rescue equipment, MSHA inspections, Preoperational checks, Qualified personnel, Redundant brakes & controls, Sump under shaft, Six hoist ropes each capable of holding load, inspections, Training and qualification, Weekly inspections, annual vendor inspection, visual inspection of structural steel assemblies, QA. Mitigation: HEPA filtration, Emergency response plan and teams.
CH6	Seismic	15 Natural events	Seismic event	No radioactive materials released	**2**	**1**	**2**	Prevention: Drum integrity, DBE qualified Class II and IIIA SSCs, TRUPACT II integrity, WAC criteria, Type A containers, QA. Mitigation: Shutdown procedure, Emergency response plan and teams.

Table 5.1-7, HAZOP Accident Scenario Ranking

Accident	Scenario	# Node	Deviation	Consequence	Qualitative Consequence Ranking (Table 5.1-6)	Qualitative Frequency Ranking (Table 5.1-5)	Risk	Prevention/Mitigation
CH7	Spontaneous ignition	27 Drum fire	Drum fire	Minor radioactive materials released	**3**	**3**	**9**	Prevention: Type A container, Waste container integrity, Reinstall ICV lid, Building Construction, Stable drum history, TRUPACT II integrity, Vented drums, WAC criteria. Mitigation: HEPA filtration, Emergency response plan and teams.
CH8	Crash/fire/breach	16 External events	Aircraft crashes into WHB	Minor radioactive materials released	**3**	**1**	**3**	Prevention: Flight patterns, Remote location. Mitigation: Emergency response plan and teams.
CH9	Fork lift mishap/breach	23 Life of facility	Floor distortion	Negligible radioactive materials released	**2**	**3**	**6**	Prevention: Drift inspections, Floor surveys, MSHA inspections, Forklift design, Type A containers, Procedures, Training. Mitigation: Ventilation flow, Emergency response plan and teams, HEPA filtration, .
CH10	Tornado	15 Natural events	Tornado	Negligible radioactive materials released	**2**	**2**	**4**	Prevention: CMR monitors weather conditions, DBT qualified Design Class II and IIIA SSCs, Drum integrity, Procedural guidance for personnel protection, TRUPACT II integrity, WAC criteria, Type A containers. Mitigation: Emergency response plan and teams.
CH11	Roof fall/breach	22 Storage room	Roof collapse during emplacement	Negligible radioactive materials released	**2**	**3**	**6**	Prevention: Inspections & assessments, Ground control, Mine instrumented and monitored, MSHA inspections, Predictive monitoring, Pre-emplacement checks, Type A containers, WAC, procedures, training. Mitigation: Emergency response plan and teams, HEPA filtration.
CH11	Roof fall	23 Life of facility	Roof collapse in life of facility area	Negligible radioactive materials released	**2**	**2**	**4**	Prevention: Floor surveys, MSHA inspections, Shift inspections, WAC criteria, Instrumentation and monitoring, Ground control, Bi-monthly visual and instrument inspections, Procedures, Training. Mitigation: Ventilation during emplacement, HEPA filtration, Emergency response plan and teams.

NOTE: **Accidents CH5, CH6, CH8, and CH11 were retained in the safety analysis due to being an external event, a natural event, or an event of significant interest.**

5.2 CH TRU Accident Analysis

This section quantitatively analyzes the postulated accident scenarios selected as discussed in Section 5.1.4. The selected accidents are considered “Derivative Design Basis Accidents,” (DBAs) as defined in DOE Standard 3009-94.[1] These derivative DBAs are used to estimate the response of WIPP systems, structures, and components (SSCs) to “the range of accident scenarios” that bound “the envelope of accident conditions to which the facility could be subjected” in order to evaluate accident consequences. The principal purpose of the accident analysis is to evaluate the derivative DBAs for the purposes of identifying safety (safety-class or safety-significant) SSCs and TSRs necessary to maintain accident consequences resulting from these derivative DBAs to within the accident risk evaluation guidelines. For the purposes of establishing safety SSCs, the consequences of these accidents are analyzed to a noninvolved worker conservatively assumed to be 100 meters from each release point, and to the MEI located at the WIPP Exclusive Use Area. An evaluation of operational accidents “beyond” the derivative design basis is conducted by evaluating the accident scenarios in response to the bounding conditions as derived from the WIPP Waste Acceptance Criteria (WAC). For simplicity, the term “derivative” is dropped for the remainder of this chapter; DBA refers to derivative DBAs.

DOE Standard 3009-94 states that use of a lower binning threshold such as 1E-06/yr is generally appropriate, but should not be used as an absolute cutoff for dismissing physically credible low frequency operational accidents without an evaluation of preventative or mitigative features. As such, DBAs identified in this section whose frequency are less than 1E-06/yr (beyond extremely unlikely), are also analyzed quantitatively for the sole purpose of providing a perspective of the risk associated with the operation of the facility. The results of these analysis are found in the respective accident evaluation in Section 5.2.3.

An assessment of immediate worker accident consequences is also conducted for the operational waste handling scenarios whose frequency is greater than 1E-06/yr (waste container breaches due to drop or impact), that may be initiated by waste handling equipment failure or directly through human error by a worker performing a waste handling operation. Again, accidents whose frequency is less than 1E-06/yr (beyond extremely unlikely) are also analyzed quantitatively in the respective accident evaluation in Section 5.2.3 for the sole purpose of providing a perspective of the risk to the immediate worker associated with the operation of the facility. The immediate worker is that individual directly involved with the waste handling operation for which the accident is postulated. As discussed in Sections 5.1.2.1.2 and 5.1.7, the assessment of immediate worker consequences will ensure that the maximum allowable radionuclide inventory, in conjunction with the other layers of defense-in-depth, will preclude worker exposure from being unacceptable.

The models and assumptions used in the analysis for determining the amount of radioactivity released to the environment and the extent of exposure to the MEI, noninvolved worker, and immediate worker are provided in the following sections. Activity releases to the environment are given for each postulated accident. Committed Effective Dose Equivalents (50 yr CEDE) were calculated for what are considered to be hypothetical individuals located: (1) MEI at the WIPP Exclusive Use Area boundary and off-site public at the site boundary (16 Section Boundary)), (2) noninvolved worker at 328 feet (100) m from each release point, and (3) immediate worker within the immediate area of the accident. The meteorological conditions under which these doses are evaluated are discussed in Section 5.2.1.

All radioactive material at the WIPP facility that has the potential to be released to the off-site environment (except contamination on the container surface) is contained within the waste container. Physical properties and assumptions for waste container inventories used in this analysis are presented in Section 5.1.2.

In evaluating hypothetical accidents, the level of conservatism in the safety analysis assumptions provide consequences which result in postulated releases that are overestimated rather than underestimated. The level of conservatism in each of the safety analysis variables is consistent with DOE-STD-3009-94 and its draft appendix. Although draft documents are not necessarily appropriate for reference in this SAR, the draft appendix provides reasonable guidance for consideration and use. The level of conservatism chosen provides reasonable assurance that when considering the variability in waste form, TRU activity content, and radionuclide distributions that: (1) the safety envelope of the facility is defined, (2) the design of the facility is adequate in response to the accident scenarios analyzed, and (3) the Technical Safety Requirements (TSRs) derived will provide for the protection of the public, the worker, and the environment.

Based on the results of the HAZOP, operational events are binned into two major accident categories, fire and breach of waste container. Since breach of waste containers may occur due to drop or vehicle impact, accidents involving both of these breach mechanisms are evaluated. Accidents involving waste container drops are further evaluated based on the energy involved due to drop height. Due to the differences in release and dispersion mechanisms possible, accidents of each category are evaluated in the above ground and underground areas of the facility. Operational, Natural and External initiating events that require further evaluation as determined by the hazard analysis are listed below.

1. Operational Events

Fires

- CH1 Spontaneous Ignition (Drum) in the WHB
- CH7 Spontaneous Ignition (Drum) in the Underground

Waste Container Breaches

- CH2 Crane Failure in the WHB
- CH3 Puncture of Waste Containers by Forklift in the WHB
- CH4 Drop of Waste Containers by Forklift in the WHB
- CH5 Waste Hoist Failure
- CH9 Drop of Waste Containers by Forklift in the Underground
- CH11 Underground Roof Fall

2. Natural Events

   - CH6 Seismic Event

   - CH10 Tornado Event

3. External Events

   - CH8 Aircraft Crash

5.2.1 Accident Assessment Methodology

5.2.1.1 Noninvolved Worker and MEI Accident Assessment Methodology

Receptors

A hypothetical maximally exposed individual (MEI) located at the Exclusive Use area (Figure 5.2-1) was selected for the accident-related consequence assessment. Review of the WIPP Land Management Plan[2] indicates that public access to the WIPP 16-section area up to the exclusive use area shown in Figure 5.2-1 is allowed for grazing purposes, and up to the DOE off limits area "for recreational purposes. Although analysis are traditionally conducted for an MEI at the facility site boundary, in accordance with DOE Order 6430.1A, Section 1300-3.2,[3] the location of the MEI is located at the "closest point of public access," or the DOE exclusive use area. The location of the MEI is also consistent with Appendix D9 of DOE/WIPP-91-005, Waste Isolation Pilot Plant RCRA Part B Permit Application, Revision 6, U.S. Department of Energy, Carlsbad, N.M.[55] Calculations are also performed at the site boundary for reference purposes.

Although prevailing winds are towards the northwest at the WIPP Site, the closest distance to the exclusive use area (without regard to direction) from the exhaust shaft vent and the WHB vent was used in the dose assessment calculations. The closest distance to the exclusive use area boundary from the exhaust shaft vent lies south at approximately 935 feet (285 meters) and the closest distance to the exclusive use area boundary from the WHB lies southeast at approximately 1150 feet (350 meters) (Figure 5.2-2).

The noninvolved worker is assumed to be a worker not directly involved with the waste handling operation for which the accident is postulated. The maximally exposed noninvolved worker is assumed to be located at a distance of 328 feet (100 meters) from each release point due to the restrictions on dispersion modeling at close-in distances.

Source Term Methodology

The following equation from *DOE Handbook 3010-94, Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities,*[5] reflects the calculation for source term:

Q = MAR * DR * ARF * RF * LPF

where:

Q	=	The Source Term (Ci or mg)
MAR	=	Material At Risk - The maximum amount and type of material present that may be acted upon with the potentially dispersive energy source (Ci or mg).
DR	=	Damage Ratio - The DR is that fraction of the MAR actually impacted by the accident condition.
ARF	=	Airborne Release Fraction - The fraction of that radioactive material actually impacted by the accident condition that is suspended in air.
RF	=	Respirable Fraction - Fraction of the airborne radioactive particles that are in the respirable size range, i.e. less than 10 μm in aerodynamic equivalent diameter.
LPF	=	Leakpath Factor - The LPF is the cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident.

The quantity MAR is calculated as the quantity (CI * CD), where CI is the waste container radiological or nonradiological inventory, CD is the number of containers damaged by the accident phenomenon (e.g., number of drums breached).

The resulting equation is:

$$Q = CI * CD * DR * ARF * RF * LPF \qquad (5\text{-}1)$$

Each of the source term variables are a function of the accident phenomenon under consideration and are derived in the following discussions. The level of conservatism in each of the safety analysis variables is consistent with DOE-STD-3009-94[1] and its draft appendix.

Waste Container Radiological and Nonradiological Inventories (CI) and Containers Damaged (CD)

The source term equation radiological CI used in the accident analyses, is based on the waste characterization analyses in Section 5.1.2. DOE-STD-3009-94[1] and its draft appendix state that the source term material at risk (MAR = CI * CD) should "represent a reasonable maximum for" a given process or activity, as opposed to artificial maximums unrepresentative of actual conditions. Additionally, Section A.3.1 of the draft appendix to DOE-STD-3009-94, states that documentation may be used to "back off" of bounding estimates of the MAR. Consistent with this statement, based on the data found in Appendix A (as discussed in Section 5.1.2.1), since CH TRU waste operations accidents may result in more than one container damaged in a postulated accident (CD > 1), for safety analysis calculation purposes it is conservatively assumed that one waste container contains the maximum radionuclide inventory and the remaining waste containers each contain an average radionuclide inventory. As described in Section 5.1.2.1, the maximum drum radionuclide inventory that is not solidified, vitrified, or overpacked is 80.0 PE-Ci, and the maximum SWB radionuclide inventory that is not solidified, vitrified, or overpacked is 130 PE-Ci. For accident scenarios which involve single waste containers (CD = 1), it is conservatively assumed that the waste container contains the maximum radionuclide inventory. The value CD is determined in each specific accident scenario.

As discussed previously, two major types of accident scenarios are identified for quantitative analysis: (1) internal waste container fire as a result of spontaneous ignition, and (2) waste container breaches from drops or waste handling equipment impacts. The waste forms defined in the BIR were examined to determine the types most susceptible to these types of scenarios. For internal waste container fire scenarios, combustible waste is defined as consisting of paper, kimwipes, and cloth (dry and damp); various plastics such as polyethylene and polyvinyl chloride; wood; and filters contaminated with trace quantities of halogenated organic solvents; and noncombustibles as sludges, filters, asphalt, soil, glass, metal, and others. Therefore, it is conservatively assumed that a spontaneous ignition occurs in a waste container classified as containing combustible waste, with a 95 percent combustible and 5 percent noncombustible content. Since the sustained waste container fire is assumed to occur in a single waste container (CD=1), the CI for the spontaneous ignition scenarios is 80 PE-Ci for drums.

For waste container breach scenarios resulting from drops or impacts, the accident is characterized by a sharp impact to the waste container and damage to the waste container, followed by an airborne release of radioactivity due to shock/vibration effects. The waste forms defined in the BIR were examined to determine the types most susceptible to waste container breach scenarios. Based on DOE-HNDBK-3010-94*, DOE Handbook, Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities,*[5] noncombustible waste forms that have a hard, unyielding surface and do not undergo brittle fracture are the most susceptible to the airborne release of radioactivity in highly respirable form due to shock/vibration effects. Although DOE-HNDBK-3010-94 bounding airborne release fraction for combustible and noncombustible waste is the same (1E-03), the respirable fraction is higher for noncombustibles (1.0) than for combustibles (0.1). Therefore, it is conservatively assumed that the breach accident scenarios occur with waste containers classified as containing noncombustible uncategorized metal waste, with a 95 percent noncombustible and 5 percent combustible content.

Uncategorized metal waste is chosen for drop and impact scenarios due to: (1) the relatively high waste volume (approximately 18.5 percent) of the total waste volume, and (2) the combustible/noncombustible fractions from the definition of the waste form in the BIR. Although heterogeneous waste has the highest projected volume (approximately 40 percent), based on the definitions in the BIR, uncategorized metal waste has the highest potential fraction of noncombustible waste (95 percent), and is therefore more conservative for use in accident analysis calculations.

As discussed in Section 5.1.2.1.2, since the breach scenarios may damage multiple waste containers, one CI is assumed to be at the maximum (80 PE-Ci drums, 130 PE-Ci SWBs), and the remaining waste containers contain an average of 8 PE-Ci each for drums, and 32 PE-Ci for SWBs (4 drum equivalents). The average values are obtained from Table A-1 for all waste streams reported as uncategorized metals (over 96 percent of the volume of this waste form has an average less than 8 PE-Ci each). Over 86 percent of the volume of all waste forms have average TRU concentrations of less than 8 PE-Ci/drum, including the predominant heterogeneous, uncategorized metal, and combustible waste forms.

Based on the data in Table A-1, use of the above values for CI and combustible/noncombustible fractions provides reasonable assurance of obtaining bounding consequences in the spontaneous ignition and waste container breach accident consequence analysis.

The nonradiological CI development process for events which involve a breach of a waste container is simplified by assuming that 100 percent of the VOC headspace inventory is released instantaneously. VOCs selected for consideration for accidental releases are listed in Table 5.1-2. These values were scaled for estimating concentrations in the SWBs based on container volumes.

Solid and liquid chemical concentrations that would be expected to be within a waste container during a spontaneous ignition of a waste container are listed in Table 5.1-3. Radiological and chemical source terms (chemical solids/liquids used in the CH1 and CH7 scenarios) developed for specific accidents are estimated using Equation 5-1.

Damage Ratio (DR)

Based on the discussion in Section A.3.3 of the draft appendix of DOE-STD-3009-94,[1] realistic values are acceptable for estimation of the DR. For internal waste container fire (as a result of spontaneous ignition), it is assumed that sufficient internal pressure is generated as a result of the accident phenomenon to cause a breach of the waste container. As a result of the airborne release generated by the fire phenomenon, it is assumed that the DR for this scenario is 1.0 (DR=1.0).

For waste container breaches from drops or waste vehicle impacts (punctures), three specific accident conditions are "realistically" examined: (1) drops of waste containers from heights greater than 4 ft, but equal to or less than 5 ft (4 ft $< h \leq$ 5 ft) (associated with drops from forklifts); (2) drops of waste containers from heights equal to or less than 10 ft (5 ft $< h \leq$ 10 ft)(associated with drops as a result of crane failure, or drops from the second and third layers of the underground waste disposal stack); and (3) impacts (punctures) from slow speed waste handling vehicles or equipment (forklifts).

The upper limit for which waste drums are certified (DOT Type A or equivalent) to not release any of their solid waste form contents is four feet. The DR from drops of waste containers from less than or equal to four feet is zero (DR=0). Tests performed on Type A packaging[6,7,8,9] and their simulated contents provides the data used to estimate damage to the waste containers from heights greater than four feet (from the conditions discussed above), and assign an estimated DR. Since the conditions associated with the accident scenarios analyzed for the WIPP (such as drums dropped in a stretch wrapped seven-pack configuration and tied down to a facility pallet or overpacked waste containers), differ from those in the relatively small amount of well-documented tests, some amount of engineering judgement is used in applying the test data in assigning the DR for WIPP breach scenarios. However, the approach is to apply the data conservatively for the analyzed accident conditions.

For drops greater than four feet, estimates of waste container damage and DR (as a function of drop height), are based on the analysis (provided in PLG-1121, *Damage Assessment of Waste Containers Involved in Accidents at the Waste Isolation Pilot Plant*)[10] of waste container weight and drop kinetic energy, impact kinetic energy (for waste handling equipment impacts and underground roof falls), and the comparison of the analyses results to the available test data.[6,7,8,9] Based on the overall test data, "light" drums (empty $<$ weight $\leq$ 400 lbs), are shown to deform less readily than heavy drums (600 lbs $<$ weight $\leq$ 800 lbs). Based on the average waste form densities found in the BIR, drums containing uncategorized metals, heterogeneous, and combustible waste are assumed to be "light" drums. Solidified waste forms contained within other waste containers such as drums, are assumed to be "heavy" waste containers. The DRs provided in Section 4 of PLG-1121 are based on tests of Type 17H waste containers conducted by Westinghouse Hanford Company (WHC).[9] These tests were performed with drums having a gross weight of 1,000 lbs (heavy drums). Consistent with the deformation test results discussed above, based on engineering judgement, the DR for light waste containers is assumed to be less that the DR for heavy waste containers. As such, the application of DRs derived from tests using heavy drums, in this safety analysis, for the light drums containing uncategorized metal waste is considered sufficiently conservative to encompass the uncertainty in the application of the test data to WIPP scenarios.

Other analyzed waste containers (standard waste boxes, and overpack containers (TDOPs, 85-gallon drum overpacks)) are also assumed to be "heavy" waste containers. However, as discussed in Section 2.2 of PLG-1121, primarily due to the robustness of the design of the SWB, no loss of contents were reported in 15-ft and 25-ft drop tests.[6] As such, based on engineering judgement, the DR for SWBs and overpack containers is assumed to be slightly less than the DR for heavy waste containers (as a function of drop height) in each evaluation in the following paragraphs.

For drops of multiple Type A waste containers associated with typical forklift waste handling operations, drops are considered to occur from a height of greater than 4 ft, and less than or equal to 5 ft. This height range is associated with the height the forklift tines are above the ground, plus the height from a fall of the top waste containers that are stacked two high (as on a facility pallet). Based on analysis,[10] it is considered by engineering judgement that the DR for releases from drops of waste containers from heights less than or equal to 5 ft is less than 0.01 (DR $<$ 0.01). However, it is conservatively assumed, to encompass the uncertainty in the application of test data and the variation in waste forms, that the DR for Type A drums (or equivalent) in this class of accident is 0.01 (DR=0.01), and the DR for SWBs and overpack containers is 0.001 (DR=0.001).

For drops of waste containers from the heights associated with crane failure, or drops from the third layer of the waste stack (from heights greater than 5 ft, and equal to or less than 10 ft ($5 \text{ ft} < h \leq 10 \text{ ft}$)), based on analysis,[10] it is conservatively assumed, to encompass the uncertainty in the application of test data and the variation in waste forms, that the DR for Type A drums (or equivalent) in this class of accident is 0.025 (DR=0.025), and the DR for SWBs and overpack containers is 0.01 (DR=0.01).

For the waste hoist accident scenario which involves a waste container drop of over 2,000 ft, it is conservatively assumed that complete lid/body separation occurs resulting in a bounding DR of 0.25 for drums, SWBs, overpack containers, and pipe overpack payload containers.

For all drops involving pipe containers in 55-gallon (208 L) drums (pipe overpack payload containers) from heights less than 11 ft, due to the robust design and drop test results,[12] the DR for this waste container is assumed to be zero (DR=0.0). The pipe overpack payload container test program demonstrated the capability of the pipe container to maintain structural integrity after hypothetical accident 30-foot drop tests.[12] No loss of containment in any impact drop test occurred.

For scenarios involving the breach of waste containers due to impact with waste handling equipment, the kinetic energy associated with slow moving waste handling equipment (primarily forklifts) was evaluated[10] to determine the level of waste container damage when compared to test data. Additionally, breaches due to forklift tine impact are evaluated based on the current WIPP forklift tine design. Based on the analyses[10] of the speeds expected during waste handling and resulting possible breach mechanisms, it is considered by engineering judgement that, to encompass the uncertainty in the application of test data and the variation in waste forms, the DR for Type A drums (or equivalent) in this class of accident is 0.05 (DR=0.05), and the DR for SWBs and overpack containers is 0.01 (DR=0.01).

For drums containing noncombustible solids "overpacked" in a SWB or overpack container, the DR for drops is determined by the algorithm provided in Table D.3.17 of the Final Supplement Environmental Impact Statement.[13] The assumption is that material is released in two stages: (1) release from the internal container (drum) due to breach from the impact, into the outer container (SWB or overpack containers), and (2) release from the interior of the SWB or overpack container to the environment from damage to the SWB or overpack container during the impact event. The algorithm models this type of a release as a product of the DR for each respective waste container. For drops that are considered to occur from a height of greater than 4 ft, and less than or equal to 5 ft, it is conservatively assumed that the DR is the product of the DR for drums and SWBs/overpack containers for this class of accident scenario, or (0.01)(0.001) or (DR=1E-05). For drops of overpacked waste containers from the heights associated with crane failure, or drops from the waste stack, the DR is conservatively assumed to be the product of the DR for drums and SWBs/overpack containers for this class of accident scenario, or (0.025)(0.01) or DR=2.5E-04.

For drums containing noncombustible solids "overpacked" in a SWB or overpack container, the DR for punctures is conservatively estimated based on the damage assessment[10] for single waste containers due to impact or puncture events. It is assumed that the combined drum and SWB/overpack container wall thickness reduces the penetration velocity, resultant damage, and thus DR for puncture events. As discussed above, the puncture DR for individual Type A drums (or equivalent) is 0.05 (DR=0.05), and the DR for SWBs and overpack containers is 0.01 (DR=0.01). It is therefore considered conservative that the puncture DR for waste drums "overpacked" in a SWB or overpack container is 0.01 (DR=0.01).

Airborne Release (ARF) and Respirable (RF) Fractions

Based on the discussion in Section A.3.2 of the draft appendix of DOE-STD-3009-94,[1] bounding values for the Airborne Release Fractions and the Respirable Fractions are utilized based on *DOE Handbook, Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities*.[5] The ARF for the burning of contaminated combustible materials in a waste container is 5.0E-04 and the airborne release fraction for noncombustible materials in a drum is 6.0E-03. These values represent bounding airborne release fractions for the burning of contaminated packaged mixed waste and the heating of noncombustible contaminated surfaces (DOE-HDBK-3010-94, subsection 5.2.1.1 and 5.3.1).[5] The bounding RFs for the burning of contaminated packaged mixed waste and the heating of noncombustible contaminated surfaces are 1 and 1.0E-02, respectively (DOE-HDBK-3010-94, subsection 5.2.1.1 and 5.3.1).[5]

The ARF for contaminated combustible materials which are subjected to impact and breach of the waste container is 0.001. This value represents a bounding ARF for packaged material in a container which fails due to impact (DOE-HDBK-3010-94, subsection 5.2.3.2).[5] The bounding RF applied to airborne combustible material released due to impact is 0.1 (DOE-HDBK-3010-94, subsection 5.2.3.2).[5] Therefore, the ARF and RF for combustible waste forms are conservatively applied to the combustible fraction of material for accident consequence analyses for the waste container impact or drop scenarios.

The ARF for contaminated noncombustible materials which are subjected to impact and breach of the waste container for solids that do not undergo brittle fracture is 0.001. This value represents a bounding ARF for packaged material in a container which fails due to impact (DOE-HDBK-3010-94, subsection 5.3.3.2.2).[5] The bounding RF for contaminated noncombustible materials which are subjected to impact and breach of the waste container is 1.0 (DOE-HDBK-3010-94, subsection 5.2.3.2).[5] Therefore, the ARF and RF for noncombustible waste forms are conservatively applied to the noncombustible fraction of material for accident consequence analyses for the waste container impact or drop scenarios.

The ARF x RF for solids that undergo brittle fracture (e.g. aggregate, glass) due to crush-impact forces is given by Equation 5-1 of DOE-HDBK-3010-94. Applying this equation for solidified waste forms to the drop of waste container from heights equal to or less than 10 ft ($5 \text{ ft} < h \leq 10 \text{ ft}$), the calculated ARF x RF = 1.64E-05. Comparing this factor with that obtained for contaminated noncombustible materials which are subjected to impact and breach of the waste container for solid that do not undergo brittle fracture, solidification offers a two order magnitude reduction in respirable airborne radioactive material for the scenarios analyzed in this SAR. A summary of the values for DR, ARF, and RF, and their overall products for waste container breach scenarios is as follows:

Waste Form	DR	ARF	RF	Overall Product
Combustible Solids (95%), drops less than 5 ft (drums)	1E-02	1E-03	1E-01	1E-06
Combustible Solids (95%), drops less than 5 ft (SWBs/overpack containers)	1E-03	1E-03	1E-01	1E-07
Combustible Solids (95%), drops less than 10 ft (drums)	2.5E-02	1E-03	1E-01	2.5E-06
Combustible Solids (95%), drops less than 10 ft (SWBs/overpack containers)	1E-02	1E-03	1E-01	1E-06
Noncombustible Solids (95%), drops less than 5 ft (drums)	1E-02	1E-03	1.0	1E-05
Noncombustible Solids (95%), drops less than 5 ft (SWBs/overpack containers)	1E-03	1E-03	1.0	1E-06
Noncombustible Solids (95%), drops less than 10 ft (drums)	2.5E-02	1E-03	1.0	2.5E-05
Noncombustible Solids (95%), drops less than 10 ft (SWBs/overpack containers)	1.0E-02	1E-03	1.0	1.0E-05
Noncombustible Solids (95%), vehicle impact and puncture (drums)	5E-02	1E-03	1.0	5E-05
Noncombustible Solids (95%), vehicle impact and puncture (SWBs/overpack containers)	1E-02	1E-03	1.0	1E-05
Solidified Solids, drops less than 10 ft (SWBs/overpack containers)	1E-02	1.6E-05	----	2E-07

Solidified Solids, vehicle impact and puncture	1E-02	1.6E-05	---	2E-07
Overpacked Noncombustible Solids, (95%) drops less than 5 ft (drum within SWB or overpack container)	1E-05	1E-03	1.0	1E-08
Overpacked Noncombustible Solids, (95%) drops less than 10 ft (drum within SWB or overpack container)	2.5E-04	1E-03	1.0	2.5E-07
Overpacked Noncombustible Solids (95%), vehicle impact and puncture	1E-02	1E-03	1.0	1E-05
Noncombustible Solids (95%), drops of 2000 ft (waste hoist)	2.5E-01	1E-03	1.0	2.5E-04

Leakpath Factor (LPF)

Specific source terms for the postulated accident scenarios described in the accident analysis represent the total amount of respirable radioactive material released to the environment from a postulated accident. The Leak Path Factor (LPF) for WIPP accident scenarios is that fraction of the airborne material released in the WHB that is not filtered out by the permanently installed continuously on-line two-stage HEPA filtration systems, or for underground releases, by the underground exhaust HEPA filtration systems when shift to filtration is actuated manually or automatically. Based on the discussion in Section A.3.3 of the draft appendix of DOE-STD-3009-94,[1] <u>realistic</u> values are acceptable for estimation of the LPF. The amount of material removed from the air due to the HEPA filters is predicted based on decontamination factors. Decontamination factors (DF) have been predicted for accident conditions in ERDA Nuclear Air Cleaning Handbook.[37] Based on the handbook, a DF of 5.0E+02 for the first stage and 2.0E+03 for the second stage are recommended. Therefore the total DF used in this analysis for both stages of filtration is 1.0E+06. The leakpath factor is considered as 1.0E-06 for the mitigated case, and 1.0 for the no-mitigation case.

Dispersion Modeling Methodology

Nuclear Regulatory Guide (NRG) 1.145,[14] "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," Revision 1, November 1982, was used to model the accidental releases from the WIPP underground exhaust shaft and the Waste Handling Building. NRG 1.145[14] provides an NRC acceptable methodology to determine site-specific relative concentrations, χ/Qs, as a result of accidents. The model reflects experimental data on diffusion from releases at ground level at open sites and from releases at various locations on reactor facility buildings during stable atmospheric conditions with low wind speeds.

Two type of release models are provided in NRG 1.145:[14] (1) releases through vents or other building penetrations; and (2) stack releases. All release points or areas that are effectively lower than 2.5 times the height of adjacent solid structures are considered nonstack releases. Release points that are at levels 2.5 times the height of adjacent solid structures or higher are considered stack, or elevated releases. Therefore, applying this criteria to the WIPP exhaust shaft and the Waste Handling Building the releases are considered as nonstack releases.

Although the criteria provided in the NRG 1.145[14] suggest a nonstack release, both stack and vent (nonstack) models were evaluated to determine the differences in the dispersion coefficients. The Atmospheric Dispersion Code, GXQ 3.1, described in "Westinghouse Hanford Corporation Support Document," WHC-SD-GN-SWD-30002, Revision 0, June 8, 1993,[15] incorporates the equations used in NRG 1.145[14] and was utilized to evaluate the different models and how they affected the dispersion coefficients. Multiple variations of the models for stack and ground level releases were analyzed with GXQ using various wind speeds and stabilities. However, a ground level release considering a constant wind speed of 4.9 ft/s (1.5 m/s) and stability F resulted in larger dispersion coefficients to the receptors of concern which would represent a vent release. These conditions were assumed to prevail for the duration of the accidental release. Therefore, for determining the consequences from the result of postulated accidental releases from the underground or the Waste Handling Building, the following were utilized:

1. NRG 1.145, Releases through Vents or Other Building Penetrations (NRG 1.145, Section 1.3.1)[14] vent release models

2. Pasquill-Gifford-Turner horizontal and vertical diffusion coefficients (GXQ Manual Section 3.1)[15]

3. Atmospheric Conditions:

   - Stability F, 4.9 ft/s (1.5 m/s) (wind speed and stability are assumed to remain constant in the direction of the receptor)

4. Dimensions (smallest cross section) of the filter building and the Waste Handling Building:

   - Filter Building - 23 feet (7 m high), 88.6 feet (27 m) wide

   - Waste Handling Building - 63 feet (19.2 m) high, 157 feet (47.8 m) wide

As recommended by the NRG 1.145 Guide,[14] χ/Q values were calculated using equations 5-2, 5-3, and 5-4 below. The values from equations 5-2 and 5-3 were compared and the higher value selected. This value was compared with the value from equation 5-4, and the lower value of these two was selected as the appropriate χ/Q value. Examples and a detailed explanation of the rational for determining the controlling conditions are given in Appendix A of the NRG 1.145 Guide.[14]

Consistent with DOE-STD-3009-94[1] and its draft appendix, the values for atmospheric conditions: Stability F, 4.9 ft/s (1.5 m/s) (wind speed and stability are assumed to remain constant in the direction of the receptor), were chosen due to the lack of reliable recorded WIPP specific meteorology data. Future SAR annual updates will include this analysis when data becomes available.

Equation $$\chi/Q = \frac{1}{U_{10}(\pi\sigma_y\sigma_z + \frac{A}{2})} \quad \textbf{(5-2)}$$

Equation $$\chi/Q = \frac{1}{U_{10}(3\pi\sigma_y\sigma_z)} \quad \textbf{(5-3)}$$

Equation $$\chi/Q = \frac{1}{U_{10}\pi\Sigma_y\sigma_z} \quad \textbf{(5-4)}$$

where:

- χ/Q is relative concentration, in sec/m^3. χ/Q (328 ft [100 m])=5.11E-03; χ/Q (935 ft [285 m])=8.43E-04; χ/Q (1150 ft [350 m])=5.96E-04.
- π is 3.14159
- U_{10} is wind speed at 33 feet (10 meters) above plant grade, in m/sec. (assumed 4.9 ft/s [1.5 m/sec.])
- σ_y is lateral plume spread, in meters, a function of atmospheric stability and distance (class F stability). σ_y (328 ft [100 m])=4.6; σ_y (935 ft [285 m])=11.9; σ_y (1150 ft [350 m])=14.3; σ_y (2625 ft [800 m])=30.2
- σ_z is vertical plume spread, in meters, a function of atmospheric stability and distance (class F stability). σ_z (328 ft [100 m])= 2.3; σ_z (935 ft [285 m])=5.3; σ_z (1150 ft [350 m])=6.2
- Σ_y is the lateral plume spread with meander and building wake affects, in meters, as a function of atmospheric stability, wind speed U_{10}, and distance (for distances of 2625 ft [800 meters] or less), $\Sigma_y = M\sigma_y$, for distances greater than 2625 feet [800 meters], $\Sigma_y = (M-1)\sigma_{y\,800m} + \sigma_y$, where M=4 determined from Figure 3 of NRG 1.145.[14]
- A is the smallest vertical-plane cross sectional area of building, in m^2.

Appendix A of NRG 1.145[14] contains a rationale section which indicates that the equations used in NRG 1.145[14] provide an assessment of atmospheric diffusion, including the effects of building wake mixing that occur during moderate wind speed conditions (>10 ft/sec [3 m/sec]). The equations have been found to provide estimates of ground-level concentrations that are consistently too high during light wind and stable or neutral atmospheric conditions for 1-hour release durations. Consequently the use of these equations in the modeling of the effluent under light wind (4.9 ft/sec [1.5 m/sec]) and stable atmospheric conditions (F-Class) provides built-in conservatism.

Consequence Methodology

Consequence assessment calculations are determined for the: (1) MEI located at the Exclusive Use Area boundary and (2) noninvolved worker (328 ft [100 m]) for releases from the WHB vent and the exhaust shaft vent. Atmospheric transport is the only significant release and exposure pathway during normal operations and accident conditions during the disposal phase. Based on the site characteristics information in Chapter 2, surface water and groundwater transport from normal or accidental releases of radioactive material is not considered likely. Human exposure pathways from the airborne radioactive material include inhalation, air immersion, ingestion, and ground-shine. Radiological dose consequences are calculated assuming the inhalation pathway in CEDE and are calculated using Equation 5-5. External (ground-shine and air immersion) and ingestion dose calculations are not performed due to their minimal contribution to the Total Effective Dose Equivalent (TEDE), therefore CEDE will be reported as the dose consequences for each of the accidents evaluated. The calculated dose in CEDE is then compared to the noninvolved worker and MEI radiological risk evaluation guidelines discussed in Section 5.2.2 (Tables 5.2-1a and 5.2-1b). For nonradiological consequence calculations, the chemical concentration at the MEI (935 ft [285 m]) and noninvolved worker (328 ft [100 m]) in mg/m^3 is calculated using Equation 5-6 for comparison with the nonradiological risk evaluation guidelines discussed in Section 5.2.2 (Table 5.2-2).

Detailed spreadsheets for the source term and consequence calculations for each postulated accident are found in Appendix E and summarized in Tables 5.2-3 and 5.2-4. To assess the potential releases of radiological and nonradiological material the following equations were utilized:

Radiological Releases

$$D = Q * \chi/Q * BR * DCF \qquad (5\text{-}5)$$

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological Source Term (Ci) (Appendix E)χ/Q
χ/Q = Atmospheric dispersion coefficients calculated for specific distances (s/m^3). χ/Q (328 ft [100 m])=5.1E-03s/m^3; χ/Q (935 ft [285 m])=8.43E-4s/m^3; χ/Q (1150 ft [350 m])=5.96E-04 s/m^3
BR = Breathing rate (standard man) (m^3/s) International Commission on Radiological Protection (ICRP) No.23[16] (Light activity 5.3 gallons/min [20.0 liters/min or 3.33 E-04 m^3/s]
DCF = Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public[17] (Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.10E+08 rem/Ci)

Chemical Releases

$$C = (Q * \chi/Q)/RR \qquad (5\text{-}6)$$

where:

C = Concentration (mg/m^3)
Q = Chemical Source Term (mg) (Section 5.1.2 and Tables 5.1-2 and 5.1-3)
RR = Release Rate [VOC releases assumed an instantaneous (1 sec) fire within a drum assumed release duration (900 sec)]
χ/Q = Atmospheric dispersion coefficients calculated for specific distances (s/m^3). χ/Q (328 ft [100 m])=5.1E-03s/m^3; χ/Q (985 ft [285 m])=8.43E-4s/m^3; χ/Q (1150 ft [350 m])=5.96E-04 s/m^3

Frequency Determination Methodology

The methodology for verifying the annual occurrence frequencies, qualitatively estimated in the HAZOP, of operational initiating events is based on the evaluation of process inherent events (spontaneous ignition), equipment failures, and human error. Section 5.2.3 and Appendix D contain the detailed assessment of occurrence frequencies of the accidents evaluated. Table D-1 presents the estimated occurrence frequencies for process events, equipment failures, and human errors, based on existing references and engineering judgement. The table provides cross references to documents from other DOE sites with similar operations, and from generic industry data bases that have been judged to be applicable and appropriate for use in WIPP accident scenarios.

Equipment failure rates and human error probabilities were combined with WIPP specific operational data to obtain WIPP specific initiating event occurrence frequencies. The individual scenario is discussed in Section 5.2.3, and the supporting detailed event tree/fault tree analysis for each postulated accident is included in Appendix D. The table and figures in Appendix D document the analysis of failure of associated preventative and mitigative systems and develops the annual occurrence frequency for both mitigated and no-mitigation accident sequences.

The annual occurrence frequencies derived from the event tree/fault tree analysis are not intended to represent detailed probabilistic calculations requiring sensitivity or uncertainty analysis. Rather, they are used to provide reasonable assurance that each scenario's accident frequency is in a specific qualitative frequency range (i.e. extremely unlikely) or “bin”for the purposes of selecting an appropriate risk evaluation consequence guideline.

To estimate the occurrence frequencies, logic models were used to describe combinations of failures that can produce a specific failure of interest (TOP event). The logic is developed and explained in Section 5.2.3 and Tables D-2 through D-20 of Appendix D. The basic events documented in Table D-1 provide specific component failure or human error rates which provide input to the logic model to calculate the frequency of the TOP event. Logical AND (*) or OR (+) functions (gates) are used to show how events can combine to cause the TOP event. The TOP event is quantified in the top row of the appropriate table, with the equation delineating the logic by which it was developed and any necessary comments. Each contributor to that equation is then developed in subsequent rows, using` references as necessary to the basic events documented in Table D-1 to complete the line of reasoning.

For the purposes of establishing safety (safety-class or safety-significant) preventative and mitigative SSCs, an iterative process is performed. The safety (safety-class or safety-significant) iterative process (see Section 3.1.3) initially involves comparing the “no-mitigation” accident consequences to the MEI and noninvolved worker (with associated “no-mitigation” accident frequency from the event tree analyses in Appendix D) to the off-site and on-site risk evaluation guidelines respectively. The process is continued taking credit for additional preventative/mitigative SSCs until the risk evaluation guidelines are met. Systems required to keep estimated consequences below the risk evaluation guidelines are designated as safety (safety-class or safety-significant) SSCs.

5.2.1.2 Immediate Worker Accident Assessment Methodology

The assessment of the immediate worker accident consequences is based on the evaluation of operational waste handling scenarios (waste container breaches), whose frequency is greater than 1E-06/yr, that may be initiated by waste handling equipment failure or directly through human error by a worker performing a waste handling operation. The immediate worker is that individual directly involved with the waste handling operation for which the accident is postulated. Although procedures dictate that workers exit the area immediately, such accidents present an immediate risk due to the inhalation of airborne radionuclides to the worker performing the waste handling operation.

Receptors

The methodology for assessment of the immediate worker consequence is based on information provided by the Environmental Evaluation Group (EEG).[18] For the assessment of consequences to workers in the waste handling building (WHB) accident scenarios, the receptor of concern is the waste handler in the immediate vicinity of the accident. Waste handling procedures, require that the worker exit the area immediately following an accident. However, it is assumed in this scenario that a worker remains within the CH Bay area for a period of 60 secs, derived from the time to: (1) stop waste handling operations (10 secs), (2) examine the dropped waste containers, recognize that a waste container has been breached, and evaluate the situation (20 secs), and (3) exit the CH Bay normally through the nearest exit (airlock) (30 secs).

Evaluations of other situations (such as disabled worker scenarios), are not performed for the type of accident breach scenarios being analyzed (forklift drops and punctures). Based on the HAZOP results and the accident scenario descriptions in Section 5.3, the conditional likelihood of scenarios involving a worker failing to follow procedure to leave the area immediately, or a coincident worker (immediate waste handler) injury during the drop and puncture scenarios, are extremely unlikely compared to receiving a survivable, specified radiological consequence. Therefore, the overall frequency of the scenario analyzed plus conditional likelihood of failing to follow procedure or immediate worker injury would be beyond extremely unlikely.

For the assessment of consequences to workers in the underground accident scenarios, due to: (1) the ventilation flow path in the underground disposal rooms and exhaust drifts, and (2) the waste emplacement process described in Section 4.3, the receptor of concern is a hypothetical worker who may be in the exhaust drift at the time a CH waste handling accident occurs "upstream." For the underground waste container breach scenarios, due to the high ventilation flow rate the workers are conservatively assumed to be exposed to the entire contaminated volume of air before exiting the area. With an assumed exhaust drift velocity of 2 ft/s (0.6 m/s) (assuming a flow rate of 883 ft^3/sec [25 m^3/sec] and exhaust drift dimensions of 33 ft x 13 ft (10 m x 4 m), it is conservatively assumed that workers are exposed to the undiluted radioactive cloud at a normal working breathing rate for one second.

For fire release scenarios, due to the extended release time (900 secs assumed), and the assumption that worker exposure in both the WHB and underground is for a period of 10 secs, the accident scenario source terms for the fire scenarios are adjusted by the factor: (exposure time / release time) or (10 secs/900 secs).

Source Term Methodology

The accident scenario specific source term for immediate worker accident assessments is the "no-mitigation" source term developed for the noninvolved worker and MEI accident assessments.

Frequency Determination Methodology

The frequency of each accident analyzed for immediate worker consequences is the "no mitigation" frequency in each detailed event tree/fault tree analysis for each postulated accident is included in Appendix D.

Immediate Worker Consequence Modeling Methodology

The onsite and offsite dose model (Equation 5-5) is modified for immediate worker consequence assessment as follows:

Radiological Releases

D = (Q *T* BR * DCF)/V (5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological Source Term (Ci) (Appendix E)
T = Exposure Time (sec) (scenario dependent)
BR = Breathing rate (standard man) (m^3/s) International Commission on Radiological Protection (ICRP) No.23[16] (Light activity 5.3 gallons/min [20.0 liters/min or 3.33 E-04 m^3/s])
DCF = Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public[17] (Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.10E+08 rem/Ci)
V = Volume in which radionuclides are released (m^3)

This model was further modified by the EEG[18] to account for the expanding nature of the contamination "cloud" within the WHB. The expanding cloud model modifies Equation 5-7 as follows:

$V = 2/3\pi\, r^3$

where:

V = volume of hemisphere of air (m^3)
r = radius of hemisphere = (a) x (t)

where:

a = cloud expansion rate 0.82 ft/s (0.25 m/s)
t = time after accident (s)

therefore:

$V = 2/3\ \pi\ (a * t)^3 = 2/3\ \pi\ a^3\ t^3$

Substituting for V in Equation 5-7 and integrating with respect to time results in the following relationship:

$$\mathbf{D = Q * BR * DCF * [3/(4\pi a^3) * (T_1^{-2} - T_2^{-2})]} \qquad \textbf{(5-8)}$$

where:

T_1 = Time cloud encountered by the worker (secs)
T_2 = Time exposure ends (secs)

For breach of waste container due to drop, the release in the WHB is modeled as an instantaneous release into an initial cloud with the same volume as a seven drum array (6.6 ft [radius 2 m]). For breach of waste container due to puncture, the release in the WHB is modeled as an instantaneous release into an initial cloud with the same volume as a two drum array (3.3 ft [radius 1 m]). For the assessment of consequences to workers in the waste handling building accident scenarios, the source term release cloud is then modeled as a hemisphere expanding at the ventilation flow rate in the CH Bay (assumed to be 0.82 ft/sec [0.25 m/sec]). For breach of waste container due to drop, the expanding cloud will take approximately 8 secs for the cloud model to provide the proper initial condition, and an additional 12 secs to reach the worker, based on an assumed distance from the crane or forklift operator to dropped/punctured waste containers of 10 ft (3 m). Thus, for breach of waste container due to drop, T_1 in Equation 5-8 is 20 secs. For breach of waste container due to puncture, the expanding cloud will take approximately 4 secs for the cloud model to provide the proper initial condition, and additional 12 secs to reach the worker. Thus, for breach of waste container due to impact, T_1 in Equation 5-8 is 16 secs.

As discussed above, it is assumed that it takes 30 secs for the worker to recognize that a release has occurred, evaluate the situation, and begin to exit the area. During this time frame the cloud is assumed to engulf the worker, and for which a dose consequence is calculated. Thus T_2 in Equation 5-8 is 30 secs.

Solution of Equation 5-8 for a seven drum array, with T_1 = 20 secs, and T_2 = 30 secs, yields:

$$\mathbf{D = Q * 3.6E{+}03\ rem/Ci} \qquad \textbf{(5-9)}$$

Solution of Equation 5-8 for a two drum array, with T_1 = 16 secs, and T_2 = 30 secs, yields:

$$\mathbf{D = Q * 7.3E{+}03\ rem/Ci} \qquad \textbf{(5-10)}$$

Equation 5-9 is carried forward into Appendix E for the assessment of immediate worker consequences in the WHB.

For the assessment of consequences to workers in the underground, the source term is assumed to be released instantaneously into a slug of air with a volume of 850 ft^3 (24 m^3). This volume is based on an instantaneous release and the assumed ventilation flow rate 0f (2 ft/s [0.6 m/sec]), and the dimensions of the underground exhaust drift, or V = (2 ft/s [0.6 m/s]) * (1 sec) * (33 ft [10 m]) * (13 ft [4 m]) = 24 m^3.

Chemical Releases

$$C = Q / V \quad (5\text{-}11)$$

where:

C = Concentration (mg/m^3)
Q = Chemical Source Term (mg) (Section 5.1.2 and Tables 5.1-2 and 5.1-3)
V = Volume (m^3) of expanding cloud, derived above for Equation 5-8, at time T_1, at which receptor first encounters chemical

5.2.2 Off-site and On-site Radiological/Nonradiological Risk Evaluation Guidelines

The on-site and off-site radiological and nonradiological risk evaluation guidelines are developed in Sections 3.3.5 and 3.3.6, and for convenience the discussion is repeated here. Guidelines do not exist for the frequency range of beyond extremely unlikely (frequency ≤ 1E-06/yr). The consequences of accidents in that range are conservatively evaluated against the guidelines for the extremely unlikely range for the sole purpose of evaluating the risk associated with facility operations.

Radiological

Off-site radiological dose criteria for accident analyses have been well established by national standards through the licensing process of nuclear facilities regulated by the Nuclear Regulatory Commission (NRC). These criteria are based on the probabilities of occurrence of the accidents or events hypothesized for the accident analysis. For nuclear power plants, the operational accidents or events are classified as Plant Conditions (PC) in accordance with the estimated frequency of occurrence.[19,20] This established scheme (ANSI/ANS-51.1)[19] has also been adopted by the WIPP to compare accidental releases from postulated events to dose limits based on estimated frequency of occurrence. Table 5.2-1a summarizes the risk evaluation guidelines for the assessment of off-site radiological exposures.

The same conceptual approach is used for the on-site risk evaluation guidelines as for the off-site (public) dose. However, on-site risk evaluation guidelines are greater than those for the public by assuming that entry onto the site implies acceptance of a higher degree of risk than that associated with the off-site public. This assumption is not considered remiss with regards to safety assurance because the on-site risk evaluation guidelines do not result in any health effects noticeable to exposed individuals at frequencies greater than 1 E-4 event per year and would not result in any acute life-threatening effects.

A three-tiered step function is again used. For accidents with an estimated frequency between 0.1 event per year and 0.01 event per year, the limit is 5 rem (50 mSv) based on the allowable yearly worker exposure limits cited in 10 CFR 835.[21] For the estimated frequency range of 1 E-2 to 1 E-4 event per year, the threshold is 25 rem (250 mSv) for the same reason the USNRC provided in 10 CFR 100[22] for using it for design basis reactor accident calculations (i.e., value at which no significant health effects result).

Potential guideline values for the final frequency range of 1 E-4 to 1 E-6 event per year were examined in detail. A value for this range is specified consistent with the use of the Emergency Response Planning Guidelines-3 (ERPG-3) value for toxicological onsite hazards. This value accepts the possibility of some noticeable health effects but precludes the possibility of lethal effects for “nearly all individuals."

The DOE *Emergency Management Guide for Hazards Assessment*[23] uses 100 rem (1 Sv) whole body exposure as a threshold for early severe effects. It also acknowledges that early severe effects would not actually be experienced for a 50-year *dose* of 100 rem (1 Sv) due to alpha emitters. The guide also selects the ERPG-3 *dosage* as a threshold for early severe effects for non-radiological releases. The two values are roughly consistent in intent. Accordingly, a value of 100 rem (1 Sv) was assigned for the 1 E-4 to 1 E-6 event per year range. This information is summarized in Table 5.2-1b.

Nonradiological

Nonradiological risk evaluation guidelines definitions are consistent with the discussion below and Table 5.2-2.

A unique set of approved nonradiological risk evaluation guidelines is not found in existing DOE orders. Proposed guidelines for application to WIPP is based on Emergency Response Planning Guidelines (ERPG) published by the American Industrial Hygiene Association (AIHA).

Other commonly used guidelines that have been considered in the development of risk evaluation guidelines for the accident analysis include the following:

- Threshold limit value-Time-weighted average (TLV-TWA)
- Threshold limit value-Short-term exposure limit (TLV-STEL)
- Threshold limit value-Ceiling (TLV-C)
- Permissible exposure limits (PEL)
- Immediately dangerous to life or health (IDLH)
- Emergency response planning guidelines (ERPGs)
- Emergency exposure guidance level (EEGL)
- Short-term public exposure guidance level (SPEGL)

Currently, ERPGs do not exist for most of the nonradiological materials found in TRU mixed waste. Chemicals without established ERPG values will use the following alternate risk evaluation guidelines to derive a substitute ERPG assignment:[24]

ERPG-1 (designated TOX-1): Alternate risk evaluation guidelines:

- PEL-STEL
- TLV-STEL
- TLV-TWA x 3

ERPG-2 (designated TOX-2): Alternate risk evaluation guidelines:

- EEGL (60 minute) or
- PEL-C
- TLV-C
- TLV-TWA x 5

ERPG-3 (designated TOX-3): Alternate risk evaluation guidelines:

- EEGL (30 minute)
- IDLH

The derived toxicological limits from the ERPG and alternate risk evaluation guidelines are labeled as TOX-1, TOX-2, and TOX-3. The TOXs correspond to ERPG-1, ERPG-2, and ERPG-3, respectively. The compilation of the basis limits for derivation of alternate ERPG limits is provided in Table 5.2-2.[25,26,27]

5.2.3 Accident Analysis

5.2.3.1 CH1 Spontaneous Ignition (Drum) in the WHB

Scenario Description - The spontaneous ignition within a drum in the WHB is an internally initiated accident resulting from failure to conform to the WIPP WAC,[29] which prohibits pyrophorics in a waste container. The HAZOP[28] for CH TRU Waste Handling System postulated a spontaneous ignition within a drum while opening the TRUPACT-II. However, it is conceivable that spontaneous ignition could occur at any time within any one of the drums being handled or temporarily held in the WHB.

The frequency and magnitude of potential releases depend on the number of drums having a given quantity of TRU waste that also contain an ignition source, as well as sufficient combustible material and oxidant to generate the energy needed to produce a breach. Due to its robust design and bolted lid, a breach of a standard waste box due to spontaneous ignition is considered incredible, so for the purposes of this analysis, all waste is assumed to be stored in 55-gallon (208 L) drums. The quantitative accident evaluation presented here makes use of the information now available in the BIR[30] to estimate the frequency of releases of varying magnitudes resulting from a sustained drum fire based on radionuclide concentration, final waste form, and method of verification of conformance to the WIPP WAC.

As analyzed in DOE/WIPP 87-005,[31] Waste Drum Fire Propagation at the WIPP, a sustained fire is expected to produce a release from only a single drum. The propagation analysis in DOE/WIPP 87-005 provides the evidence and reasoning to permit the assertion that a fire in one drum would not propagate to other drums and/or result in a loss of secondary confinement. As discussed in Section 4.4, the WHB secondary confinement system consists of the WHB structure and ventilation system which maintains static pressure differential between the primary confinement barrier and the environment and continuously high efficiency particulate air (HEPA) filters which filter exhaust air.

Preventive and Mitigative Features - General preventive and mitigative measures identified in the HAZOP process for this specific scenario are listed in Table 5.1-7. For the no-mitigation case, the HEPA filters are assumed to be open, bypassed, or not in place. For the mitigated case, credit is taken for the permanently installed continuously on-line two-stage HEPA.

The primary and most practical means of preventing spontaneous ignition is generator site compliance with the WAC. Given a drum conforms to the WAC, the likelihood of spontaneous ignition may be considered to be negligibly small. Therefore, drums will be susceptible to spontaneous ignition only if human error has been made during the packaging of the waste and the verification of their conformance to the WAC at the generator sites. The program designed to assure that the potential for errors will be held at the lowest feasible level is summarized in Section 5.1.2.2. Vigilant implementation and control of the Waste Analysis Plan (WAP) found in the WIPP RCRA Part B Application, the WIPP Quality Assurance Program Plan (QAPP)[36] and each generator site's Quality Assurance Project Plan (QAPjP) will provide high confidence that a sustained spontaneous combustion event will not occur at the WIPP. In the absence of an approved QAPjP from each generator site, the probability of human error during the preparation and certification of waste for shipment to the WIPP are conservatively addressed below under estimated frequency.

If a drum fire results in a release to the WHB, the release to the outside environment is mitigated by the WHB containment structure, which includes air lock entrances and a ventilation system containing on-line two-stage HEPA filters. Although the ventilation system is required to be operational during waste handling operations, active ventilation is not required to prevent a significant release of hazardous materials from the WHB. The intact HEPA filters will maintain the secondary confinement barrier, and there is only a small potential for only minor releases via leakage of air around both access doors of the air locks, or other minor leakage paths that might exist in the structure, resulting from the loss of differential pressure.

Estimated Frequency - The HAZOP team qualitatively estimated the frequency of occurrence of a spontaneous ignition in the WHB to be in the unlikely range ($10^{-2} \geq$ frequency $> 10^{-4}$). However, based on a quantitative evaluation using conservative assumptions documented in Appendix D and below, the overall frequency of release resulting from spontaneous ignition within the WHB is beyond extremely unlikely (frequency $\leq$ 1E-06/yr). Risk evaluation guidelines are not identified for events with frequency $\leq$1E-06/yr. However, the risk evaluation guidelines for the extremely unlikely range are conservatively used for evaluating the risk associated with this scenario.

The frequency of CH1 is calculated in Table D-8 for final waste forms and distributions of drum loading obtained from the BIR. The analytical model and supporting evidence that produced these results are presented in Tables D-1 through D-7, and an event tree illustrating the sequence of events resulting in consequences from sustained combustion within a waste drum in the WHB is shown in Figure D-1. This section discusses the evidence and reasoning used to develop and quantify these models.

The scenario is initiated by spontaneous ignition within a drum that does not conform to the WIPP WAC. It is sustained by the presence of both sufficient combustibles and an oxidant. Given a sustained fire breaches the drum, only the waste material within that drum is subject to release. The quantification of each of these contributors is discussed below:

1. Spontaneous Ignition of Pyrophoric Material and Incompatible Mixtures

Spontaneous ignition is possible when 1) a pyrophoric material of sufficient quantity and concentration is raised to its auto-ignition temperature; 2) incompatible materials chemically react in an exothermic reaction; or 3) a fuel source in an ignitible state (e.g. volatile organic compounds in the presence of an oxidant) is subjected to an ignition source, such as a discharge of static electricity. To the extent that these materials are present in the processes that directly produce TRU waste intended for long term disposal, there is a possibility for spontaneous ignition to occur in the waste containers delivered to the WIPP.

Because each of the 11 final waste form categories have their own set of processes associated with them, it is theoretically possible to establish a spontaneous ignition frequency associated with each category. Furthermore, each of the 569 waste streams listed in the BIR can be examined for the presence of potentially pyrophoric conditions in order to make more definitive conclusions regarding the absence of materials that could preclude spontaneous ignition for waste streams having high quantities of specific isotopes. The Transuranic Waste Characterization Quality Assurance Program Plan (CAO-94-1010)[36] and the generator site certification process are designed to provide this assurance. However, the detailed information needed to perform such an analysis in order to estimate the waste stream specific frequencies of spontaneous ignition for accident quantification purposes is currently not warranted, in light of the low frequency of release obtained using a generic spontaneous ignition frequency.

The quantification of the generic spontaneous ignition frequency is given in Table D-2. The frequency of spontaneous ignition in TRU waste is estimated by examining the incidents of fire within DOE facilities that generate TRU waste and comparing the conditions surrounding those incidents with the circumstances under which waste forms designated for delivery and disposal at the WIPP are generated, packaged, and stored.

- The quantity of waste at risk for spontaneous ignition is the TRU waste designated for disposal at WIPP. All the waste streams listed in the BIR[30] were included in the population estimate.

- Exposure to spontaneous ignition accumulates as waste remains in interim storage over a period of time, with the overall experience being expressed in terms of cubic meter-years (m^3-yr) of storage. The time period during which individual waste streams have been stored is not readily available. For the purposes of estimating a frequency for spontaneous ignition, TRU waste is assumed to have been placed in interim storage starting in 1970, and additional waste has been added to the stored inventory at a constant rate up to the present time. Thus, the total storage experience is estimated as one half of the current stored inventory reported in the BIR times the period of time from 1970 to the current year.

- An observed incident is counted as indication of the potential for spontaneous ignition if it occurred in a population of waste containers that could be associated with processes that result in TRU material intended for long term interim storage. An incident should be excluded if it has occurred in conjunction with process activities where potentially pyrophoric materials and mixtures are used as part of the process and the TRU waste involved was passing through the process or being temporarily stored awaiting recycling into the feed material.

Table D-3 outlines the screening rules used to judge the applicability of incidents for inclusion in the estimate of the TRU waste spontaneous ignition frequency and provides a summary of the reported incidents considered. This table addresses evidence presented in EEG-45,[32] EEG-48,[33] DOE/WIPP 91-018,[34] and DOE/NS-0013[35] to identify qualifying incidents. Additional incidents that have been examined in the past, but found to be inapplicable, are documented in DOE/WIPP 91-018.[34] In addition, the DOE Occurrence Reporting and Processing System (ORPS) online database has been queried as part of this SAR update, and no additional incidents requiring classification were identified.

- In recognition of fact that not all incidents of spontaneous ignition within a waste container may be observable, a correction factor of ten has been included in the estimate of applicable events. The correction factor multiples the observed applicable incidents to generate the total number of spontaneous ignition events for estimating the spontaneous ignition frequency used in the quantification of the release frequency. Engineering judgement is used to assess a value of ten for the correction factor based on the following evidence:

  - ♦ Waste containers have been buried at some of the generator sites for a number of years. Spontaneous ignition events in these containers would not be expected to be observable even if the containers were breached, unless the release reaches the surface and is detected by radiation monitors. Based on an estimate that less than 50 percent of the waste in interim storage is buried, a factor of two correction factor should adequately account for unobservable events in this sub-population of stored containers.

  - ♦ Spontaneous ignition events that may have occurred, but have not had either sufficient oxidant or combustibles to maintain sustained combustion, can not be observed directly. The judgement that undetected ignitions have occurred would tend to produce a larger correction factor. In the absence of definitive evidence, it is assumed that four undetected ignition events may occur for every applicable incident that has been observed, leading to an additional correction factor of five.

  - ♦ The occurrence or lack of spontaneous combustion during the repackaging and certification process will provide additional evidence to support the increase or reduction in the spontaneous ignition frequency. Evidence of internal combustion can be confirmed when containers are opened for processing or repackaging, but may be difficult to detect. To date there appear to be no reports of this type of anomalies during the repacking process. Therefore, it is reasonable to conclude that an overall correction factor that multiplies the above two factors is conservative.

2. <u>Material at Risk in Drums Susceptible to Sustained Combustion</u>

The BIR has been used to categorize material at risk by Final Waste Form and TRU waste loading, expressed in terms of waste stream averaged PE-Ci/drum. Table A-1 provides a consolidation of the 569 TRU waste categories from a query of the BIR in June 1996. A sort of the BIR by waste stream that provides the detail behind the consolidation is shown in Table A-2. Based on Table A-1, Table D-4 apportions the total currently stored into 78 separate bins for calculation of accident frequency and consequence. The 78 bins result from a combination of three attributes:

- Final Waste Form (13 categories) - There are eleven officially defined categories, plus two additional categories, "Unknown" and "Various Rocky Flats Residues." The "Unknown" category will not be allowed to be shipped to the WIPP for Disposal. Conservative assessments of all parameters influencing frequency and consequence are used to quantify the contribution of this waste streams to the composite risk assessment. The "Various Rocky Flats Residues" is a waste stream that is subject to specific plans for packaging, and thus enables a unique assessment.

- Plans for processing/repackaging prior to shipment to the WIPP (two categories) - The generator sites have reported their intent to process/repackage in the BIR on a waste stream basis, and this information is being used to gain a better perspective on the potential for human error during the WIPP WAC verification process. Waste that will not be processed and/or repackaged prior to shipment are subject to a higher human error probability (HEP) during verification of waste to the WIPP WAC than waste that will be processed and/or repackaged.

- Average waste stream concentration of radionuclides in terms of PE-Ci/drum (three categories) - The three bins are established to provide a better perspective on the frequency of the bounding consequence calculations required by the DOE. The reasoning for selection of the bin limits is discussed in Section 5.1.2.1.

3. Failure to Verify Conformance to the WIPP WAC

The failure to verify conformance to the WIPP WAC is modeled by considering the potential for human error at the generator sites. Drums that fall into a population that is susceptible to spontaneous ignition arise from at least two independent errors. The first involves failure to observe good practice and existing DOE/generator site controls to prevent pyrophoric mixtures when the original TRU waste was packaged and stored. The second is a failure of the WIPP WAC verification process to detect and correct potentially pyrophoric materials in the drums being certified for shipment to the WIPP. A graded approach does not warrant an investigation of the practices of individual generator sites in order to quantify these human errors. Therefore, this section makes a scoping estimate of these errors for use in this quantification.

Generator Site Control Table D-5 summarizes the evidence and reasoning used to estimate the failure to maintain control over processes, and thus create a potential for susceptibility to spontaneous ignition during long term storage at a generator site for each Final Waste Form. As spontaneous ignition has always been a safety concern, controls have existed in the past and it is reasonable to assert that susceptibility to fires result from failure of those controls. The table estimates the HEP using the definitions of the final waste forms to provide an indication of the anticipated degree of consistency within a waste stream process.

- As a baseline scoping estimate for any generic waste stream, an HEP of 1E-01 is assessed for failure to assure that pyrophoric materials or combustible mixtures are not included in waste container intended for long term storage. This corresponds to an error by a checker to detect the abnormal condition during the packaging of the waste and closure of the waste container. The source of this value is given in Table D-1 for the variable "H_check." This estimate is considered to be conservative, because it takes no credit for the waste stream process design and operational procedures to minimize the opportunity for the introduction of pyrophoric materials or combustible mixtures into the waste container. Simply stated, without further evidence, the scoping baseline estimate assumes that ten percent of stored drums have the potential of containing pyrophoric materials or combustible mixtures.

- By their physical composition, some final waste forms provide better control over the introduction of pyrophoric materials or combustible mixtures into the waste container than others. Final waste forms generated in facilities having a variety of activities have the highest potential for inadvertent mixing of pyrophoric materials with TRU waste, while waste forms generated from controlled production processes provide strong confidence of a consistent and well defined physical properties with little likelihood of violating the WIPP WAC. For the purpose of estimating susceptibility of TRU Final Waste Forms to spontaneous ignition, it is judged that containers holding waste forms which are comprised of 95 percent of a single type of non-volatile combustible material are less likely to also include incompatible materials capable of a vigorous exothermic reaction or volatile components capable of being ignited by external ignition sources. As a scoping estimate, these processes are estimated to reduce the potential for erroneous introduction of pyrophoric materials or combustible mixtures into the waste materials by an additional factor of ten. This corresponds to an independent error in checking that the materials are not introduced during the waste generation process.

Table D-5 delineates the assessment of the HEP for controlling pyrophoric materials at the generator sites. It states the assessed value of the HEP for each final waste form based on the two arguments given above. The evidence and engineering judgement used to justify each HEP is provided for each final waste form. The Final Waste Forms are defined in the BIR, and a general review of the constituents in the waste streams given in Appendix A of the BIR. It should be noted that one of the special cases mentioned earlier, Various Rocky Flats Residues, has a unique assessment that reflects the more specific plans currently made for that material.

Verification of Drum Conformance to the WIPP WAC. Prior to shipment to the WIPP, each waste container must be certified as complying to the WIPP WAC. The HEP for failing to properly verify conformance of a drum to the WIPP WAC depends on both the method by which the verification is accomplished and the final waste form.

- The highest error rate arises when stored inventory is verified without opening the drums. Verification of waste drums that have been packaged in the past by assay and records checks provide indirect confirmatory evidence, which is dependent on the quality control exerted at the time of packaging. External detection means will be used to further characterize drums that are not processed and repackaged. However, since Table A-1 indicates that the generator sites currently plan to process/repackage over 80 percent of the waste volume, no effort has been made to determine the effectiveness of these methods. Therefore, for the purpose of this quantification, no credit is taken for the detection of potentially pyrophoric materials and combustible mixtures within unopened drums.

- Verification that includes processing and/or repackaging will be able to directly observe the waste form, but the form of the waste could inadvertently conceal potentially pyrophoric mixtures. Verification by processing and/or repacking waste provides an additional independent check over and above that produced by the combination of assay and process knowledge. However, this process may not eliminate improperly verified drums, and the HEP of 1E-01 associated with checking is used to reflect this potential error.

- Finally, it is anticipated that the most confidence in conformance will be achieved by the careful control of the processes that will generate waste in the future. Measures to control future processes are anticipated to produce low error rates for the verification of all projected inventory. Errors of commission would have to be accomplished within the defined process in order to inadvertently introduce pyrophoric materials into the waste containers. For this to occur, the pyrophoric material must be physically present. Once, the container is declared ready for closure and shipment to WIPP the verification process will provide an additional check for conformance to the WIPP WAC, at which time errors can be corrected. Therefore, as a screening estimate, the combination of an HEP for an error of commission and checking, 1E-03*1E-01 = 1E-04, is used to estimate the fraction of projected waste containers that may not conform to the WIPP WAC.

4. Availability of Oxidant

For sufficient oxidant to be present to support combustion, either it must be present in the container when ignition occurs, or there must be a leak path and a means to convect oxidant to the point of combustion at a rate sufficient to sustain combustion. A model has been presented in DOE/WIPP 87-005[31] that estimates the probability that sufficient oxidant will be available either as an internal oxidant, or via in-leakage through the filter or an undetected operationally caused breach. It estimates the probability of sufficient oxygen to support sustained combustion to be 4.2E-03. The arguments presented to support this estimate are physically reasonable, and in the absence of other evidence it is used in this quantification.

It should be noted that the likelihood that sufficient oxidant to support sustained combustion may be dependent on the physical properties of the Final Waste Form. For example, some solidified material may be anticipated to have few materials having enough available oxygen to support combustion directly and also a small void fraction to provide an air pathway to the ignition site. These combination of conditions would make the frequency of sustained combustion extremely unlikely. Where waste is more loosely packed conditions may be more favorable. Based on the quantities of waste at risk and the resultant risk, this level of detail is judged to be unnecessary.

The presence of backfill within the disposal rooms is also expected to reduce the availability of oxidant to the drums once they are placed in the U/G horizon. Pathways for air flow to the burning drum will be very restricted in the drum stack. However, the impact of this is not specifically quantified in this scenario.

5. Heat of Combustion

Based on the definitions given of each waste form in Section 5.1.2.2, and the weight concentrations of materials in each specific waste stream defined in Appendix A of the BIR[30], the final waste forms could be categorized for potential of containing sufficient combustibles to support sustained combustion to breach a drum. Examination of Appendix A would lead one to infer that many of the waste streams associated with final waste forms such as salt wastes, soils, solidified inorganics, lead/cadmium metal, and uncategorized metal, would not be able to support the sustained combustion necessary to produce a breach. However, since the amount of thermal energy that must be generated to breach a drum has not been analyzed, it is assumed that any drum containing sufficient pyrophoric material to permit spontaneous ignition will also contain the materials to generate enough heat of combustion to breach the drum.

Description of Calculation for One Waste Stream

The calculation of the frequency of sustained combustion due to spontaneous ignition is illustrated by the event tree in Figure D-1. This event tree calculates the frequency of release for TRU waste categorized as combustible, having a radionuclide concentration of over 20 PE-Ci per equivalent 55- gallon drum volume, and will not be reprocessed/repackaged, one of the 78 categories of waste form bins defined for this quantification. This bin was selected for illustration, because it produces the largest consequence, given a release occurs.

Spontaneous ignition within a drum is the initiating event of the event tree. It arises from an inventory weighted time-averaged quantity of waste being stored in the Waste Handling Building, some fraction of which is susceptible to spontaneous ignition at the generic frequency. This quantity is very small, because a drum containing this waste stream will be present in the WHB very infrequently.

The calculation of the spontaneous ignition frequency is shown in Table D-6. The volume of TRU waste at risk for a spontaneous ignition is defined to be the maximum volume that can be held in the WHB at any one time. The maximum volume is assumed for CH1 because the time averaged inventory of waste that will be present in the WHB will depend on circumstances that can not now be predicted.

Given the initiating event occurs, the presence of sufficient oxidant and heat of combustion, the two other necessary conditions for sustained combustion, are questioned as top events of the tree. For this scoping quantification, sufficient heat of combustion is assumed.

The product of all events necessary for sustained combustion is then expressed as release events per year at the end point of the "no-mitigation" branch of the event tree. The frequency expressed in this event tree is for the contribution of the combustible waste form that will not be processed/repackaged before certification for shipment to the WIPP with a waste form average radionuclide content greater than 20 PE-Ci. Recall that this is just one of 78 possible combinations of waste form frequency and consequence that contribute to the overall risk of spontaneous ignition. For information purposes, a "mitigated" subtree is also included to show the impact of containment features designed into the WIPP to prevent releases offsite.

Table D-7 shows the overall calculations for all 78 possible combinations of final waste form, processing/repackaging plan, and radionuclide concentration. For simplicity, the order of calculation has been changed slightly from that represented in the event tree. The table first calculates the frequency of release for each of the 78 combinations on a per m^3-year of storage basis. The spontaneous ignition event frequency is calculated across the top row. The dot product symbol is used to indicate that cells in the same relative location of the matrices delineating each of the combinations are multiplied together to obtain the product. The second row then multiplies the spontaneous ignition frequency by the likelihood of sufficient oxidant and heat of combustion to obtain the release frequency on a per m^3-year of storage basis. This final matrix is then applied to the waste volumes at risk in Table D-8.

Overall Calculation

Table D-8 illustrate the calculations required to obtain an overall frequency of release due to spontaneous ignition in the WHB. The frequencies for stored non-processed/repackaged and process/repackage waste streams are repeated in the left columns for convenience. These frequencies are then multiplied by the material at risk for each waste form, which is obtained from the product of the waste form volume percent and the total stored volume. That product is in turn multiplied by the percentage of the waste form that falls into each of the radionuclide concentration bins for the non-processed/repackaged and processed/repackaged waste streams respectively. These two results are then added and listed under the composite frequency of release for that Final Waste Form.

It can be seen from Table D-8 that the overall frequencies of spontaneous ignition within the WHB is approximately 1.4E-07/year (beyond extremely unlikely). Moreover, less than two percent of this frequency (2E-09/year) involves drums containing over 20 PE-Ci of TRU waste, the consequences of which are calculated assuming a bounding content of 80 PE-Ci. Finally, over 90 percent of the frequency involves drums that will have at least an order of magnitude less consequence than the bounding case.

Source Term Development

Radiological Waste Container Inventory (CI) - Based on the postulated scenario, the radiological CI for this accident has been determined to be the maximum inventory contained in a single drum (CD=1). As discussed in Section 5.1.2, a maximum drum inventory has been established as 80.0 PE-Ci which provides the radiological CI for a spontaneous ignition within a drum.

Nonradiological Waste Container Inventory (CI)- As discussed in Section 5.1.2, the solid and liquid chemical compound concentrations that would be expected to be within a waste container (Table 5.1-3) are used as the nonradiological CI.

Damage Ratio - The accident scenario involves a spontaneous ignition in a drum, therefore it is necessary to first discuss the amount of material that will burn (combustible fraction) and the amount of material that will be subjected to thermal stress (heating without ignition) (noncombustible fraction) in order to determine the amount of material that could be released to receptors of concern. The waste form within a drum (combustibles vs noncombustibles) is estimated based on information provided in the Section 5.1.2. Combustible waste is defined as consisting of paper, kimwipes, and cloth (dry and damp); various plastics such as polyethylene and polyvinyl chloride; wood; and filters contaminated with trace quantities of halogenated organic solvents.

The combustible waste distribution is conservatively assumed to be 95 percent of the waste container contents. The remainder of the material in the drum (5 percent) is assumed to be noncombustible (sludges, filters, asphalt, soil, glass, metal, other). The radioisotopes within the drum are assumed to be evenly distributed throughout the waste in the drum, therefore 95 percent of the radioactivity is assumed to be combustible material at risk and 5 percent of the radioactivity is assumed to be noncombustible material at risk.

For internal waste container fire as a result of spontaneous ignition, it is conservatively assumed that sufficient internal pressure is generated as a result of the accident phenomenon to cause a breach of the waste container. As a result of the airborne release generated by the fire phenomenon, it is conservatively assumed that the DR for this scenario is 1.0 (DR=1.0).

Airborne Release Fraction - The ARF for combustible materials in a drum is 5.0E-04 and the airborne release fraction for noncombustible materials in a drum is 6.0E-03. These values represent bounding airborne release fractions for the burning of contaminated packaged mixed waste and the heating of noncombustible contaminated surfaces (DOE-HDBK-3010-94, subsection 5.2.1.1 and 5.3.1).[5]

Respirable Fraction -The bounding RFs for the burning of contaminated packaged mixed waste and the heating of noncombustible contaminated surfaces are 1 and 1.0E-02, respectively (DOE-HDBK-3010-94, subsection 5.2.1.1 and 5.3.1).[5]

Leakpath Factor - Based on the scenario description, it is not expected that the internal waste container fire will also disable the waste handling ventilation or HEPA filtration systems. If a waste container fire results in a release to the WHB, the release to the outside environment is mitigated by the permanently installed continuously on-line two-stage HEPA. Although the ventilation system is required to be operational during waste handling operations, active ventilation is not required to prevent a significant release of hazardous materials from the WHB. The intact HEPA filters will maintain the secondary confinement barrier, with a potential for only minor releases via leakage around access doors, etc. resulting from the loss of differential pressure. The amount of material removed from the air due to the HEPA filters is predicted based on decontamination factors. Decontamination factors (DF) have been predicted for accident conditions in ERDA Nuclear Air Cleaning Handbook.[37] Based on the handbook a DF of 5.0E+02 for the first stage and 2.0E+03 for the second stage are recommended. Therefore the total DF used in this analysis for both stages of filtration is 1.0E+06. The leakpath factor is considered as 1.0E-06 for the mitigated case, and 1.0 for the no-mitigation case.

Estimated Noninvolved Worker and MEI Consequences and Comparison to Risk Evaluation Guidelines - Based on values for the source term variables as presented above, the MEI and noninvolved worker non-mitigated consequences (see Appendix E, Tables E-1, E-2, E-3, and E-4) of the Spontaneous Ignition (Drum) in the WHB (CH1) are well within the radiological and nonradiological risk evaluation guidelines (for the extremely unlikely range). Risk evaluation guidelines are not identified for events with frequency $\leq$ 1E-06/yr, however, the risk evaluation guidelines for the extremely unlikely range are conservatively used for evaluating the risk associated with this scenario.

Assessment of Immediate Worker Consequences - No current risk evaluation guidelines exist for the assessment of <u>accident</u> consequences to immediate workers. Therefore, in the absence of guidelines, and for conservatism, the noninvolved worker radiological guidelines are used as a reference point for the assessment of consequences to immediate workers and the evaluation of the adequacy of the WIPP defense-in-depth features. The worst-case consequences to the immediate worker from CH1 (Table E-49) are well within the risk evaluation guidelines. Therefore, no specific additional worker protection engineering or administrative controls beyond those already qualitatively identified as providing defense-in-depth for the immediate worker, are needed based on the quantitative consequence assessment results.

Safety Structures, Systems, and Components - Based on the estimated worst-case no-mitigation MEI and noninvolved worker consequences and comparison to the risk evaluation guidelines, Safety Class or Safety Significant SSCs are not required.

The defense-in-depth SSCs which are applicable to this scenario, per the criteria provided in Chapter 3, Section 3.1.3 are assigned as follows:

- Waste Handling Building Structure - Secondary Confinement
- WHB CH HVAC System - Secondary Confinement
- WHB HEPA Filters - Secondary Confinement
- Vented DOT Type A or equivalent Waste Container - Primary Confinement

Section 5.2.4.1, Evaluation of the Design Basis, discusses in greater detail: (1) the evaluation of safety SSCs, and (2) the applicability of functional and performance requirements (system evaluation) and controls (TSRs). Detailed design descriptions for the above defense-in-depth SSCs may be found in Chapter 4 and the applicable Systems Design Descriptions.

Due to the importance of the WIPP Emergency Management Program,[11] and the WIPP WAC to restrict waste elements (such as the presence of pyrophorics) that may cause the initiating event for this accident, TSR ACs are derived in Chapter 6 and required in the WIPP TSR Document.

5.2.3.2 CH2 Crane Failure in the WHB

Scenario Description - The possibility of a crane accident in the WHB was identified in the HAZOP[28] performed for the CH TRU Waste Handling system. This scenario represents an internally initiated operational accident which involves a breach of waste container(s) during crane handling. Table 5.1-7 lists three crane failure/breach events which result from 1) failure of lifting equipment , 2) failure to secure load, and 3) failure to remove payload. As determined in the HAZOP each of the events involve negligible release of radioactive and nonradioactive materials and all occur within the WHB. The failure of lifting equipment during TRUDOCK crane operations bounds all other crane handling accidents in the WHB due to height of lift and total waste containers involved.

A typical TRUPACT II contains fourteen 55-gallon (208 L) drums that are stretch wrapped or banded together into seven packs or the TRUPACT II may contain up to two SWBs or a TDOP in place of the 55-gallon (208 L) drums. For this scenario, during TRUPACT unloading, the TRUDOCK crane is assumed to drop the load at the point at which the load is at its greatest height, just over the TRUDOCK railing, crushing the bottom waste containers (seven drums or one SWB). Although the primary confinement (waste container) is assumed to breach and result in a release of radiological and nonradiological material within the WHB, it is not expected to result in a loss of secondary confinement. As discussed in Section 4.4, the WHB secondary confinement consists of the WHB structure and ventilation system which maintains static pressure differential between the primary confinement barrier and the environment and continuously HEPA filters exhaust air.

Also, waste handlers are trained and qualified in safe and proper equipment operation (following accepted hoisting and rigging practices) and preoperational inspections. Additionally, the crane design provides for fail safe condition during loss of power (brake set during loss of power). Nevertheless, a release of radiological and nonradiological material is assumed to occur as a result of waste containers falling in excess of 4 ft due to equipment or human (operator) error.

Preventive and Mitigative Features - General preventive and mitigative measures identified in the HAZOP process for this specific scenario are listed in Table 5.1-7. For the no-mitigation case, the HEPA filters are assumed to be open, bypassed, or not in place. For the mitigated case, credit is taken for the permanently installed continuously on-line two-stage HEPA.

Estimated Frequency - The HAZOP team qualitatively estimated the frequency of occurrence of a crane dropping the load to be in the unlikely range ($10^{-2} \geq$ frequency $> 10^{-4}$).As shown in the event tree analysis for this accident scenario in Appendix D, Figure D-2, the <u>quantitative</u> evaluation of the no-mitigation annual occurrence frequency of the accident scenario is also in the unlikely range.

A fault tree analysis[38] was performed to determine the reliability of the WHB 6-ton bridge crane. The results of the analysis indicates that the dominant source of crane failure which could result in dropped loads are crane hook or wire rope failures. However, the WIPP facility has an aggressive crane test, maintenance, and inspection program including: (1) preoperational checks and inspections of the hook, wire ropes, and lifting and balancing assembly; (2) no-load test once per shift; (3) monthly inspection of the hook and wire rope; and (4) yearly non-destructive testing of the hook and wire rope. These provisions provide assurance that the analysis failure rate is a very conservative estimate of the frequency of the initiating event for this accident scenario.

As shown in the fault tree analysis,[38] scenarios involving loss of power or motor failure, and crane system brake failure are beyond extremely unlikely (frequency ≤ 1E-06/yr). Power failure may be due to loss of off-site power or coincident with the Design Basis Tornado, or Earthquake. Motor failure may be due to mechanical failure or electrical short leading to a motor fire. Regardless of the power or motor failure scenario, the crane systems brakes are designed to engage upon loss of power, and as such, hold the load, with no resulting credible waste container breach scenario.

Source Term Development

Radiological Waste Container Inventory (CI) - Based on the postulated scenario, the CD for this accident has been determined to be the inventory contained in seven drums or one SWB. As discussed in Section 5.2.1.1, it is assumed that one waste container contains the maximum radionuclide inventory (80 PE-Ci for drums, and 130 PE-Ci for SWBs), and the remaining six drums contain an average radionuclide inventory of 8 PE-Ci each. The one SWB contains the maximum CI. The waste container is conservatively assumed to contain 95 percent noncombustible material and five percent combustible material, as discussed in Section 5.2.1.1.

Nonradiological Waste Container Inventory (CI)- As discussed in Section 5.2.1.1, the nonradiological CI development process for events which involve a breach of a waste container is simplified by assuming that 100 percent of the VOC headspace inventory is released instantaneously. VOCs selected for consideration for accidental releases are listed in Table 5.1-2. These values were scaled for estimating concentrations in the SWBs based on container volumes.

Damage Ratio - As discussed in Section 5.2.1.1, for drops of waste containers from the heights associated with crane failure, (from heights greater than 5 ft, and equal to or less than 10 ft (5 ft < h ≤ 10 ft)), based on analyses,[10] it is conservatively assumed, to encompass the uncertainty in the application of test data and the variation in waste forms, that the DR for Type A drums (or equivalent) in this class of accident is 0.025 (DR=0.025), and the DR for SWBs and TDOPs is 0.01 (DR=0.01).

Airborne Release Fraction and Respirable Fraction - As discussed in Section 5.2.1.1, the ARF for contaminated combustible materials which are subjected to impact and breach of the waste container is 0.001. This value represents a bounding ARF for packaged material in a container which fails due to impact (DOE-HDBK-3010-94, subsection 5.2.3.2).[5] The bounding RF is 0.1 (DOE-HDBK-3010-94, subsection 5.2.3.2).[5]

The ARF for contaminated noncombustible materials which are subjected to impact and breach of the waste container for solids that do not undergo brittle fracture is 0.001. This value represents a bounding ARF for packaged material in a container which fails due to impact (DOE-HDBK-3010-94, subsection 5.3.3.2.2).[5] The bounding RF is 1.0 (DOE-HDBK-3010-94, subsection 5.2.3.2).[5]

Leakpath Factor - Based on the scenario description, it is not expected that the crane failure in the WHB will also disable the waste handling ventilation or HEPA filtration systems. If crane failure results in a release to the WHB, the release to the outside environment is mitigated by the permanently installed continuously on-line two-stage HEPA. Although the ventilation system is required to be operational during waste handling operations, active ventilation is not required to prevent a significant release of hazardous materials from the WHB. The intact HEPA filters will maintain the secondary confinement barrier, with a potential for only minor releases via leakage around access doors, etc. resulting from the loss of differential pressure.

The amount of material removed from the air due to the HEPA filters is predicted based on decontamination factors. Decontamination factors have been predicted for accident conditions in the ERDA Nuclear Air Cleaning Handbook, ERDA 76-21.[37] Based on this handbook a DF of 5.0E+02 for the first stage and 2.0E+03 for the second stage are recommended. Therefore, the total DF used in this analysis for both stages of filtration is 1.0E+06. The leakpath factor is considered as 1.0E-06 for the mitigated case and for the no-mitigation case an LPF of 1.0 is assumed.

Estimated noninvolved worker and MEI Consequences and Comparison to Risk Evaluation Guidelines - Based on the data provided in Table A-5 of Appendix A, considering the conditional likelihood of receiving the analyzed worst-case waste container contents and distribution (one waste container >20 PE-Ci, and the remaining at > 2.7 PE-Ci), it is concluded that the frequency for the analyzed worst-case no-mitigation scenario is extremely unlikely. Therefore, the accident risk evaluation guidelines for the extremely unlikely range are used for the comparison of the no-mitigation noninvolved worker and MEI consequences.

Based on the values for the source term variables as presented above, the worst-case, no-mitigation MEI and noninvolved worker consequences (see Appendix E, Tables E-5, E-6, E-7, and E-8) of the Crane Drop in the WHB (CH2) are well within the radiological and nonradiological risk evaluation guidelines for the extremely unlikely range

Assessment of Immediate Worker Consequences- No current risk evaluation guidelines exist for the assessment of accident consequences to immediate workers. Therefore, in the absence of guidelines, and for conservatism, the noninvolved worker radiological guidelines are used as a reference point for the assessment of consequences to immediate workers and the evaluation of the adequacy of the WIPP defense-in-depth features. The worst-case consequences to the immediate worker from CH2 (Tables E-50 and E-65) are well within the risk evaluation guidelines. Therefore, no specific additional worker protection engineering or administrative controls beyond those already qualitatively identified as providing defense-in-depth for the immediate worker, are needed based on the quantitative consequence assessment results.

Safety Structures, Systems, and Components - Based on the estimated worst-case no-mitigation MEI and noninvolved worker consequences and comparison to the risk evaluation guidelines, Safety Class or Safety Significant SSCs are not required.

The defense-in-depth SSCs which are applicable to this scenario, per the criteria provided in Chapter 3, Section 3.1.3 are assigned as follows:

- Waste Handling Building Structure - Secondary Confinement
- WHB CH HVAC System - Secondary Confinement

- WHB HEPA Filters - Secondary Confinement
- Vented DOT Type A or equivalent Waste Container - Primary Confinement
- TRUDOCK Crane - Designed to prevent failure resulting in a dropped load.
- Adjustable Center of Gravity Lift Fixture - Design to prevent load from swinging

Section 5.2.4.1, Evaluation of the Design Basis, discusses in greater detail: (1) the evaluation of safety SSCs, and (2) the applicability of functional and performance requirements (system evaluation) and controls (TSRs). Detailed design descriptions for the above defense-in-depth SSCs may be found in Chapter 4 and the applicable Systems Design Descriptions.

Due to the importance of WIPP programs relating to configuration and document control, quality assurance, conduct of operations, preventative maintenance and inspection, waste handling procedures and training, the WIPP WAC, and the WIPP Emergency Management Program[54] and associated procedures, in the WIPP defense-in-depth strategy for this accident, TSR ACs are derived in Chapter 6 and required in the WIPP TSR Document.

5.2.3.3 CH3 Puncture of Waste Containers by Forklift in the WHB

Scenario Description - The possibility of a puncture of waste containers by a forklift in the WHB was identified in the HAZOP[28] performed for the CH TRU Waste Handling system. This scenario represents an internally initiated operational accident which involves a breach of waste container(s) during waste handling. Table 5.1-7 lists one forklift mishap event which results from forklift improper engagement of the load. This scenario bounds all other puncture events involving forklift operations in the WHB due to the total number of waste containers handled during these operations.

The facility pallet is designed to carry the contents of two TRUPACT IIs, (28 drums stretch wrapped or banded together in seven packs, or four SWBs) from the TRUPACT unloading area to the underground horizon. The waste containers are placed onto the facility pallet in two stacks, each with seven drums per layer, stacked two layers high, or one SWB per layer stacked two layers high. After the facility pallet is loaded, a forklift equipped with blunt tipped tines is used to transport the facility pallet to the conveyance loading room, temporary WHB storage, or the shielded holding area. During this process, the operator may improperly engage the fork lift tines in the facility pallet, or a hardware failure prevent the operator from controlling the forklift. Either of these failures may result in the forklift tines impacting the waste containers.

The impact from the forklift tines is assumed to puncture two drums or two SWBs on the bottom layer of the stacks on the facility pallet. Operating procedures caution the operator not to disengage the forklift once the drums have been punctured, but, for the no-mitigation accident scenario, it is assumed that the forklift tines are disengaged from the drums causing material to be released. Although the waste containers are Type A packages certified through design and testing to withstand a fall from four feet without releasing the contents this analysis also assumes two drums (or two SWBs) are knocked off the stacks during impact breaching their containers in order to provide bounding consequences. Thus, a release of radiological and nonradiological material is assumed to occur as a result of two drums (or two SWBs) that are punctured and two drums (or two SWBs) that are dropped as a result of equipment or human (operator) error.

Preventive and Mitigative Features - General preventive and mitigative measures identified in the HAZOP process for this specific scenario are listed in Table 5.1-7. For the no-mitigation case, the HEPA filters are assumed to be open, bypassed, or not in place. For the mitigated case, credit is taken for the permanently installed continuously on-line two-stage high efficiency particulate filters (HEPA).

The facility pallet design provides a wide margin for human error during the engagement before the waste containers can be penetrated. The pallet is approximately 10" thick. The two forklift tine pockets channels are located adjacent to the floor, and are approximately 7" high, so that an approximately 3" of side wall is available as a buffer to stop misaligned tines. Because the pockets are very close to the floor, vertically raising of the tines to just clear the floor is all that is required for pocket insertion. This minimizes the likelihood that the tines will be raised above the upper surface of the facility pallet during forklift engagement. Additionally, the waste containers are located in or over a circular impression at the center of the pallet, requiring the forklift to travel an additional 18" after missing the pocket and the side wall before it comes into contact with the waste containers.

Safe operation of forklifts at the WIPP is accomplished through: 1) qualified and fully trained operators that are responsible for the care and operating condition of their equipment, 2) operation of the forklifts at slow speeds within the WHB, 3) stopping operation and reporting mechanical difficulties with the equipment, and (4) the presence of a spotter. Waste handlers are trained and qualified in safe and proper equipment operation and preoperational inspections.

Given a puncture event does occur, the release will be mitigated by the permanently installed continuously on-line two-stage high efficiency particulate filters (HEPA). For the no-mitigation case, the HEPA filters are assumed to be open, bypassed, or not in place.

Estimated Frequency - The HAZOP team qualitatively estimated the frequency of occurrence of a puncture of waste containers to be in the unlikely range ($10^{-2} \geq$ frequency $> 10^{-4}$). However, since this accident evaluation indicated that most of the consequences arise from the puncture event, it is conservatively assumed that the total consequences due to both the punctured and dropped containers will occur at the frequency associated with the puncture of the containers (This is equivalent to stating that the upper drums are guaranteed to fall if the lower drums are punctured). As shown in the event tree analysis for this accident scenario in Appendix D, Figure D-3, the <u>quantitative</u> evaluation of the no-mitigation annual occurrence frequency of the accident scenario is also in the unlikely range.

Given the combination of the above safeguards, the frequency of human error leading to puncture events for use in this accident quantification, is judged to be an upper bound on the frequency of human error generated accidents that can be anticipated at the WIPP. As documented in Appendix D, Table D-1, the human error probability developed for forklift operations at the Savanna River Plant is used as the estimate of the frequency of the human error. In light of the discussion above, the lower value developed by Savanna River was used as the HEP for operations at the WIPP.

Source Term Development

Radiological Waste Container Inventory (CI) - Based on the postulated scenario, the CD for this accident has been determined to be the inventory contained in four drums or two SWBs. As discussed in Section 5.2.1.1, it is assumed that one waste container contains the maximum radionuclide inventory (80 PE-Ci for drums, and 130 PE-Ci for SWBs), and the remaining three drums contain an average radionuclide inventory of 8 PE-Ci each. It is conservatively assumed that of the two of four drums breached by impact, one is at the maximum CI. It is assumed that both SWBs are breached due to impact, one at the maximum of 130 PE-Ci, the second at the average of 32 PE-Ci. The waste container is conservatively assumed to contain 95 percent noncombustible material and five percent combustible material, as discussed in Section 5.2.1.1.

Nonradiological Waste Container Inventory (CI)- As discussed in Section 5.2.1.1, the nonradiological CI development process for events which involve a breach of a waste container is simplified by assuming that 100% of the VOC headspace inventory is released instantaneously. VOCs selected for consideration for accidental releases are listed in Table 5.1-2. These values were scaled for estimating concentrations in the SWBs based on container volumes.

Damage Ratio - As discussed in Section 5.2.1.1, for scenarios involving the breach of waste containers due to impact with waste handling equipment, the kinetic energy associated with slow moving waste handling equipment (primarily forklifts) was evaluated[10] to determine the level of waste container damage when compared to test data. Additionally, breaches due to forklift tine impact are evaluated based on the current WIPP forklift tine design. Based on the analyses[10] of the speeds expected during waste handling and resulting possible breach mechanisms, it is considered by engineering judgement that a "puncture" of a waste container (resulting in a relatively large exit path for waste materials) may occur. It is conservatively assumed using engineering judgement, to encompass the uncertainty in the application of test data and the variation in waste forms, that the DR for Type A drums (or equivalent) in this class of accident is 0.05 (DR=0.05), and the DR for SWBs and TDOPs is 0.01 (DR=0.01).

For the two drums not breached due to impact, which are assumed to fall from the second level of drums on the facility pallet, based on the discussion in Section 5.2.1.1, for drops of multiple Type A waste containers associated with typical forklift waste handling operations, drops are considered to occur from a height of less than or equal to five feet. This height range is associated with the height the forklift tines are above the ground, plus the height from a fall of the top waste containers that are stacked two high (as on a facility pallet). Based on analyses,[10] it is considered by engineering judgement that the DR for releases from drops of waste containers from heights less than or equal to five feet is less than 0.01 (DR $<$ 0.01). However, it is conservatively assumed, to encompass the uncertainty in the application of test data and the variation in waste forms, that the DR for Type A drums (or equivalent) in this class of accident is 0.01 (DR=0.01), and the DR for SWBs and TDOPs is 0.001 (DR=0.001).

Airborne Release Fraction and Respirable Fraction - As discussed in Section 5.2.1.1, the ARF for contaminated combustible materials which are subjected to impact and breach of the waste container is 0.001. This value represents a bounding ARF for packaged material in a container which fails due to impact (DOE-HDBK-3010-94, subsection 5.2.3.2).[5] The bounding RF is 0.1 (DOE-HDBK-3010-94, subsection 5.2.3.2).[5]

The ARF for contaminated noncombustible materials which are subjected to impact and breach of the waste container for solids that do not undergo brittle fracture is 0.001. This value represents a bounding ARF for packaged material in a container which fails due to impact (DOE-HDBK-3010-94, subsection 5.3.3.2.2).[5] The bounding RF is 1.0 (DOE-HDBK-3010-94, subsection 5.2.3.2).[5]

Leakpath Factor - Based on the scenario description, it is not expected that a forklift puncture in the WHB will also disable the waste handling ventilation or HEPA filtration systems. If forklift puncture results in a release to the WHB, the release to the outside environment is mitigated by the permanently installed continuously on-line two-stage HEPA. Although the ventilation system is required to be operational during waste handling operations, active ventilation is not required to prevent a significant release of hazardous materials from the WHB. The intact HEPA filters will maintain the secondary confinement barrier, with a potential for only minor releases via leakage around access doors, etc. resulting from the loss of differential pressure.

The amount of material removed from the air due to the HEPA filters is predicted based on decontamination factors. Decontamination factors have been predicted for accident conditions in ERDA Nuclear Air Cleaning Handbook, ERDA 76-21.[37] Based on this handbook a DF of 5.0E+02 for the first stage and 2.0E+03 for the second stage are recommended. Therefore, the total DF used in this analysis for both stages of filtration is 1.0E+06. The leakpath factor is considered as 1.0E-06 for the mitigated case and for the no-mitigation case a LPF of 1.0 is assumed.

Estimated Consequences and *Comparison to Risk Evaluation* Guidelines - Based on the data provided in Table A-5 of Appendix A, considering the conditional likelihood of receiving the analyzed worst-case waste container contents and distribution (1 waste container >20 PE-Ci, and the remaining at > 2.7 PE-Ci), it is concluded that the frequency for the analyzed worst-case no-mitigation scenario is extremely unlikely. Therefore, the accident risk evaluation guidelines for the extremely unlikely range are used for the comparison of the no-mitigation noninvolved worker and MEI consequences.

Based on the values for the source term variables as presented above, the worst-case no-mitigation MEI and noninvolved worker consequences (see Appendix E, Tables E-15, E-16, E-17, and E-18) of the Puncture of Waste Containers in the WHB (CH3) are well within the radiological and nonradiological risk evaluation guidelines for the extremely unlikely range.

Assessment of Immediate Worker Consequences - No current risk evaluation guidelines exist for the assessment of accident consequences to immediate workers. Therefore, in the absence of guidelines, and for conservatism, the noninvolved worker radiological guidelines are used as a reference point for the assessment of consequences to immediate workers and the evaluation of the adequacy of the WIPP defense-in-depth features. The worst-case consequences to the immediate worker from CH3 (Tables E-51 and E-66) are well within the risk evaluation guidelines. Therefore, no specific additional worker protection engineering or administrative controls beyond those already qualitatively identified as providing defense-in-depth for the immediate worker, are needed based on the quantitative consequence assessment results.

Safety Structures, Systems, and Components - Based on the estimated worst-case no-mitigation MEI and noninvolved worker consequences and comparison to the risk evaluation guidelines, Safety Class or Safety Significant SSCs are not required.

The defense-in-depth SSCs which are applicable to this scenario, per the criteria provided in Chapter 3, Section 3.1.3 are assigned as follows:

- Waste Handling Building Structure - Secondary Confinement
- WHB CH HVAC System - Secondary Confinement
- WHB HEPA Filters - Secondary Confinement
- Vented DOT Type A or equivalent Waste Container - Primary Confinement
- Forklift and Attachments - Designed to minimize waste container punctures
- Facility Pallet - Designed to minimize waste container punctures

Section 5.2.4.1, Evaluation of the Design Basis, discusses in greater detail: (1) the evaluation of safety SSCs, and (2) the applicability of functional and performance requirements (system evaluation) and controls (TSRs). Detailed design descriptions for the above defense-in-depth SSCs may be found in Chapter 4 and the applicable Systems Design Descriptions.

Due to the importance of WIPP programs relating to configuration and document control, quality assurance, conduct of operations, preventative maintenance and inspection, waste handling procedures and training,WIPP WAC, and the WIPP Emergency Management Program[54] and associated procedures, in the WIPP defense-in-depth strategy for this accident, TSR ACs are derived in Chapter 6, and required in the WIPP TSR Document.

5.2.3.4 CH4 Drop of Waste Containers by Forklift in the WHB

Scenario Description - The possibility of waste container breaches due to drops in the WHB was identified in the HAZOP[28] performed for the CH TRU Waste Handling system. This scenario represents an internally initiated operational accident which involves a breach of waste container(s) during waste handling. For this type of event Table 5.1-7 lists three failure/breach events which result from 1) mislocation on the conveyance car , 2) moving accidents, and 3) moving accident with payload. As determined in the HAZOP each of the events involve negligible release of radioactive and nonradioactive materials and all occur within the WHB. The drop of waste containers from a forklift during waste handling operations in the WHB bounds all other moving or forklift drops due to the total number of waste containers involved during these operations.

Once the waste containers are loaded onto the facility pallet (contents of two TRUPACT IIs, 28 drums or four SWBs), a forklift equipped with blunt tipped tines is used to transport the facility pallet to the conveyance loading room or the shielded storage room. Although the waste containers are Type A packages certified through design and testing to withstand a fall from four feet without releasing the contents it is assumed during the transport of waste containers within the WHB that waste containers are dropped and breached. A release of radiological and nonradiological material is assumed to occur as a result of four drums (or two SWBs) dropped from the facility pallet causing a breach of the waste containers due to equipment or human (operator) error. The TRUPACT-II contents of 14 drums are stretch wrapped or banded together into two seven packs. Each seven pack pair (or SWB pair) is placed on the facility pallet and held in place by tie-downs. As such, it is conservatively assumed that two drums from the top seven packs (or top SWB) of each seven pack pair (or SWB pair) fall due to failure of the tie-downs and stretch wrap (four drums or two SWBs total).

Preventive and Mitigative Features - General preventive and mitigative measures identified in the HAZOP process for this specific scenario are listed in Table 5.1-7. Safe operation of forklifts at the WIPP is accomplished through: 1) only qualified and fully trained operators are permitted to operate forklifts; 2) qualified operators will be responsible for the care and operating condition of their equipment; 3) qualified operators complete preoperational inspections; 4) forklifts shall be operated at slow speeds within the WHB; 5) in the case of mechanical difficulties, the operator is responsible to stop the equipment and report the problem; and (6) the presence of a spotter.

Given a forklift drop event does occur, the release will be mitigated by the permanently installed continuously on-line two-stage high efficiency particulate filters (HEPA). For the no-mitigation case, the HEPA filters are assumed to be open, bypassed, or not in place.

Estimated Frequency - The HAZOP team qualitatively estimated the frequency of occurrence of a drop of waste containers to be in the unlikely range ($10^{-2} \geq$ frequency $> 10^{-4}$). As shown in the event tree analysis for this accident scenario in Appendix D, Figure D-4, the quantitative evaluation of the no-mitigation annual occurrence frequency of the accident scenario is also in the unlikely range.

Source Term Development

Radiological Waste Container Inventory (CI) - Based on the postulated scenario, the CD for this accident has been determined to be the inventory contained in four drums or two SWBs. As discussed in Section 5.2.1.1, it is assumed that one waste container contains the maximum radionuclide inventory (80 PE-Ci for drums, and 130 PE-Ci for SWBs), and the remaining three drums contain an average radionuclide inventory of 8 PE-Ci each. It is assumed that one SWB contains the maximum CI of 130 PE-Ci, and the second contains an average of 32 PE-Ci. The waste container is conservatively assumed to contain 95 percent noncombustible material and five percent combustible material, as discussed in Section 5.2.1.1.

Nonradiological Waste Container Inventory (CI)- As discussed in Section 5.2.1.1, the nonradiological CI development process for events which involve a breach of a waste container is simplified by assuming that 100% of the VOC headspace inventory is released instantaneously. VOCs selected for consideration for accidental releases are listed in Table 5.1-2. These values were scaled for estimating concentrations in the SWBs based on container volumes.

Damage Ratio - As discussed in Section 5.2.1.1, for drops of multiple Type A waste containers associated with typical forklift waste handling operations, drops are considered to occur from a height of less than or equal to 5 ft. This height range is associated with the height the forklift tines are above the ground, plus the height from a fall of the top waste containers that are stacked two high (as on a facility pallet). Based on analyses,[10] it is considered by engineering judgement that the DR for releases from drops of waste containers from heights less than or equal five feet is less than 0.01 (DR $<$ 0.01). However, it is conservatively assumed, to encompass the uncertainty in the application of test data and the variation in waste forms, that the DR for Type A drums (or equivalent) in this class of accident is 0.01 (DR=0.01), and the DR for SWBs and TDOPs is 0.001 (DR=0.001).

Airborne Release Fraction and Respirable Fraction - The ARF for contaminated combustible materials which are subjected to impact and breach of the waste container is 0.001. This value represents a bounding ARF for packaged material in a container which fails due to impact (DOE-HDBK-3010-94, subsection 5.2.3.2).[5] The bounding RF is 0.1 (DOE-HDBK-3010-94, subsection 5.2.3.2).[5] The ARF for contaminated noncombustible materials which are subjected to impact and breach of the waste container for solids that do not undergo brittle fracture is 0.001. This value represents a bounding ARF for packaged material in a container which fails due to impact (DOE-HDBK-3010-94, subsection 5.3.3.2.2).[5] The bounding RF is 1.0 (DOE-HDBK-3010-94, subsection 5.2.3.2).[5]

Leakpath Factor - Based on the scenario description, it is not expected that a forklift drop in the WHB will also disable the waste handling ventilation or HEPA filtration systems. If forklift drop results in a release to the WHB, the release to the outside environment is mitigated by the permanently installed continuously on-line two-stage HEPA. Although the ventilation system is required to be operational during waste handling operations, active ventilation is not required to prevent a significant release of hazardous materials from the WHB. The intact HEPA filters will maintain the secondary confinement barrier, with a potential for only minor releases via leakage around access doors, etc., resulting from the loss of differential pressure.

The amount of material removed from the air due to the HEPA filters is predicted based on decontamination factors. Decontamination factors have been predicted for accident conditions in ERDA Nuclear Air Cleaning Handbook, ERDA 76-21.[37] Based on this handbook a DF of 5.0E+02 for the first stage and 2.0E+03 for the second stage are recommended. Therefore the total DF used in this analysis for both stages of filtration is 1.0E+06. The leakpath factor is considered as 1.0E-06 for the mitigated case, and for the no-mitigation case a LPF of 1.0 is assumed.

Estimated Consequences and Comparison to Risk Evaluation Guidelines - Based on the data provided in Table A-5 of Appendix A, considering the conditional likelihood of receiving the worst-case analyzed waste container contents and distribution (one waste container >20 PE-Ci, and the remaining at > 2.7 PE-Ci), it is concluded that the frequency for the analyzed worst-case no-mitigation scenario is extremely unlikely. Therefore, the accident risk evaluation guidelines for the extremely unlikely range are used for the comparison of the no-mitigation noninvolved worker and MEI consequences.

Based on the values for the source term variables as presented above, the worst-case no-mitigation MEI and noninvolved worker consequences of the Drop of Waste Containers by forklift in the WHB (CH4) are well within the radiological (see Appendix E, Tables E-25 and E-26) and nonradiological (same as for CH3, Tables E-17 and E-18) risk evaluation guidelines (for the extremely unlikely range) (Table 5.2-3, 5.2-4).

Assessment of Immediate Worker Consequences- No current risk evaluation guidelines exist for the assessment of <u>accident</u> consequences to immediate workers. Therefore, in the absence of guidelines, and for conservatism, the noninvolved worker radiological guidelines are used as a reference point for the assessment of consequences to immediate workers and the evaluation of the adequacy of the WIPP defense-in-depth features. The worst-case consequences to the immediate worker from CH4 (Tables E-52 and E-67) are well within the risk evaluation guidelines. Therefore, no specific additional worker protection engineering or administrative controls beyond those already qualitatively identified as providing defense-in-depth for the immediate worker, are needed based on the quantitative consequence assessment results.

Safety Structures, Systems, and Components - Based on the estimated worst-case no-mitigation MEI and noninvolved worker consequences and comparison to the risk evaluation guidelines, Safety Class or Safety Significant SSCs are not required.

The defense-in-depth SSCs which are applicable to this scenario, per the criteria provided in Chapter 3, Section 3.1.3 are assigned as follows:

- Waste Handling Building Structure - Secondary Confinement
- WHB CH HVAC System - Secondary Confinement
- WHB HEPA Filters - Secondary Confinement
- Vented DOT Type A or equivalent Waste Container - Primary Confinement
- Forklift and Attachments - Minimize Waste Container drops
- Facility Pallet - Designed to minimize waste container drops

Section 5.2.4.1, Evaluation of the Design Basis, discusses in greater detail: (1) the evaluation of safety SSCs, and (2) the applicability of functional and performance requirements (system evaluation) and controls (TSRs). Detailed design descriptions for the above defense-in-depth SSCs may be found in Chapter 4 and the applicable Systems Design Descriptions.

Due to the importance of WIPP programs relating to configuration and document control, quality assurance, conduct of operations, preventative maintenance and inspection, waste handling procedures and training,the WIPP WAC, and the WIPP Emergency Management Program[54] and associated procedures, in the WIPP defense-in-depth strategy for this accident, TSR ACs are derived in Chapter 6 and required in the WIPP TSR Document.

5.2.3.5 CH5 Waste Hoist Failure

Scenario Description - The possibility of a waste hoist failure has been identified as part of the HAZOP[28] performed for the CH TRU Waste Handling system. This scenario represents an internally initiated operational accident which may involve a breach of waste container(s) during a waste hoist failure. Table 5.1-7 lists one waste hoist drop event which results from hoist failure.

The waste hoist is a counterbalanced multi-rope friction hoist that operates a single conveyance in the waste shaft. It is used primarily to transport waste from the surface facilities to the underground repository and secondarily to transport personnel and machinery.

During transportation to the underground, it is postulated that a simultaneous break of the hoisting cables (six) or loss of power event occurs and, a failure in the hoist braking system.

Preventive and Mitigative Features - General preventive and mitigative measures were identified in the HAZOP process for this specific scenario and are listed in Table 5.1-7. These measures should be reviewed to comprehend the amount of features that are in place that either prevent and/or mitigate against this accident. For the no-mitigation case, automatic or manual shift of the underground ventilation system to HEPA filtration is assumed to not respond to mitigate a release for this scenario.

Estimated Frequency - The HAZOP team qualitatively estimated the frequency of occurrence of a hoist failure to be (beyond extremely unlikely) ($10^{-6} \geq$ frequency). This estimated frequency of occurrence has also been verified in Appendix D. As shown in the event tree analysis for this accident scenario in Appendix D, Figure D-5, the annual occurrence frequency of the no-mitigation accident scenario is confirmed to be beyond extremely unlikely. Risk evaluation guidelines are not identified for events with frequency ≤ 1E-06/yr, however, the risk evaluation guidelines for the extremely unlikely range are conservatively used for evaluating the risk associated with this scenario.

As shown in the event tree for this scenario, loss of power (to the hoist motor) is assumed to be the initiating event. WTSD-TME-063, Probability of a Catastrophic Hoist Accident at the Waste Isolation Pilot Plant, July, 1985,[39] identifies four dominant hoist accident scenarios, the most likely is power loss and hoist overtravel up. Power failure may be due to loss of off-site power or coincident with the Design Basis Wind, Tornado, or Earthquake. An evaluation of the off-site power loss frequency is conducted in Table D-9 of Appendix D. Comparing the frequency of the DBE (CH6) and DBT (CH10) with the frequency of off-site power loss indicates that the most likely scenario is loss of off-site power.

Regardless of the initiating event, the hoist brake system functions to prevent the uncontrolled movement of the hoist, and thus prevents the resultant waste container breach accident scenario. Due to the importance of this system, a fault tree analysis[40] on the waste hoist brake system was conducted: (1) to quantify the failure frequency on demand, (2) to verify system reliability, and (3) to identify system improvements or controls. The fault tree analysis of the current hoist configuration quantifies the frequency of failure as 1.3E-07/demand.

Additionally, an analysis has been performed by the Environmental Evaluation Group[41] of the frequency of brake system failure. The extensive uncertainty analysis performed in EEG-59, indicates that the mean frequency of 1.3E-07 corresponds to an 82 percent confidence level. At the 95 percent confidence level, the analysis indicates that the annual failure rate is 4.5E-07. The mean value of 1.3E-07 is used in the event tree in Table D-9 for the failure probability of the brake system. The EEG analysis confirms, that the no-mitigation accident scenario frequency is beyond extremely unlikely.

The primary outcome of both the previous and existing WIPP Waste Hoist Brake System fault tree analyses, and EEG-59 were design changes and identification of administrative controls which significantly enhance the system safety and reliability. As identified in EEG-59, the performance of preoperational tests is of paramount importance to system reliability (for the waste hoist, as well as other WIPP SSCs) , and as such, is a primary element of the first layer of WIPP defense-in-depth. Section 8.3.3.5 discusses the elements of preoperational checks as required by the conduct of operations program.

Source Term Development

Radiological Waste Container Inventory (CI) - Based on the postulated scenario, the CD for this accident has been determined to be 28 drums or four SWBs. As discussed in Section 5.2.1.1, it is assumed that one waste container contains the maximum radionuclide inventory (80 PE-Ci for drums, and 130 PE-Ci for SWBs), and the remaining 27 drums or three SWBs contain an average radionuclide inventory of 8 PE-Ci each and 32 PE-Ci respectively. The waste container is conservatively assumed to contain 95 percent noncombustible material and 5 percent combustible material, as discussed in Section 5.2.1.1.

Nonradiological Waste Container Inventory (CI)- As discussed in Section 5.2.1.1, the nonradiological CI development process for events which involve a breach of a waste container is simplified by assuming that 100 percent of the VOC headspace inventory is released instantaneously. VOCs selected for consideration for accidental releases are listed in Table 5.1-2. These values were scaled for estimating concentrations in the SWBs based on container volumes.

Damage Ratios - As discussed in Section 5.2.1.1, a bounding DR of 0.25 for the drums and for SWBs is assumed.

Airborne Release and Respirable Fraction -The ARF for contaminated combustible materials which are subjected to impact and breach of the waste container is 0.001. This value represents a bounding ARF for packaged material in a container which fails due to impact (DOE-HDBK-3010-94, subsection 5.2.3.2).[5] The bounding RF is 0.1 (DOE-HDBK-3010-94, subsection 5.2.3.2).[5]

The ARF for contaminated noncombustible materials which are subjected to impact and breach of the waste container for solids that do not undergo brittle fracture is 0.001. This value represents a bounding ARF for packaged material in a container which fails due to impact (DOE-HDBK-3010-94, subsection 5.3.3.2.2).[5] The bounding RF is 1.0 (DOE-HDBK-3010-94, subsection 5.2.3.2).[5]

Leakpath Factor - Based on the scenario description, it is not expected that a waste hoist drop in the WHB will also disable the waste handling or underground ventilation or HEPA filtration systems. Shift of the underground ventilation system may occur manually or automatically as discussed in detail in Section 4.4.2.3. However, it is assumed that automatic shift to filtration will not respond to mitigate a release for this scenario. For the mitigated case, it is assumed that the CMR operator will be notified or be aware of the accident and actuate the shift to filtration. Credit is not taken for the natural attenuation provided by the discharge path.

Estimated Consequences and Comparison to Risk Evaluation Guidelines - Based on the values for the source term variables as presented above, the no-mitigation MEI and noninvolved worker consequences (see Appendix E, Tables E-31, E-32, and E-33) of the Waste Hoist Failure (CH5) are well within the radiological and nonradiological risk evaluation guidelines (for the extremely unlikely range). Risk evaluation guidelines are not identified for events with frequency ≤ 1E-06/yr, however, the risk evaluation guidelines for the extremely unlikely range are used for evaluating the risk associated with this scenario.

Assessment of Immediate Worker Consequences- No current risk evaluation guidelines exist for the assessment of accident consequences to immediate workers. Therefore, in the absence of guidelines, and for conservatism, the noninvolved worker radiological guidelines are used as a reference point for the assessment of consequences to immediate workers and the evaluation of the adequacy of the WIPP defense-in-depth features. The worst-case consequences to the immediate worker from CH5 (Table E-53) are well within the risk evaluation guidelines. Therefore, no specific additional worker protection engineering or administrative controls beyond those already qualitatively identified as providing defense-in-depth for the immediate worker, are needed based on the quantitative consequence assessment results.

Safety Structures, Systems, and Components - Based on the estimated worst-case no-mitigation MEI and noninvolved worker consequences and comparison to the risk evaluation guidelines, Safety Class or Safety Significant SSCs are not required.

The defense-in-depth SSCs which are applicable to this scenario, per the criteria provided in Chapter 3, Section 3.1.3 are assigned as follows:

- Underground Ventilation Exhaust System - Secondary Confinement
- Underground Ventilation Exhaust HEPA Filters - Secondary Confinement
- Central Monitoring System (for actuation of underground shift to filtration only) - Secondary Confinement
- Waste Hoist and Brake System - Waste Hoist design to prevent failure resulting in an uncontrolled movement of the hoist
- Vented DOT Type A or equivalent Waste Container - Primary Confinement

Section 5.2.4.1, Evaluation of the Design Basis, discusses in greater detail: (1) the evaluation of safety SSCs, and (2) the applicability of functional and performance requirements (system evaluation) and controls (TSRs). Detailed design descriptions for the above defense-in-depth SSCs may be found in Chapter 4 and the applicable Systems Design Descriptions.

Due to the importance of WIPP programs relating to configuration and document control, quality assurance, conduct of operations (including performance of preoperational checks), preventative maintenance and inspection, waste handling procedures and training, the WIPP WAC, and the WIPP Emergency Management Program[54] and associated procedures, in the WIPP defense-in-depth strategy for this accident, TSR ACs are derived in Chapter 6 and required in the WIPP TSR Document.

5.2.3.6 CH6 Seismic Event

Scenario Description - The possibility of a seismic event has been identified as part of the HAZOP[28] performed for the CH TRU Waste Handling system. This scenario represents a natural phenomena induced accident which may involve the potential breach of waste containers.

As discussed in Chapters 2 and 3 of this SAR, the Design Basis Earthquake (DBE) is the most severe credible earthquake expected to occur at the WIPP Site. The DBE is based on a 1,000-year return interval established through a site specific study. The maximum ground acceleration for the DBE is 0.1 g in both the horizontal and vertical directions, with ten maximum stress cycles.

It is postulated that as a result of the DBE, internal events within the Waste Handling Building (WHB) may cause the loss of <u>primary</u> confinement (e.g. process/equipment disruption resulting in waste container drops/falls and breaches) and release airborne radiological and/or nonradiological hazardous materials. The above ground WHB CH waste handling process was reviewed to determine the process step (1) most vulnerable to the DBE, and (2) bounding in terms of potential to release airborne hazardous materials.

Two process steps were identified: (1) the processes of TRUPACT unloading and movement of waste containers on the facility pallet to the conveyance loading room, and (2) waste storage in the CH Bay for a period of up to five days awaiting transfer to the underground, are considered as the most vulnerable to DBE movement, and bounding in terms of number of waste containers involved (28 drums on facility pallet or four SWBs). As discussed in Chapter 4, the 6-ton TRUDOCK cranes are designed to hold their loads in the event of the DBE. Therefore, no resultant release of hazardous materials can be postulated during TRUPACT unloading.

Design Class II DBE SSCs (see Table 4.1-1), including the WHB structure and structural components, and tornado doors are designed to withstand a DBE free-field horizontal and vertical ground acceleration of 0.1 g, based on a 1,000-year recurrence period, and retain their design function. Additionally, the main lateral force resisting members of the Support Building and Building 412 are DBE designed to protect the WHB from their structural failure.

The original design for WIPP used the 1982 Uniform Building Code and predated both DOE 6430.1A[3] and UCRL-15910.[42] An updated assessment of the DBE was performed in 1990 by Bechtel.[43] The assessment showed that the design classifications shown in the original design for WIPP either met or exceeded the newer standards for DBE for nonreactor facilities.

Based on the discussion in Section 4.3.1.1.1, up to seven facility pallets (196 drums or 28 SWBs) of waste may be stored in the CH Bay for a period of up to five days awaiting transfer to the underground. It can be postulated that drum fall/drops and breaches may occur , however, as a result of: (1) the drop height is less than or equal to 4 feet, (2) the existing process design (Type A container design, facility pallet and tie-down and lateral straps, etc.), no credible release scenario can be postulated.

Therefore, no credible release scenario could be postulated for loss of primary confinement (waste container breach) as a result of the DBE. In conclusion, there are no consequences to the MEI as a result of the WIPP DBE aboveground.

With regard to coincident power loss during a DBE, off-site power loss is analyzed in the initiating event development for the CH2, Crane Failure, and CH5 Waste Hoist Failure accident scenarios. The crane and waste hoist design provides for fail safe condition during loss of power (brake set during loss of power). Also, since the hoist system (headframe, waste shaft, and shaft furnishings) will withstand the DBE, no release scenarios are postulated involving failure of the hoist as a result of a DBE initiating event. The frequency of coincident DBT and/or DBT power loss, and failure of the crane or waste hoist brakes is beyond extremely unlikely. The analyses in CH2 and CH5 consider, in quantification of the event frequency, the more likely scenario of loss of normal off-site power, as opposed to resulting from a less likely DBE. Regardless of initiating event frequency, the consequences of CH2 and CH5, if off-site power loss and failure of the brake systems were to occur, are analyzed for the scenario, in each respective accident scenario evaluation in this section.

Preventive and Mitigative Features - General preventive and mitigative measures identified in the HAZOP process for this specific scenario are listed in Table 5.1-7. These measures should be reviewed to comprehend the amount of features that are in place that either prevent and/or mitigate against this accident.

Estimated Frequency - The DBE is based on a 1,000-year return interval.

Source Term Development - No hazardous material is postulated to be released during the DBE, therefore, no source term is developed.

Estimated Consequences and Comparison to Risk Evaluation Guidelines - No hazardous material is postulated to be released during the DBE, therefore, no consequence analysis is developed.

Safety Structures, Systems, and Components - No hazardous material is postulated to be released during the DBE, therefore Safety Class or Safety Significant SSCs are not required.

The defense-in-depth SSCs which are applicable to this scenario, per the criteria provided in Chapter 3, Section 3.1.3 are assigned as follows:

- Waste Handling Building - WHB structure (includes structure and structural components) designed to prevent failure during a DBE resulting in a loss of secondary confinement

- TRUDOCK Crane and Waste Hoist - WHB 6-ton bridge crane and waste hoist design prevent uncontrolled movement during DBE

- Vented DOT Type A or equivalent Waste Container - Primary Confinement

Section 5.2.4.1, Evaluation of the Design Basis, discusses in greater detail: (1) the evaluation of safety SSCs, and (2) the applicability of functional and performance requirements (system evaluation) and controls (TSRs). Detailed design descriptions for the above defense-in-depth SSCs may be found in Chapter 4 and the applicable Systems Design Descriptions.

As shown in Chapter 6, based on the criteria for assigning Technical Safety Requirement (TSR) Limiting Conditions for Operation (LCOs), these equipment are not assigned TSR LCOs. However, due to the importance of DBE qualification, and programs relating to configuration and document control, quality assurance, preventative maintenance and inspection, the WIPP WAC, and the WIPP Emergency Management in the WIPP defense-in-depth strategy for this accident, TSR ACs are derived in Chapter 6 and required in the WIPP TSR Document.

5.2.3.7 CH7 Spontaneous Ignition (Drum) in the Underground

The spontaneous ignition within a drum in the underground horizon is an internally initiated accident resulting from failure to conform to the WIPP WAC,[29] which prohibits pyrophorics in a waste container. With the generic information available to it, the HAZOP team qualitatively estimated the frequency of a release as the result of spontaneous ignition to be in the unlikely range ($10^{-2} \geq$ frequency $> 10^{-4}$/year). The quantitative accident evaluation presented here makes use of the information contained in the BIR to estimate the frequency of releases of varying magnitudes resulting from a sustained drum fire based on radionuclide concentration, final waste form, and method of verification of conformance to the WIPP WAC.

Scenario Description - The HAZOP for CH TRU Waste Handling System postulates a spontaneous ignition within a drum in route to or within the waste disposal panel. The most likely area is within a panel room where drums are being emplaced. Based on DOE/WIPP 87-005,[31] Waste Drum Fire Propagation at the WIPP, the fire is not postulated to propagate to additional drums.

The frequency and magnitude of potential releases depend on the number of drums having a given quantity of TRU waste, that also contain an ignition source, as well as sufficient combustible material (heat of combustion) and oxidant to generate the energy needed to produce a breach.

Although the primary confinement (waste container) is assumed to breach and result in a release of radiological and nonradiological material within the underground, it is not expected to result in a loss of secondary confinement. As discussed in Section 4.4, the underground secondary confinement consists of the natural barrier formed by the salt in the underground disposal areas or the underground bulkheads, separating the disposal and mining areas, and the underground ventilation system. Shifting of the exhaust system to the filtration mode can be accomplished manually either locally at the exhaust filtration building or by the Central monitoring room (CMR) operator, or automatically due to a continuous air monitor (CAM) alarm logic sequence.

Preventive and Mitigative Features - General preventive and mitigative measures identified in the HAZOP process for this specific scenario are listed in Table 5.1-7. For the no-mitigation case: (1) automatic shift of the underground ventilation system to HEPA filtration is assumed to not respond to mitigate a release for this scenario. Additionally, a spontaneous ignition release may go undetected during nonworking hours, and thus unlike the underground waste handling scenarios, it is assumed that the CMR operator will not be notified or be aware of the accident and actuate the shift to filtration.

The primary means of preventing spontaneous ignition is compliance with the WAC. Given a drum conforms to the WAC, the frequency of spontaneous ignition is considered to be negligibly small. Therefore, drums will be part of a population of drums that is susceptible to spontaneous ignition only if an error has been made in verifying their conformance to the WAC, which involves human error at the generator sites. The potential for these errors depends on both the final waste form and the method by which verification to the WAC is achieved (see Section 5.1.2.2), both of which are discussed further under estimated frequency.

Only that portion of the panel that is being actively ventilated is capable of producing consequences to humans. A release from a drum within a room that has already been isolated from ventilation has no motive force to propagate the released material beyond the immediate vicinity of the drum.

Estimated Frequency - As part of the HAZOP[28], the team qualitatively estimated the frequency of occurrence of each event. Based on this study, the frequency of occurrence of a spontaneous ignition has been estimated to be in the unlikely range ($10^{-2} \geq$ frequency $> 10^{-4}$). However, based on a quantitative evaluation using conservative assumptions documented in Appendix D the quantification of CH7 indicates that the overall frequency of release is extremely unlikely (10^{-4}/year $\geq$ frequency $> 10^{-6}$/year) considering all final waste forms and waste drum TRU loadings. However, the frequency of release from a drum containing more than 8 PE-Ci of TRU waste is beyond extremely unlikely (frequency $\leq$ 1E-06/yr).Risk evaluation guidelines for the extremely unlikely range are used for evaluating the risk associated with this scenario.

The frequency of CH7 is calculated in Table D-15 for final waste forms and distributions of drum loading obtained from the BIR. The analytical model and supporting evidence that produced these results are presented in Tables D-1 through D-7, and an event tree illustrating the sequence of events resulting in consequences from sustained combustion within a waste drum in the underground is shown in Figure D-6. As spontaneous ignition initiates inside the drum, the model of the accident frequency is the same as CH1, with the only exception being the total volume of waste susceptible to combustion. Consequently only the aspects of the scenario that are unique to the underground will be discussed here.

The calculation of the frequency of sustained combustion due to spontaneous ignition is illustrated by the event tree in Figure D-6. As done in CH1, the event tree calculates the frequency of release for TRU waste streams categorized as combustible. The calculation of the spontaneous ignition frequency is shown in Table D-14. The volume of TRU waste at risk for a spontaneous ignition in an area where it can produce a consequence is the time averaged volume present during emplacement in a ventilated panel room. The time averaged value is used because it is anticipated that the room will be filled at a relatively constant throughput rate, with the average value being most representative of the volume that will actually be at risk.

Table D-15 calculates the overall frequency of release due to spontaneous ignition for all 78 combinations of Final Waste Form, processing/repackaging plans, and radionuclide content per drum. It can be seen from this table that the overall frequencies of sustained combustion within the ventilated U/G is approximately 5.3E-06/year, in the range of extremely unlikely accidents. However, less than two percent of this frequency (8.6E-08/year) involves drums containing over 20 PE-Ci of TRU waste, the consequences of which are calculated assuming a bounding content of 80 PE-Ci. Moreover, over 90 percent of the frequency involves drums that will have at least an order of magnitude less consequence than the bounding case. Therefore, one may conclude that releases due to spontaneous ignition in the actively ventilated U/G horizon that would involve a drum containing more than 8 PE-Ci/drum are beyond extremely unlikely.

Source Term Development

Radiological Waste Container Inventory (CI) - Based on the postulated scenario, the radiological CI for this accident has been determined to be the maximum inventory contained in a single drum(CD=1). As discussed in Section 5.1.2, a maximum drum inventory has been established as 80.0 PE-Ci which provides the radiological CI for a spontaneous ignition within a drum.

Nonradiological Waste Container Inventory (CI) - As discussed in Section 5.1.2, the solid and liquid chemical compound concentrations that would be expected to be within a waste container (Table 5.1-3) are used as the nonradiological CI.

Airborne Release Fraction - The ARF for combustible materials in a drum is 5.0E-04 and the airborne release fraction for noncombustible materials in a drum is 6.0E-03. These values represent bounding airborne release fractions for the burning of contaminated packaged mixed waste and the heating of noncombustible contaminated surfaces (DOE-HDBK-3010-94, subsection 5.2.1.1 and 5.3.1).[5]

Respirable Fraction - The bounding RFs for the burning of contaminated packaged mixed waste and the heating of noncombustible contaminated surfaces are 1 and 1.0E-02, respectively (DOE-HDBK-3010-94, subsection 5.2.1.1 and 5.3.1).[5]

Damage Ratio - The accident scenario involves a spontaneous ignition in a drum, therefore it is necessary to discuss the amount of material that will burn (combustible fraction) and the amount of material that will be subjected to thermal stress (heating without ignition) (noncombustible fraction) in order to determine the amount of material that could be released to receptors of concern. The waste form within a drum (combustibles vs noncombustibles) is estimated based on information provided in Section 5.2.1.1. Combustible waste is defined as consisting of paper, kimwipes, and cloth (dry and damp); various plastics such as polyethylene and polyvinyl chloride; wood; and filters contaminated with trace quantities of halogenated organic solvents.

The combustible waste distribution is conservatively assumed to be 95 percent of the waste container contents. The remainder of the material in the drum (five percent) is assumed to be noncombustible (sludges, filters, asphalt, soil, glass, metal, other). The radioisotopes within the drum are assumed to be evenly distributed throughout the waste in the drum, therefore 95 percent of the radioactivity is assumed to be combustible material at risk and five percent of the radioactivity is assumed to be noncombustible material at risk.

For internal waste container fire as a result of spontaneous ignition, it is conservatively assumed that sufficient internal pressure is generated as a result of the accident phenomenon to cause a breach of the waste container. As a result of the airborne release generated by the fire phenomenon, it is conservatively assumed that the DR for this scenario is 1.0 (DR=1.0).

Leakpath Factor - Based on the scenario description, it is not expected that the internal waste container fire will also disable the underground ventilation or HEPA filtration systems. Shift of the underground ventilation system may occur manually or automatically as discussed in detail in Section 4.4.2.3. However, shift to filtration is not assumed to occur in this scenario. A spontaneous ignition release may go undetected during nonworking hours, and thus unlike the underground waste handling scenarios, it is assumed that the CMR operator will not be notified or be aware of the accident and actuate the shift to filtration. Credit is not taken for the natural attenuation provided by the discharge path.

Estimated Consequences and Comparison to Risk Evaluation Guidelines - Based on the values for the source term variables as presented above, the no-mitigation MEI and noninvolved worker consequences (see Appendix E, Tables E-34, E-35, E-36, and E-37) of a spontaneous ignition in the Underground (CH7) are well within the radiological and nonradiological risk evaluation guidelines (for the extremely unlikely range). Risk evaluation guidelines are not identified for events with frequency ≤ 1E-06/yr, however, the risk evaluation guidelines for the extremely unlikely range are used for evaluating the risk associated with this scenario.

Assessment of Immediate Worker Consequences- No current risk evaluation guidelines exist for the assessment of accident consequences to immediate workers. Therefore, in the absence of guidelines, and for conservatism, the noninvolved worker radiological guidelines are used as a reference point for the assessment of consequences to immediate workers and the evaluation of the adequacy of the WIPP defense-in-depth features. The worst-case consquences to the immediate worker from CH7 (Table E-54) are well within the risk evaluation guidelines. Therefore, no specific additional worker protection engineering or administrative controls beyond those already qualitatively identified as providing defense-in-depth for the immediate worker, are needed based on the quantitative consequence assessment results.

Safety Structures, Systems, and Components - Based on the estimated worst-case no-mitigation MEI and noninvolved worker consequences and comparison to the risk evaluation guidelines, Safety Class or Safety Significant SSCs are not required.

The defense-in-depth SSCs which are applicable to this scenario, per the criteria provided in Chapter 3, Section 3.1.3 are assigned as follows:

- Underground Ventilation Exhaust System - Secondary Confinement

- Underground Ventilation Exhaust HEPA Filters - Secondary Confinement

- Radiation Monitoring System (active waste disposal room exit alpha CAM for underground shift to filtration) - Secondary Confinement

- Central Monitoring System (for actuation of underground shift to filtration only) - Secondary Confinement

- Vented DOT Type A or equivalent Waste Container - Primary Confinement

Section 5.2.4.1, Evaluation of the Design Basis, discusses in greater detail: (1) the evaluation of safety SSCs, and (2) the applicability of functional and performance requirements (system evaluation) and controls (TSRs). Detailed design descriptions for the above defense-in-depth SSCs may be found in Chapter 4 and the applicable Systems Design Descriptions.

Due to the importance of WIPP programs relating to configuration and document control, quality assurance, conduct of operations, preventative maintenance and inspection, waste handling procedures and training, and the WIPP Emergency Management Program[54] and associated procedures, in the WIPP defense-in-depth strategy for this accident, TSR ACs are derived in Chapter 6 and required in the WIPP TSR Document.

Due to the importance of the WIPP WAC to restrict waste elements (such as the presence of pyrophorics) that may cause the initiating event for this accident, a TSR AC is derived in Chapter 6 and required in the WIPP TSR Document.

5.2.3.8 CH8 Aircraft Crash

Scenario Description - The possibility of an aircraft crash into the WHB has been identified as part of the HAZOP[28] performed for the CH TRU Waste Handling system. This scenario represents an external accident which may involve the potential breach of waste containers. It is postulated that a military or civilian aircraft crashes into the WHB. For the development of the frequency of aircraft crashes, the U.S. Nuclear Regulatory Commission Standard Review Plan (SRP) NUREG-0800[44] is used. This SRP provides criteria for the development of frequencies of aircraft accidents to be used in analyses for nuclear power plants. The SRP provides criteria for crash frequency contributions associated with airport operations (takeoffs and landings), and federal airway activity (overflights).

As described in Chapter 2 of this SAR, two federal ten-mile wide airways (one jet route and one low-altitude route) pass within five miles of the WIPP. Traffic data show that the combined traffic is about 28 instrument flight rule flights per day.

There are no airports or approaches within a five-mile radius of the WIPP. The nearest airstrip, 12 miles north of the site, and privately owned by Transwestern (TW) Pipeline Co. is no longer in use and TW filed for abandonment in 1990 with the Federal Aviation Administration. The nearest commercial airport is in Carlsbad (28 miles to the west).

There are no military facilities within a five mile radius of the WIPP, however, some military installations in New Mexico and Texas have operations that might affect the WIPP (the closest is Holloman Air Force Base, 138 miles NW of the site).

Using NUREG-800[44], the total aircraft hazard probability (combined airway, and airport) at the WIPP site is 1.2E-07/yr.

Preventive and Mitigative Features - Air space above facility not part of normal flight patterns and WIPP is in a remote location.

Estimated Frequency - The HAZOP team qualitatively estimated the frequency of occurrence of an aircraft crash to be beyond extremely unlikely ($10^{-6} \geq$ frequency). This estimated frequency of occurrence has also been verified in Appendix D using NUREG-0800[44], considering the total aircraft hazard probability (combined airway, airport, and military designated airspace operations probability of an aircraft crash).

Source term Development - The frequency of the accident scenario is beyond extremely unlikely therefore, source term development is unnecessary.

Estimated Consequences and Comparison to Risk Evaluation Guidelines - The frequency of the accident scenario is beyond extremely unlikely therefore, consequence analysis is unnecessary.

Assessment of Immediate Worker Consequences- As discussed in Section 5.2.1.2, this scenario is not evaluated for immediate worker consequences.

Safety Structures, Systems, and Components - This scenario is considered beyond extremely unlikely and no hazardous material is postulated to be released during this scenario, therefore, no Safety Class or Safety Significant SSCs are required.

There are no defense-in depth SSCs applicable to this scenario, per the criteria provided in Chapter 3, Section 3.1.3.

5.2.3.9 CH9 Drop of Waste Containers by Forklift in the Underground

Scenario Description - The possibility of waste container breaches due to drops in the underground was identified in the HAZOP[28] performed for the CH TRU Waste Handling system. This scenario represents an internally initiated operational accident which involves a breach of waste container(s) during waste emplacement. For this type of event Table 5.1-7 lists one forklift mishap/breach event which results from the operator not observing the floor distortion which causes the forklift to tip and result in dropping of the load. Floor surveys and MSHA inspections are conducted to preclude this type of event, however it is assumed the drop could also occur not only from human error but also from equipment failure. The drop of waste containers from a forklift during waste emplacement operations in the underground bounds all other forklift drops due to the total number of waste containers involved during these operations.

Once the waste containers are at the bottom of the waste shaft, the pallet locking pins are removed and the facility pallet is pulled from the hoist to the transporter with a hydraulic driven screw hook latch. The transporter then carries the pallet to the emplacement area.

In the emplacement room, the tie-down and lateral straps are removed and a fork lift is used to place the waste containers in their final location. The fork lift uses a solid platform with a hydraulic push-pull device to handle the seven-drum arrays or a vertical tanged lifting device to engage the standard waste box lifting slots. The operator, aided by a spotter and the transporter operator, places the waste containers in the desired emplacement position (seven-drum arrays, stacked three layers high, or single SWBs stacked three layers high).

During emplacement of a seven-or 14-drum array, or one or two SWBs, the operator is assumed to improperly disengage the forklift and the waste containers drop from a height of greater than 4 ft, causing a breach of seven drums or a single SWB.

Although the primary confinement (waste container) is assumed to breach and result in a release of radiological and nonradiological material within the underground it is not expected to result in a loss of secondary confinement. As discussed in Section 4.4, the underground secondary confinement consists of the natural barrier formed by the salt in the underground disposal areas or the underground bulkheads, separating the disposal and mining areas, and the underground ventilation system. Shifting of the exhaust system to the filtration mode can be accomplished manually either locally at the exhaust filtration building or by the CMR, or automatically due to a CAM alarm logic sequence.

Preventive and Mitigative Features - General preventive and mitigative measures identified in the HAZOP process for this specific scenario are listed in Table 5.1-7. For the no-mitigation case, automatic or manual shift of the underground ventilation system to HEPA filtration is assumed to not respond to mitigate a release for this scenario.

Estimated Frequency - The HAZOP team qualitatively estimated the frequency of a drop of waste containers to be in the unlikely range ($10^{-2} \geq$ frequency $> 10^{-4}$). As shown in the event tree analysis for this accident scenario in Appendix D, Figure D-7, the quantitative evaluation of the no-mitigation annual occurrence frequency of the accident scenario is also in the unlikely range.

Source Term Development

Radiological Waste Container Inventory (CI)- Based on the postulated scenario, the CD for this accident has been determined to be the inventory contained in seven drums or one SWB. As discussed in Section 5.2.1.1, it is assumed that one waste container contains the maximum radionuclide inventory (80 PE-Ci for drums, and 130 PE-Ci for SWBs), and the remaining six drums contain an average radionuclide inventory of 8 PE-Ci each. The SWB is assumed to be at the maximum CI. The waste container is conservatively assumed to contain 95 percent noncombustible material and 5 percent combustible material, as discussed in Section 5.2.1.1.

Nonradiological Waste Container Inventory (CI)- As discussed in Section 5.2.1.1, the nonradiological CI development process for events which involve a breach of a waste container is simplified by assuming that 100 percent of the VOC headspace inventory is released instantaneously. VOCs selected for consideration for accidental releases are listed in Table 5.1-2. These values were scaled for estimating concentrations in the SWBs based on container volumes.
Damage Ratio- As discussed in Section 5.2.1.1, for drops of waste containers from the heights associated with drops from the third layer of the waste stack (from heights equal to or less than 10 ft (5 ft $<$ h $\leq$ 10 ft)), based on analyses,[10] it is conservatively assumed using engineering judgement, to encompass the uncertainty in the application of test data and the variation in waste forms, that the DR for Type A drums (or equivalent) in this class of accident is 0.025 (DR=0.025), and the DR for SWBs and TDOPs is 0.01 (DR=0.01).

Airborne Release and Respirable Fraction - The ARF for contaminated combustible materials which are subjected to impact and breach of the waste container is 0.001. This value represents a bounding ARF for packaged material in a container which fails due to impact (DOE-HDBK-3010-94, subsection 5.2.3.2).[5] The bounding RF is 0.1 (DOE-HDBK-3010-94, subsection 5.2.3.2).[5]

The ARF for contaminated noncombustible materials which are subjected to impact and breach of the waste container for solid that do not undergo brittle fracture is 0.001. This value represents a bounding ARF for packaged material in a container which fails due to impact (DOE-HDBK-3010-94, subsection 5.3.3.2.2).[5] The bounding RF is 1.0 (DOE-HDBK-3010-94, subsection 5.2.3.2).[5]

Leakpath Factor - Based on the scenario description, it is not expected that a waste container drop in the underground will also disable the underground ventilation or HEPA filtration systems. Shift of the underground ventilation system may occur manually or automatically as discussed in detail in Section 4.4.2.3. However, it is assumed that an automatic shift to filtration will not respond to mitigate a release for this scenario. For the mitigated case, it is assumed that the CMR operator will be notified or be aware of the accident and actuate the shift to filtration. Credit is <u>not</u> taken for the natural attenuation provided by the discharge path.

Estimated Consequences and Comparison to Risk Evaluation Guidelines -Based on the data provided in Table A-5 of Appendix A, considering the conditional likelihood of receiving the analyzed worst-case waste container contents and distribution (1 waste container >20 PE-Ci, and the remaining at > 2.7 PE-Ci), it is concluded that the frequency for the analyzed worst-case no-mitigation scenario is extremely unlikely. Therefore, the accident risk evaluation guidelines for the extremely unlikely range are used for the comparison of the no-mitigation noninvolved worker and MEI consequences.

Based on the values for the source term variables as presented above, the worst-case no-mitigation MEI and noninvolved worker consequences (see Appendix E, Tables E-38, E-39, and E-40) of a drop of waste containers from a forklift in the underground (CH9) are well within the radiological and nonradiological risk evaluation guidelines (for the extremely unlikely range) (Table 5.2-3, 5.2-4).

Assessment of Immediate Worker Consequences- No current risk evaluation guidelines exist for the assessment of <u>accident</u> consequences to immediate workers. Therefore, in the absence of guidelines, and for conservatism, the noninvolved worker radiological guidelines are used as a reference point for the assessment of consequences to immediate workers and the evaluation of the adequacy of the WIPP defense-in-depth features. The worst-case consequences to the immediate worker from CH9 (Tables E-55 and E68) are well within the risk evaluation guidelines. Therefore, no specific additional worker protection engineering or administrative controls beyond those already qualitatively identified as providing defense-in-depth for the immediate worker, are needed based on the quantitative consequence assessment results.

Safety Structures, Systems, and Components - Based on the estimated worst-case no-mitigation MEI and noninvolved worker consequences and comparison to the risk evaluation guidelines, Safety Class or Safety Significant SSCs are not required.

The defense-in-depth SSCs which are applicable to this scenario, per the criteria provided in Chapter 3, Section 3.1.3 are assigned as follows:

- Underground Ventilation Exhaust System - Secondary Confinement

- Underground Ventilation Exhaust HEPA Filters - Secondary Confinement

- Radiation Monitoring System (active waste disposal room exit alpha CAM for underground shift to filtration) - Secondary Confinement

- Central Monitoring System (for actuation of underground shift to filtration only) - Secondary Confinement
- Vented DOT Type A or equivalent Waste Container - Primary Confinement
- Forklift and Attachments - Designed to minimize waste container drops
- Facility Pallet - Designed to minimize waste container drops

Section 5.2.4.1, Evaluation of the Design Basis, discusses in greater detail: (1) the evaluation of safety SSCs, and (2) the applicability of functional and performance requirements (system evaluation) and controls (TSRs). Detailed design descriptions for the above defense-in-depth SSCs may be found in Chapter 4 and the applicable Systems Design Descriptions.

Due to the importance of WIPP programs relating to configuration and document control, quality assurance, conduct of operations, preventative maintenance and inspection, waste handling procedures and training, the WIPP WAC, and the WIPP Emergency Management Program[54] and associated procedures, in the WIPP defense-in-depth strategy for this accident, TSR ACs are derived in Chapter 6 and required in the WIPP TSR Document.

5.2.3.10 CH10 Tornado Event

The processes at WIPP have been examined for the need to protect against high wind, tornado, and wind blown missiles. Underground facilities are inherently protected against these phenomenon, and as such, the examination deals only with surface facilities. Areas of concern for the release of radiological and nonradiological hazardous materials associated with TRU waste are: (1) TRUPACT-II transporter parking and unloading area; (2) TRUPACT-II and waste handling areas within the WHB, the waste hoist, and WHB and underground ventilation systems. These are described below:

- The TRUPACT-II container is designed to withstand the effects of high wind, tornado, tornado driven missiles, and overturning without the release of waste contents as part of the TRUPACT-II Safety Analysis Report for Packaging (SARP).
- The WHB and waste hoist are protected by the WHB steel frame structure with insulated steel siding, and the tornado doors. The structure, and doors, passively withstand the winds, pressure change, and missile forces to ensure that the waste and waste hoist are not subjected to unacceptable forces.
- The WHB exhaust system and HEPA filters are contained within the WHB and are protected from wind forces and missiles by the tornado hardened features of the building structure and the tornado hardened closures (doors). The ventilation system is not required to remain operating during and after the tornado, but rather is protected against dispersal of minor contamination on HEPA filters. No tornado coincident need for confinement active ventilation is postulated due to the extremely low tornado frequency and the absence of common cause events since all crane and hoisting mechanisms are protected (with braking systems that actuate upon loss of power) from accident conditions due to loss of power.

- Underground ventilation is designed to function through DBE/DBT phenomenon, however, as discussed above, is not required to function during the extremely unlikely DBT. Since coincident events such as radionuclide release in the underground and DBT are not coincident or common cause design basis conditions, the function or protection of the intake or exhaust equipment is not required.

Scenario Description - The possibility of a tornado event has been identified as part of the HAZOP[28] performed for the CH TRU Waste Handling system. This scenario represents a natural phenomena induced accident which may involve the potential breach of waste containers.

As discussed in Chapters 2 and 3 of this SAR the Design Basis Tornado (DBT) is the most severe credible tornado that could occur at the WIPP Site. The DBT used for the WIPP has a maximum wind speed of 183 mi/hr (including effects of suction vortices), translational velocity of 41 mi/hr, tangential velocity of 124 mi/hr, a 325 ft radius of maximum wind, pressure drop of 0.5 lb/in^2, and rate of pressure drop of 0.09 lb/in^2/sec, with a mean recurrence interval of 1,000,000 years.

Design Class II DBT SSCs (see Table 4.1-1) are designed to withstand winds generated by this tornado (183 mi/h), based on a 1,000,000-year recurrence period, and retain their safety function. The WHB structure and structural components, including tornado doors are designed to withstand the DBT.

Therefore, no credible internal events within the WHB can be postulated to cause the loss of primary confinement (e.g. process/equipment disruption resulting in waste container drops/falls and breaches) and release airborne radiological or nonradiological hazardous materials as a result of the DBT.

With regard to coincident power loss during a DBT, off-site power loss is analyzed in the initiating event development for the CH2, Crane Failure, and CH5 Waste Hoist Failure accident scenarios in this section. The crane and waste hoist design provides for fail safe condition during loss of power (brake set during loss of power). The frequency of coincident DBT caused power loss and failure of the crane or waste hoist brakes is beyond extremely unlikely. The analyses in CH2 and CH5 consider, in quantification of the event frequency, the more likely scenario of loss of normal off-site power, as opposed to resulting from a less likely DBT. The consequences of CH2 and CH5, if off-site power loss and failure of the brake systems were to occur, are analyzed in each respective accident scenario evaluation in this section.

With regard to the effects of missiles generated by the DBT, the WIPP is designed on a single failure basis. It is considered incredible that two or more failure events (breach of waste handling building and breach of waste container by a DBT missile which results in a release of significant quantities of radionuclides that require confinement) can occur simultaneously, therefore, the effects of missiles are not evaluated.

Table 4.1-1, identifies those Design Class II and IIIA DBT SSCs, Table 3.1-2 identifies the applicable design code requirements, and Section 3.2 identifies the applicable DBT structural design criteria for WIPP DBT SSCs. Detailed design information may be found in the respective System Design Description.

Design Class II and IIIA SSCs from Table 4.1-1 applicable to the DBT aboveground are the:

- WHB structure and structural components including tornado doors - Design Class II (Provides physical confinement)

Additionally, the Auxiliary Air Intake Shaft and Tunnel (Bldg. 465) is DBT, and the main lateral force resisting members of the support building and building 412 are DBT designed to protect the WHB from their structural failure.

As shown in Table 3.1-2, Design Class II, and IIIA structures and supports necessary for the confinement of radioactivity are DBT designed. The function provided is to prevent tornado forces or missiles from causing failure of the primary confinement boundaries (waste containers). Therefore, no releases of hazardous materials are postulated as a result of the WIPP DBT designed mitigative/preventative SSCs.

Preventive and Mitigative Features - General preventive and mitigative measures identified in the HAZOP process for this specific scenario are listed in Table 5.1-7.

Estimated Frequency - The Design Basis Tornado (DBT) is the most severe credible tornado (183 mi/hr) that could occur at the WIPP site, based on a 1,000,000-year recurrence period.

The DBT was developed by a site specific study SMRP No. 155, "A Site-Specific Study of Wind and Tornado Probabilities at the WIPP Site in Southeast New Mexico," Department of Geophysical Sciences, T. Fujita, University of Chicago, February 1978 and its Supplement of August 1978.[45]

Source Term Development - No hazardous material is postulated to be released as a result of the DBT, therefore, the source term development is not required.

Estimated Consequences and Comparison to Risk Evaluation Guidelines - No hazardous material is postulated to be released as a result of the DBT, therefore, consequence analysis is not required.

Assessment of Immediate Worker Consequences- As discussed in Section 5.2.1.2, this scenario is not evaluated for immediate worker consequences.
Safety Structures, Systems, and Components - No hazardous material is postulated to be released during the DBT; therefore, Safety Class or Safety Significant SSCs are not required.

The defense-in-depth SSCs which are applicable to this scenario, per the criteria provided in Chapter 3, Section 3.1.3 are assigned as follows:

- Waste Handling Building - WHB structure (includes structure and structural components) designed to prevent failure during a DBT resulting in a loss of secondary confinement

Additionally, the main lateral force resisting members of the support building and building 412 are DBT designed to protect the WHB from their structural failure.

Section 5.2.4.1, Evaluation of the Design Basis, discusses in greater detail: (1) the evaluation of safety SSCs, and (2) the applicability of functional and performance requirements (system evaluation) and controls (TSRs). Due to the importance of DBT qualification, and programs relating to configuration and document control, quality assurance, preventative maintenance and inspection, the WIPP WAC, and the WIPP Emergency Management Program, in the WIPP defense-in-depth strategy for this accident, TSR ACs are derived in Chapter 6 and required in the WIPP TSR Document.

5.2.3.11 CH11 Underground Roof Fall

Scenario Description - The possibility of waste container breaches due to a roof fall in the underground was identified in the HAZOP[28] performed for the CH TRU Waste Handling system. Given the evidence available to it, the HAZOP team qualitatively estimated the frequency of releases from roof fall events to be in the unlikely range ($10^{-2} \geq$ frequency $> 10^{-4}$), indicating that further evidence should be collected to gain a better quantitative estimate of the frequency.

Roof fall is a natural event that has the potential to breach drums through either direct damage to the drums or by causing drums to fall from the storage stack. Table 5.1-7 lists two nodes where roof fall events can occur: in a disposal panel and in the life of facility area.

A roof fall event in an actively ventilated storage room during emplacement operations in the underground bounds all other roof falls because waste containers are present in the area during these operations and there is a mechanism present to transport hazardous material to the external environment. The CH11 scenario described in this section quantifies the anticipated frequency and consequences of this event.

The following scenarios related to other areas in an active panel or life of facility area are not quantified for the reasons given:

- A roof fall in a room of an active panel that has been filled with waste containers and isolated by the room ventilation barriers is expected to produce no consequences because of the lack of a significant motive force. There is a possibility of an initial pressure pulse due to the disruption, but a majority of the displaced air is expected to flow into the voids in the roof (back) created by the falling salt. Unless a roof fall event occurs on a barrier, the room ventilation barriers are expected to prevent a significant puff release of hazardous material into the ventilated portion of the repository. In addition, if the roof fall occurs in anywhere but the most recently filled room, there will be multiple ventilation barriers in place with emplaced drums on both sides of the barrier to provide additional assurance that material will not reach the ventilated area. PLG-1167, Analysis of Roof Falls and Methane Gas Explosions in Closed Rooms and Panels,[11] judged the conditional likelihood that the chain-link/brattice cloth ventilation barrier system will fail to continue to isolate ventilation to a closed room to no greater than 1E-4.

- PLG-1167,[11] also concluded that, that a breach of waste drums due to expected energy absorption mechanisms is highly unlikely. The anticipated crushing action will tend to fold over the sides of the drums as a result of plastic deformation, rather than splitting them open. In addition, it is judged that the falling salt will tend to crush lids into the drums rather than dislodge them. Thus, two of the primary failure mechanisms leading to releases should have a minimal impact. The analysis did not take into account failure mechanisms due to irregularities in the falling salt and the support system that may have been emplaced in the roof prior to waste emplacement. These mechanisms can not be completely discounted, but by their very nature they should produce localized effects that do not involve many drums. Accounting for the uncertainties involved in actual roof fall events, the likelihood that a significant release from drums may occur as a result of a roof fall is assessed to be 1E-3. This likelihood is considered to be a conservative but reasonable upper bound because the material must be released from the drums but not entombed by the salt. Hazardous material will be available for transport to the actively ventilated portion of the mines only if both these conditions are met.

- Combining the above two likelihoods with the likelihood of a roof fall in a closed room, (PLG-1167 [11]) the overall frequency of a release from drums to the ventilated area of the mine is 1E-7 per year.

- After a panel has been filled, the panel closure is designed to provide isolation of that panel from the rest of the mine.

- Although roof falls in the active life of facility areas of the mine could potentially injure personnel or damage equipment within the affected area, the frequency that such a roof fall could damage drums is extremely remote, because of the small amount of time that a facility pallet is in transit in the underground.

The roof fall accident analysis focuses on panel 1, as it is considered the most susceptible to roof fall. Panels 2 through 8 will be mined, filled with waste, and closed before a roof fall in these panels becomes a concern. Each panel can be mined in about two years. Based on the throughput described in Chapter 4, an individual panel will be filled in approximately 2.5 years, yielding a total open life of approximately 4.5 years. Newly mined rooms are expected to remain stable against roof fall for the expected length of time to completely fill and close a panel at the expected throughput. As evidence to support this, Room 1 in the Site and Preliminary Design Validation (SPDV) was eight years old when the roof fall occurred in 1991 (DOE/WIPP 93-033).[46] In addition, ground control operations will be conducted in each panel room segment prior to the emplacement of waste to provide high confidence that a roof fall will not occur during emplacement.[48,49]

The events necessary for a roof fall in an actively ventilated room containing drums are shown in the fault tree given in Appendix D, Figure D-9. For completeness, the analysis considers roof fall due to:

- Anticipated/Observable Failure Mechanisms. This event addresses the failure mechanisms characterized and discussed by the Geotechnical Expert Panel in DOE/WIPP 91-023.[47] DOE/WIPP 93-033[46] provides very strong arguments for the assertion that the progression of salt instabilities that lead to roof fall due to known mechanisms is very gradual, occurring on the order of months to years after the precursor instability is revealed by monitoring. WIPP/WID-94-2027[48] describes the WIPP program to characterize, monitor, and trend salt behavior that might result in roof fall in Panel 1 due to these mechanisms, so that remedial actions may be formulated as deemed necessary.

- Unanticipated/Unobservable Failure Mechanisms. This event assesses the likelihood that, despite all the efforts to characterize, prevent, and monitor salt behavior that might result in roof fall, a surprise roof fall could occur with no prior observable indications.

Should a roof fall occur, it is postulated that it would be of size equivalent to the roof fall that occurred in the Site and Preliminary Design Validation (SPDV) Room 1 on February 4, 1991 (DOE/WIPP 93-033).[46] The section that fell was in the shape of an elongated pyramid approximately 33 ft wide by seven ft high by 180 ft long, and weighed about 700 tons. The roof fall is expected to produce a static force in the vertical direction of approximately 143 lb_m/ft.[3]

Waste containers may be breached by either being directly damaged by the falling salt, or by being knocked from the waste container stack by lateral forces generated by the stack matrix recoiling from the impact of the fall. An engineering evaluation of the response of the waste container stack to forces generated directly by the falling salt indicate that it is highly unlikely to produce a breach in the drum stack.[10] Even if some of the containers are breached by the falling salt, the material is expected to provide a natural barrier against the transport of the waste, and the material available to be released will be minimal. Therefore, the scenario produced by lateral displacement of the drums is assumed to be bounding for the purposes of calculating consequences.

As a bounding case for consequence analysis, it is hypothesized that up to seven 7-packs may fall from the third level at the edge of the stack. This is equivalent to every 7-pack at the leading edge of the waste container stack. Furthermore, as a result of the fall an average of three drums per 7-pack are breached, producing a source term involving release from a total of 21 drums.

Although the primary confinement (waste container) may breach and result in a release of radiological and nonradiological material within the underground it is not expected to result in a loss of secondary confinement. As discussed in Section 4.4, the underground secondary confinement consists of the natural barrier formed by the salt in the underground disposal areas or the underground bulkheads, separating the disposal and mining areas, and the underground ventilation system. Shifting of the exhaust system to the filtration mode can be accomplished manually either locally at the exhaust filtration building or by the central monitoring room (CMR) operator, or automatically due to a CAM alarm logic sequence.

Preventive and Mitigative Features - General preventive and mitigative measures identified in the HAZOP process for this specific scenario are listed in Table 5.1-7. Evidence available to the WIPP regarding salt mechanics indicates that a roof fall will result from instabilities that progress very gradually and can be observed.[46,47] A vigorous geotechnical monitoring and ground control program is in place to provide high confidence that instabilities will be detected and corrected through resupport operations long before they progress to roof fall.

It is important to recognize that if a roof instability is detected and recognized within as little as a few minutes of an impending roof fall, WIPP personnel will have the time to evacuate the affected area of the mine and take action to prevent a discharge of any materials released by the collapse to the accessible environment. An immediate action available to prevent the possibility of transport of material to the accessible environment is transferring to the filtered ventilation mode. Once personnel are evacuated, plant management has the option to terminate ventilation of the underground horizon until the roof fall event has occurred, thus limiting the spread of hazardous material to that which can be displaced as a result of the shock of the fall.

With a few days prior notice, there will be sufficient time to isolate the affected area and install emergency barriers to cut off air flow to and from the area. Materials are readily available at the WIPP to construct an emergency barrier having sufficient strength and integrity to greatly reduce the potential for transport of material released from the waste containers beyond the barriers, and a monitoring program can be set up to verify that containment integrity is maintained. This will enable evaluation of the stability of the remainder of the underground horizon while minimizing the potential for a release of hazardous materials from the roof fall zone. With these response capabilities, the success criteria for avoiding a roof fall due to anticipated/observable failure mechanisms is defined to be the failure to recognize an impending roof fall up to two days prior to the event.

If necessary for safety, further emplacement activities in the panel can be abandoned. The emergency barrier will inhibit ventilation of the roof fall zone sufficiently to enable safe construction of the panel closure system. As described in Section 4.2.3.4, the panel closure system is designed to maintain acceptable containment of hazardous materials within the panel following a wide variety of postulated disruptive events as the panel progresses to its final disposal configuration. When combined with a stability assessment for the remainder of the underground horizon, this is judged to provide adequate confidence that an unanticipated roof fall in one panel will not impact emplacement operations in other portions of the repository. For the no-mitigation case, automatic or manual shift of the underground ventilation system to HEPA filtration is assumed to not respond to mitigate a release for this scenario.

Estimated Frequency - The overall accident sequence is modeled with the event tree for CH11 given in Appendix D, Figure D-8. Roof fall is the initiating event of the event tree. As shown in the event tree analysis for this accident scenario, the annual occurrence frequency of the no-mitigation accident scenario, evaluated as unlikely by the HAZOP, is quantitatively evaluated to be beyond extremely unlikely (less than 1E-06/yr). Risk evaluation guidelines are not identified for events with frequency $\leq$ 1E-06/yr, however, the risk evaluation guidelines for the extremely unlikely range are used for evaluating the risk associated with this scenario.

Roof Fall Initiating Event. The frequency of a roof fall is quantified as 4.7E-07 per year using the logic developed in Table D-19 and illustrated in the fault tree following it. This section describes the reasoning used to develop and quantify the table.

Either anticipated/observable or unanticipated/unobservable failure mechanisms may cause the roof fall.

Known and Observable Failure Mechanisms. As shown in the fault tree, roof collapse due to known and observable failure mechanisms during emplacement would require the coincident failure of a number of activities, which are discussed below.

- First, the ground control operations done prior to emplacement of waste in a specific room must be done improperly. These operations are designed to provide high confidence that major roof fall events will not occur for at least four years after the room is declared ready for waste, and if done properly would virtually assure that a major roof fall event would not occur in an actively ventilated room. The fault tree is developed for Panel 1, where bolts will be installed to provide this confidence.

  The quantification took a graded approach that used the collective engineering judgement of safety analysis, ground control, and geotechnical engineering personnel to hypothesize both the number of errors required for an improper installation and the number of opportunities for these errors. To create sufficient unsupported length for propagation to exceed the strength of adjacent bolts, geotechnical engineering have estimated that three or four closely located bolts would have to fail. This can happen due to either hardware failures or human error during installation. In addition, the torque testing of the adhesion of the hardened resin to the bolt and salt must fail to reveal the improper installation.

  - As a screening estimate, a likelihood of 10^{-3} was assigned to installing flawed hardware. This likelihood encompasses both the delivery of out-of-specification bolts or resin and the failure of acceptance inspections to detect the anomalies. As the bolts and resin system represents a straightforward and mature technology, a screening value on the same order of magnitude as an error of omission is judged to bound the likelihood of installing flawed hardware.

- Human error that could lead to the improper insertion of the bolts was quantified using the THERP methodology, which has been widely applied to routine actions during nuclear power plant operations. Improper insertion of bolts is judged to be an error of commission. As bolts are inserted close enough to provide mutual support, a series of adjacent bolts must be improperly inserted to provide a potential for an instability to propagate. However, once an error of commission is accomplished, the likelihood of the same installation personnel repeating that error is high. Conversely, once the proper procedure is set during a given shift, the installation personnel have a high likelihood of continuing with a proper installation. Using these arguments, the opportunity for errors was judged to occur once per shift, with one error of commission being sufficient to leave the room with an unsupported span large enough to propagate to the entire room, e.g. cause the failure of the remaining bolts as the instability spreads. The quantification of these events is documented in Appendix D.

- After the resin has had an opportunity to attain its full strength, the bond between the bolt and the salt is verified with a torque test. Although this is a formal independent check, as a screening estimate, the likelihood of an error in accomplishing this test that would result in a poor bond being undetected is assessed as a checking error, which is quantified in the basic event table in Appendix D with a likelihood of 1E-01.

- Throughout the emplacement operations, the measurements collected by geotechnical engineering to monitor the creep of the salt formation to predict its stability will have to be either errantly reported by the installed instruments or improperly evaluated by the geotechnical engineers. The installation of the geomechanical instrumentation is documented and the initial data from each instrument is reviewed to ensure proper operation. The installation and monitoring of the geomechanical instrumentation are governed by approved procedures. An assessment of the convergence measurements and geotechnical observations are made after each round of measurements, and a complete analysis is performed on an annual basis, as a minimum. The likelihood of these assessments may be changed as warranted by changing ground conditions. The geotechnical monitoring program is further described in Section 4.3.5.5 of this SAR.

  The likelihood that the instability will not be detected because of a failure in the monitoring equipment is judged to be negligible compared to the potential for human error. The monitoring system consists of multiple sensors that would have to fail in a mode that provides false stable readings while giving no other indication of malfunction.

  Based on the above information, the following screening assessments have been made for the likelihood of human error that would lead to a failure of that program. These assessments are combined in Table D-19 to produce a geotechnical monitoring failure rate of 5.0E-05 for each room in which waste will be emplaced:

  - The likelihood of the initial geotechnical evaluation of the data failing to detect an instability trend as it progresses within a panel room is assessed to be equivalent to the median likelihood of an error of commission (H_com = 1E-03) related to the misinterpretation of the data. It is highly unlikely that geotechnical engineering will fail to monitor the room in a timely fashion, and without more detailed evaluation the basic failure rate for an error of commission is considered to be an upper bound. Trends from a number of monitors will be collected and compared, so there is ample opportunity for the detection of errors and inconsistencies. Moreover, the evaluation process is not done under a strict time constraint.

- Because more than one person will have the opportunity to examine the data, an error in checking (H_check = 0.1) is hypothesized to reflect the fact that the initial failure to detect a trend will be identified by these reviewers. Only one opportunity to detect the error is hypothesized for a given round of measurements, reflecting an assumed total dependency among multiple reviewers. In other words, if one reviewer will also misinterpret the data, so will all the other reviewers.

- Despite the fact that the current understanding of salt mechanics predicts that an instability will progress over months, high dependency (H_High_dep = 0.5) is assessed for the misinterpretation of the next set of measurements detecting the trend. Trend data tend to become one body of information, and this assessment of dependency allows for the possibility that some yet unknown systemic problem could lead to the continuing failure to detect the trend. If the second set of measurements fails to detect the trend, all subsequent assessments are assumed to also fail.

- For roof fall incidents that might occur near the edge of the emplaced waste stack in a region that can be observed by ground control, surface indications of impending roof fall may provide sufficient warning. However, because roof falls may occur within the stack where ground control personnel no longer have access, the likelihood that they will not detect some indication of the precursor to a large roof fall is accessed to 0.5. This corresponds to a high dependency with the non-detection of instabilities by geotechnical engineering.

Unanticipated/Unobservable Mechanisms. The roof fall accident analysis recognizes that, despite all the efforts to characterize, prevent, and monitor salt behavior that might result in roof fall, a surprise roof fall could occur with no prior observable indications. The frequency assessment of unanticipated/unobservable roof fall mechanisms has considered the following evidence:

- As documented in DOE/WIPP-91-023,[47] the current geotechnical engineering program has been found to be sound and appropriate for both predicting and preventing roof fall by an international panel of mine experts with considerable experience. A surprise event would indicate the combined expertise and experience of this group, together with the active and continuing geotechnical monitoring and ground control program at the WIPP, was insufficient to predict an imminent roof fall.

- The time frame in which the failure mechanisms would be required to develop into a roof fall is very short compared to the known behavior of salt instabilities, which develop over a period of months. A surprise failure mechanism would have to develop at a rate that is almost two orders of magnitude faster than those that are currently understood.

- In order to produce the consequences hypothesized for this accident, the roof fall is assumed to laterally displace up to seven 7-packs that have been placed on the third level at the edge of the stack, which then fall and breach an average of three drums per 7-pack. This would require a large roof fall relatively close to the edge of the stack. For this to occur as a surprise, no prior indications would have to be observed on all the monitoring equipment in the affected zone, and the weight of the material involved would have to overwhelm any support systems that had been placed in the room prior to the start of emplacement.

- Salt mines are common and have been in operation for a long time. As part of their professional duties, ground control and geotechnical engineering personnel at the WIPP review current industrial experience regarding the performance of salt mines and analyze it for similarities with conditions at WIPP. They are not aware of any events that would be indicative of failure mechanisms that could occur at the WIPP other than those for which they have accounted.

The variable representing unobservable/undetectable failure mechanisms is quantified by interpreting the uncertainty in the above evidence using the following line of reasoning:

- The evidence provides high confidence that unknown mechanisms have only an extremely small chance to develop at a rate that would not be detected, but they do not necessarily make a surprise roof fall incredible. Therefore, it was judged that the frequency of an undetected roof fall anywhere within the actively monitored portion of the mine should be above 1E-06/year.

- Although considerable experience has been accumulated to support the technical understanding of the behavior of salt, WIPP ground control and geotechnical engineering personnel recognize that salt is not homogeneous, production mines are not monitored as well as the WIPP, and incidents that have occurred, but did not result in injury, may not be reported. Consequently, it was judged that the frequency of an undetected roof fall anywhere within the actively monitored portion of the mine could be as high as 1E-04 per year, but the combined experience and engineering knowledge of the salt formation would make higher frequencies very unlikely.

- To encompass both the upper and lower values, the frequency is modeled as a lognormal distribution with a median value of 1E-05/year and a range factor of ten. The range factor of ten relates a 95 percent confidence that the frequency is above 1E-06/year, and a 95 percent confidence that the frequency is below 1E-04/year. The mean value of this distribution is 2.6E-05/year, which is used for this quantification.

- A roof fall can occur in any part of the active underground; however, only a fall in the fraction of the underground having both CH and active ventilation will produce hazardous material consequences. On the average ½ of a room will be filled.

Source Term Development

Radiological Waste Container Inventory (CI)- Based on the postulated scenario, the CD for this accident has been determined to be the inventory contained in twenty one drums or five SWBs. It is conservatively assumed that of the 21 drums breached, one is at the maximum CI of 80 PE-Ci, and the remaining 20 drums are at the average of 8 PE-Ci each. Of the five SWBs breached, one is assumed to be at the maximum CI of 130 PE-Ci, the remaining four are at the average of 32 PE-Ci. The waste container is conservatively assumed to contain 95 percent noncombustible material and 5 percent combustible material, as discussed in Section 5.2.1.1.

Nonradiological Waste Container Inventory (CI)- As discussed in Section 5.2.1.1, the nonradiological CI development process for events which involve a breach of a waste container is simplified by assuming that 100 percent of the VOC headspace inventory is released instantaneously. VOCs selected for consideration for accidental releases are listed in Table 5.1-2. These values were scaled for estimating concentrations in the SWBs based on container volumes.

Damage Ratio -

Two evaluations of the roof fall event were performed:

1) Bottom layer of drums subjected to axial loads caused by the weight of overlying drums, backfill supersacks and mini-sacks, and 7 feet of roof fall.

2) Roof fall dislodges drums from upper stack and they fall to floor (drop accident with the potential for additional loading due to additional drums and debris).

(1) Damage to Drums due to Impact of Falling Salt

The following evidence provides confidence that the inherent strength of the drum matrix and its backfill has a high likelihood of preventing a significant release from the drums due to direct damage from falling salt.

For the static axial loading case, the crush force on the bottom seven-pack of drums is equal to the sum of the following:

- Weight of the 14 overlying drums (each containing the maximum weight of 1,000 lb) plus 12 mini-sacks (each weighing approximately 25 lb)

- Weight of the supersacks acting on the reinforcement sheet (equal to approximately 133 lb/ft^2 of reinforcement sheet surface).

- Weight of the fallen roof acting over the supersacks (equal to approximately 1000 lb/ft^2 of reinforcement sheet surface assuming a roof thickness of 7 ft)

Based on the emplacement configuration, the total crush force acting on the bottom seven-pack of drums is approximately 41,000 lb or 5900 lb/drum. Based on the Sandia tests[7] for "new" DOT-17C drums, plastic deformation did not begin in axial crush tests until the load reached approximately 15,000 lb. No lid separation was observed in these tests and no contents were released. Lateral crush tests indicated no lid separation at loads below 17,100 lb. If the results for the DOT-17C drums are scaled by the wall thickness for the DOT-17H drums, the allowable axial load per drum would be approximately 10,000 lb. Clearly, the maximum crush force is substantially less than the capacity of the drums if they are in a "new condition."

Considering the conservatism in the roof fall and drum weight loading, and the apparent margin between maximum loading and the crush capacity of new drums, it is assumed that the conclusion applies to slightly corroded and damaged drums as well. Based on minimum wall thickness, the DOT-17C and DOT-17H drums could lose approximately 61 percent and 41 percent, respectively, of their original thickness before the apparent allowable load would be exceeded. Consequently, one may conclude that even slightly degraded drums have a high likelihood of not being breached by the static loading induced by the fallen salt.

The ability of the drums to maintain their integrity was also examined from a limiting energy perspective[10] and was updated in PLG-1167, Analysis of Roof Falls and Methane Gas Explosions in Closed Rooms and Panels.[11] The report cited experimental evidence that drum deformations of up to 15 inches produced no breach of the crushed drums. Since there was no data on deformations greater than 15 inches, these were assumed to result in a release of material from the drums. The report concluded that the axial crush energy required to displace a Type 17C drum 15 inches for content weights of 0 to 640 pounds are 186,500 to 650,000 in-lb. A roof fall of 53 inches (including 15 inches of compression) for three layers of drums and the supersack, would produce a potential energy release of 182,000 in-lb. A roof fall of 74 inches (including 15 inches of compression) for three layers of drums and without supersack, would produce a potential energy release of 254,000 in-lb.

The duration of time during which only one or two layers of drums are emplaced is very small compared to the duration of storage. These configurations will exist only at the leading edge of the stack for one or two seven-packs that may be stacked one or two high until the next facility pallet is unloaded. Therefore, these configurations do not pose any significant risk. The results for the remaining two configurations indicate that only modest levels of drum contents are required to ensure that the drums will not be compressed more than 15 inches. Thus, based on the available evidence, Type 17C drums should retain their radioactive material contents following a roof fall event once three layers of drums are emplaced.

Based on axial buckling considerations, it has been shown[10] that the Type 17C drums are approximately 50 percent stronger than the Type 17H drums. If it is argued that the energy range for Type 17C drum lid separation is a factor of 1.5 times higher than that for Type 17H drums, then the corresponding limit for the latter drums lies in the range of 124,955 to 435,500 in-lb. The potential energy associated with a roof slab thickness falling 53 inches has been determined[77] to be of the order of 182,000 in-lb.

Type 17H drums must contain more waste than the Type 17C drums to ensure that they will not be compressed more than 15 inches during a roof fall event. Nevertheless, for the emplacement configurations of interest, the Type 17H drums require only modest content amounts to survive the fall. For the long-term configuration, the drums must contain only 110 lbs to prevent compressions greater than 15 inches, the arbitrary limit in this evaluation. It is unlikely that drums will be shipped to WIPP with such a small amount of contents.

The following factors combine to ensure that the estimate of drum damage is conservative:

- The conclusions reached in PLG-1167, [11] for Type 17H Type 17C drums, assume that all of the potential energy of the roof fall is absorbed by only one of the drums in the vertical stack. If some of this energy is absorbed by the remaining drums in the vertical stack, the drums will require less contents than those indicated above.

- The roof will "sag" significantly before it actually falls, reducing the potential energy available for crushing the drums. It must also be emphasized that no lid separation or drum splitting was actually observed when the drums were compressed by 15 inches. The anticipated crushing action will tend to fold over the sides of the drums as a result of plastic deformation, rather than splitting them open. In addition, it is judged that the falling salt will tend to crush lids into the drums rather than dislodge them. Thus, two of the primary failure mechanisms leading to releases should have a minimal impact. The above analysis did not take into account failure mechanisms due to irregularities in the falling salt and the support system that may have been emplaced in the roof prior to waste emplacement. These mechanisms can not be completely discounted, but by their very nature they should produce localized effects that do not involve many drums.

- If drums were breached by the roof fall event, the reinforcing sheets and stretch wrap will tend to minimize the degree of lid separation. These features were not included in any of the cited tests. The fallen roof itself may provide a barrier against the release of drum contents to the underground room and subsequent entrainment of this material by the ventilation stream.

(2) Drum Damage Due to an Induced Fall from the Waste Stack

As discussed in Section 5.2.1.1, for drops of waste containers from the heights associated with drops from the third layer of the waste stack (from heights equal to or less than 10 ft ($5 \text{ ft} < h \leq 10 \text{ ft}$)), based on analyses,[10] it is conservatively assumed using engineering judgement, to encompass the uncertainty in the application of test data and the variation in waste forms, that the DR for Type A drums (or equivalent)in this class of accident is 0.025 (DR=0.025), and the DR for SWBs and TDOPs is 0.01 (DR=0.01).

Airborne Release and Respirable Fraction - The ARF for contaminated combustible materials which are subjected to impact and breach of the waste container is 0.001. This value represents a bounding ARF for packaged material in a container which fails due to impact (DOE-HDBK-3010-94, subsection 5.2.3.2).[5] The bounding RF is 0.1 (DOE-HDBK-3010-94, subsection 5.2.3.2).[5]

The ARF for contaminated noncombustible materials which are subjected to impact and breach of the waste container for solids that do not undergo brittle fracture is 0.001. This value represents a bounding ARF for packaged material in a container which fails due to impact (DOE-HDBK-3010-94, subsection 5.3.3.2.2).[5] The bounding RF is 1.0 (DOE-HDBK-3010-94, subsection 5.2.3.2).[5]

Leakpath Factor - Based on the scenario description, it is not expected that the roof fall in the underground will also disable the underground ventilation or HEPA filtration systems. Shift of the underground ventilation system may occur manually or automatically as discussed in detail in Section 4.4.2.3. However, it is assumed that an automatic shift to filtration will not respond to mitigate a release for this scenario. For the mitigated case, it is assumed that the CMR operator will be notified or be aware of the accident and actuate the shift to filtration. Credit is not taken for the natural attenuation provided by the discharge path.

Estimated Consequences and Comparison to Risk Evaluation Guidelines - Based on the values for the source term variables as presented above, the no-mitigation MEI and noninvolved worker consequences (see Appendix E, Tables E-45, E-46, and E-47) of a roof fall in the underground (CH11) are well within the radiological and nonradiological risk evaluation guidelines (for the extremely unlikely range). Risk evaluation guidelines are not identified for events with frequency ≤ 1E-06/yr, however, the risk evaluation guidelines for the extremely unlikely range are used for evaluating the risk associated with this scenario.

Assessment of Immediate Worker Consequences - No current risk evaluation guidelines exist for the assessment of accident consequences to immediate workers. Therefore, in the absence of guidelines, and for conservatism, the noninvolved worker radiological guidelines are used as a reference point for the assessment of consequences to immediate workers and the evaluation of the adequacy of the WIPP defense-in-depth features. The worst-case consequences to the immediate worker from CH11 (Table E-56) are well within the risk evaluation guidelines. Therefore, no specific additional worker protection engineering or administrative controls beyond those already qualitatively identified as providing defense-in-depth for the immediate worker, are needed based on the quantitative consequence assessment results.

Safety Structures, Systems, and Components - Based on the estimated worst-case no-mitigation MEI and noninvolved worker consequences and comparison to the risk evaluation guidelines, Safety Class or Safety Significant SSCs are not required.

The defense-in-depth SSCs which are applicable to this scenario, per the criteria provided in Chapter 3, Section 3.1.3 are assigned as follows:

- Underground Ventilation Exhaust System - Secondary Confinement
- Underground Ventilation Exhaust HEPA Filters - Secondary Confinement
- Radiation Monitoring System (active waste disposal room exit alpha CAM for underground shift to filtration) - Secondary Confinement
- Central Monitoring System (for actuation of underground shift to filtration only) - Secondary Confinement
- Vented DOT Type A or equivalent Waste Container - Primary Confinement
- Underground Disposal Area - Designed to minimize failure resulting in a breach container

Section 5.2.4.1, Evaluation of the Design Basis, discusses in greater detail: (1) the evaluation of safety SSCs, and (2) the applicability of functional and performance requirements (system evaluation) and controls (TSRs). Detailed design descriptions for the above defense-in-depth SSCs may be found in Chapter 4 and the applicable Systems Design Descriptions.

Due to the importance of WIPP programs relating to geotechnical monitoring, configuration and document control, quality assurance, conduct of operations (including ground control), preventative maintenance and inspection, waste handling procedures and training, the WIPP WAC and the WIPP Emergency Management Program[54] and associated procedures, in the WIPP defense-in-depth strategy for this accident, TSR ACs are derived in Chapter 6 and required in the WIPP TSR Document.

5.2.4 Assessment of WIPP CH Facility Design Basis and Waste Acceptance Criteria

5.2.4.1 Assessment of WIPP CH Facility Design Basis

Accident Analysis Frequency Results

As shown in Section 5.2.3, the quantitative frequency analysis for each accident produced the following grouping of accidents:

Unlikely Range (10^{-2}/year $\geq$ frequency $>10^{-4}$/year)

CH2, Crane Failure in the Waste Handling Building (WHB)

CH3, Puncture of Waste Containers in the Waste Handling Building

CH4, Drum Drop in WHB

CH9, Drum Drop in the Underground

Extremely Unlikely Range (10^{-4}/year $\geq$ frequency $>10^{-6}$/year)

CH7, Spontaneous Ignition in the Underground (For the population of drums < 8 PE-Ci)

Beyond Extremely Unlikely Range (10^{-6}/year $\geq$ frequency)

CH1, Spontaneous Ignition in The Waste Handling Building

CH5, Waste Hoist Failure

CH7, Spontaneous Ignition in the Underground (For the population of drums > 8 PE-Ci)

CH11, Roof Fall

For all accidents, the quantitative frequency analysis has verified that the qualitative frequency ranges assigned for these scenarios in the Hazard and Operability Study (HAZOP) were either correctly or conservatively assigned.

Additional quantitative frequency analyses in the form of event/fault tree analyses were performed to identify systems, structures, components (SSCs), or processes that contribute most to the accident phenomena frequency for the purposes of verifying their adequacy or identifying improvements to reduce the accident frequency and therefore risk to immediate workers (as well as noninvolved worker and MEI). Specific accidents evaluated in this manner were: (1) CH1 and CH7, Spontaneous Ignition in the WHB and Underground; (2) CH2, Crane Failure in the WHB; (3) CH5, Waste Hoist Failure; and (4) CH11, Roof Fall in the Underground. With the exception of the Waste Handling Building 6-ton bridge crane (CH2) and spontaneous ignition in drums containing <8 PE-Ci/ drum in the underground (CH7), the event tree/fault tree analyses indicate that the no-mitigation frequency of the identified accidents occurring are beyond extremely unlikely (frequency $\leq$ 1E-06/yr).

Accident Analysis Consequence Results

Based on the CH accident source term and release mechanism analyses presented in Section 5.2.3, for worst-case scenarios with a frequency greater than 1E-06/yr (CH2, CH3, CH4, and CH9), the calculated worst-case no-mitigation accident consequences to the noninvolved worker and MEI, and immediate worker were found to be well below the selected accident risk evaluation guidelines for the extremely unlikely range. The highest consequences are obtained from CH3, with an estimated 3.8 rem (38 mSv) to the noninvolved worker (100 m) (four percent of 100 rem (1 Sv) guideline), 440 mrem (4.4 mSv) to the MEI at the exclusive use area (two percent of 25 rem (250 m Sv) guideline), and 32 rem (0.32 Sv) (32 percent of 100 rem guideline) to the immediate worker. It should be noted that: (1) the MEI consequences for worst-case scenarios with a frequency greater than 1E-06/yr (CH2, CH3, CH4, and CH9), are also well within the value of 500 mrem (5 mSv) temporary annual dose limit **for normal operations** derived from DOE Order 5400.5, and (2) the noninvolved worker consequences are within the 5 rem (50 mSv) annual dose limit for workers for normal operations.

The worst-case consequences to the immediate worker from CH3 are estimated to be 32 rem (320 mSv). No current risk evaluation guidelines exist for the assessment of accident consequences to immediate workers. Therefore, in the absence of guidelines, and for conservatism, the noninvolved worker radiological guidelines were used as a reference point for the assessment of consequences to immediate workers and the evaluation of the adequacy of the WIPP defense-in-depth features. The consequences to the immediate worker from CH3 are also well within the on-site risk evaluation guidelines. Therefore, no specific additional worker protection, engineering, or administrative controls (such as respiratory protection, more stringent maximum waste container inventory, or additional WAC controls such as immobilization) beyond those already qualitatively identified as providing defense-in-depth for the immediate worker, are needed based on the quantitative consequence assessment results

For scenarios with a frequency less than 1E-06/yr (CH1, CH5, CH7, and CH11), the calculated no-mitigation accident consequences to the noninvolved worker, and MEI were also found to be below the selected accident risk evaluation guidelines. The worst-case noninvolved worker and MEI consequences are obtained from CH5, with an estimated 60 rem (600 mSv) to the noninvolved worker (100 m [328 ft]) (60% of 100 rem [1 Sv] on-site guideline) and 9 rem (90 mSv) to the MEI at the exclusive use area (36% of 25 rem [250 mSv] off-site guideline). Risk evaluation guidelines are not identified for events with frequency < 1E-06/yr, however, the 25 rem (250 mSv) risk evaluation guideline for the extremely unlikely range (25 rem siting criteria in DOE Order 6430.1A) is used for evaluating the risk associated with these scenarios.

It should be noted that the MEI (exclusive use area) no-mitigation consequences for all accidents analyzed, regardless of frequency, were found to be well below 25 rem (250 mSv) risk evaluation guideline. The worst-case calculated dose to an immediate worker is from CH5 with an estimated 500 rem (5 Sv). Although the immediate worker dose for CH5 exceeds the on-site risk evaluation guidelines for the extremely unlikely range, no specific additional worker protection engineering or administrative controls are identified. The risk associated with this potential exposure is deemed acceptable for the following reasons:

- The conservatism in the risk evaluation guidelines as discussed in Section 5.2.2, as well as the application of the on-site guidelines to the immediate worker,

- The very low frequency of this scenario, primarily due to the design changes and identification of administrative controls which significantly enhance the system safety and reliability. As identified in EEG-59, the performance of preoperational tests are of paramount importance to system reliability (for the waste hoist, as well as other WIPP SSCs), and as such, is a primary element of the first layer of WIPP defense-in-depth. Section 8.3.3.5 discusses the elements of preoperational checks as required by the conduct of operations program, and a TSR AC is derived in Chapter 6 for inclusion in the WIPP Technical safety Requirements,

- The conservatism inherent in all of the accident analysis source term variables used to estimate the above consequences,

- The existing elements for protection of the worker discussed in detail in Section 5.1.7.

Evaluation of the Design Basis

The accident analyses indicate that Design Class I (Safety Class) SSCs are not required for the WIPP to mitigate any MEI accident radiological and nonradiological consequence to below risk evaluation guideline levels. Secondary confinement is required to remain functional (following DBAs) to the extent that the guidelines in DOE Order 6430.1A, Section 1300-1.4.2,[3] Accidental Releases, are not violated. The risk evaluation guidelines developed in this safety analysis report were used in the absence of definitive criteria in DOE Order 6430.1A and DOE safety analysis orders or guidance documents for evaluation of secondary confinement. As stated above, the MEI (exclusive use area) noninvolved worker no-mitigation consequences were found to be well below the selected risk evaluation guidelines, including accidents whose frequency is < 1E-06/yr, and as such, secondary confinement is not required. However, existing Design Class II and IIIA secondary confinement SSCs, while not required to mitigate the consequences of an accident from exceeding the risk evaluation guidelines, support the second layer of the WIPP defense-in-depth philosophy.

As discussed in the accident scenarios in Section 5.2.3, there is no credible physical mechanism by which the operational accidents analyzed in the WHB or the underground will also disable the respective ventilation or HEPA filtration systems. Again, no releases are postulated requiring ventilation or HEPA filtration for the DBE and DBT scenarios. If waste container breach occurs in the WHB during a credible operational accident (CH2, CH3, CH4), the release to the outside environment is mitigated by the permanently installed continuously on-line two-stage HEPA filter. For credible accident scenarios in the underground (CH9), shift of the underground ventilation system may occur manually (it is assumed that the CMR operator will be notified or be aware of the accident and actuate the shift to filtration), or automatically. With regard to DBE and DBT scenarios, no release scenarios are expected to be initiated during the DBE or DBT, primarily due to the DBE/DBT design of the WHB structure including tornado doors and specific waste handling equipment such as the WHB 6-ton bridge crane and waste hoist. As such, the WHB ventilation and filtration systems are not required to mitigate the consequences of the DBE or DBT scenarios.

Based on criteria in Chapter 3, Section 3.1.3.2, the factors that lead to designation of a component as Safety Significant are:

- SSCs whose preventive or mitigative function is necessary to keep hazardous material exposure to the noninvolved worker below on-site risk evaluation guidelines,

- SSCs that prevent acute worker fatality or serious injury from hazardous material release that is outside the protection of standard industrial practice, OSHA regulation, or mine safety regulation (MSHA) (e.g. potentially explosive waste containers).

As concluded from the WIPP SAR Section 5.2, Accident Analysis, none of the worst-case analyzed scenarios (note: all scenarios are analyzed without regard for occurrence frequency) resulted in noninvolved worker consequences exceeding the risk evaluation guidelines. Therefore, there are no SSCs that are considered Safety Significant due to need to prevent or mitigate noninvolved worker consequence.

The HAZOP identified two potential scenarios related to WIPP waste handling operations, that could result in worker fatality: (1) potentially explosive waste containers, and (2) waste hoist failure while transporting personnel. With regard to explosive waste containers, SAR Section 5.2.3.1 evaluates such scenarios as beyond extremely unlikely. These events are effectively controlled through rigorous application of the preventive function provided by the WAC administrative control, and as such, preventive or mitigative SSCs are not evaluated or required.

With regard to the waste hoist failure scenario, the consequences involving waste hoist failure while transporting waste containers were evaluated in SAR Chapter 5. Based on the analysis, Safety SSCs are not applicable for that scenario. Personnel **and** waste containers will not be transported simultaneously. Failure of the waste hoist while transporting personnel does not constitute a process related accident involving radioactive materials and as such is considered a standard industrial hazard associated with standard mining operations. Hoisting operations are required to comply with the requirements of 30 CFR 57 and the New Mexico Safety Code for all Mines. As such, Safety Significant SSCs are not designated for failure of the waste hoist while transporting personnel.

Specific SSCs that fulfill a defense-in-depth safety function are: (1) the waste handling equipment such as the WHB 6-ton TRUDOCK bridge crane, adjustable center of gravity lift fixture (ACGLF), electric forklifts, facility pallets (including tie-downs and stretchwrap), waste-hoist, underground transporter, the Loron/BRUDI attachments, and (2) WIPP confinement SSCs including waste containers, Waste Handling Building (WHB) and underground structure, and WHB and underground ventilation and filtration systems. With regard to waste handling equipment, in each instance their reliability and functionality are important to the prevention of damage to the waste containers (first layer of defense in depth). As such, their designation as defense-in-depth SSCs ensures that they are designed, maintained, and operated to prevent failure resulting in an accident. WIPP confinement SSCs (WHB and underground ventilation and filtration systems, and WHB and underground structure) support the second layer of defense in depth. All other WIPP SSCs are considered as balance of plant.

DOE-STD-3009-94, requires that for Safety (Safety Class or Safety Significant) SSCs, a SAR define the SSC safety function and functional requirements, performance requirements (system evaluation), and controls (TSRs). Since Safety SSCs are not defined for WIPP, these requirements are not applicable to the WIPP SAR.

Specific WIPP SSCs are classified as Defense-in-Depth SSCs, based on the above functional classification results. Rather than the WIPP SAR specify functional requirements and performance criteria for those defense-in-depth SSCs, the applicable System Design Descriptions (SDDs) describe their intended safety functions, and specify the requirements for design, operation, maintenance , testing, and calibration.

As discussed in detail in SAR Chapter 6, based on application of the criteria in DOE Order 5480.22 for the selection of safety and operational limits, and the fact that Safety Class and Safety Significant SSCs are not selected for WIPP, TSR Safety Limits (SLs), Limiting Conditions for Operation (LCOs), and Surveillance Requirements are not required. TSR ACs assigned for features discussed above that play a role in supporting the WIPP defense-in-depth approach are derived in SAR Chapter 6. Table 6-1 provides a summary of defense-in-depth safety features and applicable TSR controls.

Based on the fact that TSR Operational Limits and Surveillance Requirements are not defined for WIPP, operability definitions for Defense-in-Depth SSCs are not required in the SAR. SSCs are required in the TSR to be as operated as required during each facility mode as described in Table 6-2, to support the overall WIPP defense-in-depth strategy.

Evaluation of Human Factors

A systematic inquiry of the importance to safety of reliable, correct, and effective human-machine interactions, considering the mission of the WIPP facility and the physical nature of the radioactive wastes that it will receive was conducted. The specific human errors that can contribute to accidental releases of hazardous materials were evaluated as an integral part of each hypothesized accident. Based on the analysis of those accidents and the discussion below, it can be concluded that the WIPP waste acceptance criteria for transuranic wastes, facility design, and operational controls provide high confidence that all potential releases can be contained with passive safety features that eliminate the need for human actions requiring sophisticated human-machine interfaces.

To provide additional support for the conclusion that no detailed human factor evaluation of human-machine interfaces is required, a scoping assessment of the effectiveness of the human-machine interfaces that support important design functions of the Table 4.1-1 Design Class II and IIIA systems was performed. It can be seen in Table 4.8-1 that most of the Design Class II and IIIA WIPP systems and equipment do not require human actions to initiate or sustain their function relative to the release of radiological or nonradiological waste materials. In most cases these functions are accomplished with automatic passive mechanisms designed to provide containment for the waste materials.

Functions allocated to automatic passive mechanisms or automatic active systems may be influenced by human error during maintenance. However, using the graded approach, human-machine interfaces for maintenance activities at WIPP are judged to be adequate because they are deliberate, and there is ample opportunity to discover errors and correct them with no adverse safety consequences.

The ability of the staff to accomplish their responsibilities in potential accident environments was evaluated. The limited magnitude of the hazard and the lack of dispersal driving forces provide very high confidence that the staffing and training presented in those sections will enable the staff to perform their responsibilities in potential accident environments.

The magnitude of hazardous materials that can be involved in an accident leading to a release is very limited. The radioactive material is delivered to the site in closed containers, and the waste handling operations are designed to maintain that integrity throughout the entire process required to safely emplace those containers in the site's underground waste disposal rooms. Inventory limits on individual containers ensure that heat generated by radioactive decay can be easily dissipated by passive mechanisms. Finally, only a limited number of waste containers have the possibility of being breached as a result of any one accident initiating event. As a result, the consequences of unmitigated releases from all accidents hypothesized in Chapter 5, including those initiated by human error, do not produce significant offsite health consequences.

The facility has no complex system requirements to maintain an acceptable level of risk. The facility is designed to minimize the presence and impact of other energy sources that could provide the heat or driving force to disperse hazardous materials. When something unusual happens during normal operations, such as support systems becoming unavailable, **waste handling can be simply stopped** and personnel evacuated until an acceptable operating condition is reestablished.

Should an initiating event occur that breaches the waste containers, **the plant design permits the immediate cessation of activity and isolation of the area where the breach occurs.** Once isolation is achieved, there is no driving force within the waste or waste handling area that could result in a release of the waste material. Consequently, **sufficient time is available to thoroughly plan and prepare for the remediation process prior to initiating decontamination and recovery actions.**

Human factors considered in this SAR is limited to that time necessary to properly emplace the transuranic waste designated for disposal at WIPP. The operations will be straightforward, proceduralized, and consistent. Moreover, they will continue for only the period of time needed to complete the disposal process. Once a panel is filled and sealed off, the natural properties of the salt and the location of the mine combine to provide passive isolation of the waste from the environment. The potential for human intrusion after the facility closure is beyond the scope of the human factors evaluation considered here.

Conclusion

It is therefore concluded from the hazards and accident analyses in this SAR that the design basis of the WIPP CH TRU waste handling system is adequate in response to postulated range of CH TRU normal operations and accident conditions for the facility.

5.2.4.2 Analysis of Beyond the Design Basis

Operational Events

An evaluation of operational accidents "beyond" the derivative design basis accident (BDBA) is conducted to provide perspective of the residual risk associated with the operation of the facility. As discussed in DOE-STD-3009-94,[1] beyond DBAs are simply those accidents with more severe conditions or equipment failure. The operational scenarios analyzed in this section as "beyond the design basis" take into consideration the effect of the WIPP Waste Acceptance Criteria Pu-239 Equivalent Activity, and Thermal Power Criteria on the assumed accident scenario material at risk (MAR) and accident consequences of the most credible accident sequences. Based on the analyses in Section 5.2.3, the operational accident scenarios involving potential consequences to the noninvolved worker individual, MEI, and immediate worker, whose frequency is greater than 1E-06/yr are: (1) CH2, Crane Failure in the Waste Handling Building (WHB); (2) CH3, Puncture of Waste Containers in the Waste Handling Building; (3) CH4, Drum Drop in WHB; and (4) CH9, Drum Drop in the Underground.

The source term MAR developed in Section 5.2.3 is based on the waste container inventory derived in Section 5.1.2.1.2. The analyses assumed that based on the data in Appendix A, that: (1) one waste container contains a maximum radionuclide inventory, and (2) the remaining waste containers contain an average radionuclide inventory of 8 PE-Ci (Table A-1 lowest bin upper cutoff). The 8 PE-Ci average bounds 86 percent of the volume for all waste forms, including the predominant heterogeneous, uncategorized metal, and combustible waste forms, and bounds over 96 percent of the volume of uncategorized metals, chosen in Section 5.2.1.1 as the waste form for waste container breach/impact analyses. For accident scenarios which involve single waste containers, it was conservatively assumed that the waste container contains a maximum radionuclide inventory.

As discussed in Section 5.1.2.1.2, the WIPP WAC Thermal Power TRUPACT-II requirements, limit the decay heat from all CH-TRU waste to 40 watts per TRUPACT-II. Using the Pu-238 "heat source" distribution in Table A-4 of Appendix A, calculations indicate that the maximum total PE-Ci for a shipment of Pu-238 waste is approximately 1,117 PE-Ci. The analyses of beyond the design basis considers the effect, and thus the residual risk, on the accident consequences evaluated for CH2, CH3, CH4, and CH9 of a hypothetical TRUPACT-II shipment of **untreated** (not solidified or vitrified) Pu-238 waste with each drum at 80 PE-Ci. Receipt of fourteen drums each at 80 PE-Ci is plausible, considering the above thermal wattage limit PE-Ci equivalent of 1,117 PE-Ci (14 drums x 80 PE-Ci approximately equals 1,117 PE-Ci). However, based on the data presented in Table A-5 of Appendix A, as a result of the conditional likelihood of receiving such a shipment, the on-site and off-site risk evaluation guidelines for the extremely unlikely range are used for the consequence evaluation.

As shown in Appendix E Tables E-13, E-14, E-23, E-24, E-29, E-30, E-43, and E-44, the analysis of CH2, CH3, CH4, and CH9 with each damaged drum at 80 PE-Ci, indicates that the highest immediate worker consequences are obtained from CH3 and CH9.

The radiological consequences of CH3 are discussed here assuming that each drum involved in the scenario is at 80 PE-Ci. The same assumptions regarding waste form combustible and noncombustible composition, damage ratio, airborne release fraction, and respirable fraction are assumed. Substitution of these values into the consequence calculations for CH3, indicate doses of approximately 12 rem (120 mSv) to the noninvolved worker individual (12 percent of the 100 rem noninvolved worker risk evaluation guideline for the extremely unlikely range), and 1.4 rem (14 mSv) (six percent of 25 rem MEI risk evaluation guideline for the extremely unlikely range) to the MEI. The noninvolved worker and MEI doses therefore remain well within the risk evaluation guidelines. The estimated dose to an immediate worker for the CH3 beyond design basis scenario approaches 70 rem (700 mSv), but does not exceed the noninvolved worker risk evaluation guideline of 100 rem (1 Sv) for the extremely unlikely range (Table E-62).

Thus, no significant risk is incurred to the immediate worker, noninvolved worker, or MEI considering the beyond design basis most credible operational accident scenarios above involving a maximally loaded TRUPACT-II shipment of untreated Pu-238 heat source waste, with each drum at 80 PE-Ci.

Natural Phenomenon

As discussed in Section 3.4.3 of DOE-STD-3009, natural phenomenon beyond design basis accidents are defined by a frequency of occurrence less than that assumed for the DBA. Since the DBT is defined with a 10^6 yr return period, and the DBE as a 10^3 yr return period, the most credible beyond DBA natural phenomenon event is an earthquake with a vertical ground acceleration of greater than 0.1 g (considered extremely unlikely). DBE SSCs: (1) the WHB structure, and (2) WHB 6-ton bridge crane, are assumed to fail resulting in a release of radioactive material.

It is assumed that the bridge crane fails while removing a load from a TRUPACT II (CH2). The WHB structure is also assumed to fail resulting in some damage to the seven facility pallets (196 drums or 28 SWBs) of waste that may be stored in the CH Bay for a period of up to five days awaiting transfer to the underground. It is conservatively assumed that one-half of the drums in storage are breached by the falling WHB structure debris, with a DR equivalent to that from the heights associated with drops from the third layer of the waste stack (DR=0.025). This equivalent to 14 times the consequences of the CH2 accident (0.31 rem) or 4.3 rem (43 mSv) to the MEI. Combining this with the MEI consequences of CH2 (0.3 rem), the total MEI (exclusive use area) consequence from the postulated beyond DBE is 4.6 rem (46 mSv) (20 percent of 25 rem MEI risk evaluation guideline for the extremely unlikely range). For the noninvolved worker, the combined consequences are 41 rem (410 mSv) (41 percent of the 100 rem noninvolved worker guideline). Therefore, the radiological risk associated with a greater than 0.1 g earthquake is considered acceptable.

5.2.4.3 Assessment of WIPP Waste Acceptance Criteria (WAC)

WAC Pu-239 Equivalent Activity Operations and Safety Requirement

Based on the beyond design basis accident analysis results in Section 5.2.4.2 above (using conservative assumptions, and in conjunction with elimination of the WAC Revision 4.0 Immobilization Criteria), the estimated radiological consequences for CH3, Puncture in the Waste Handling Building, to the immediate worker, approach the selected accident risk evaluation guidelines. Therefore, the 80 PE-Ci for drums and 130 PE-Ci for SWBs derived in Section 5.1.2.1.2, are established as the WAC Pu-239 Equivalent Activity Operations and Safety maximum allowable waste container radionuclide inventories for untreated CH TRU waste. The establishment of the 80 and 130 PE-Ci values, provides a defense-in-depth based approach to ensure that the estimated immediate worker accident consequences from untreated CH TRU waste remain acceptable.

Waste containers exceeding these values must be overpacked or treated (solidified, or vitrified) prior to acceptance at WIPP. Such a defense-in-depth approach, focuses on the prevention of potential higher dose consequences to the immediate worker from high PE-Ci untreated waste containers by reducing: (1) the conditional likelihood of waste container breach, and the damage ratio (DR) term of the source term equation (Equation 5-1) for overpacked containers (drums overpacked in SWBs or ten-drum overpacks); and (2) the combined airborne release fraction (ARF) and respirable fraction (RF) for solidified or vitrified waste containers. The CH1 and CH7 sustained internal waste container fire scenarios were evaluated in Section 5.2.3 to be beyond extremely unlikely. Therefore, for the evaluation of solidification, vitrification, and overpacking options, these scenarios are not evaluated.

The WIPP WAC Thermal Power TRUPACT-II requirements, limit the decay heat from all CH-TRU waste to 40 watts per TRUPACT-II. Using the Pu-238“ heat source” distribution in Table A-4 of Appendix A, calculations indicate that the maximum total PE-Ci for a TRUPACT-II shipment of Pu-238 waste is approximately 1,117 PE-Ci.

The acceptability of the WAC Pu-239 Equivalent Activity Operations and Safety maximum allowable waste container radionuclide inventory of 1,100 PE-Ci for overpacked and 1,800 PE-Ci for solidified/vitrified waste, established in Section 5.1.2.1.2 is verified by evaluating the most credible worst-case accident scenarios involving the largest potential consequences for each scenario of interest to the noninvolved worker, MEI, and immediate worker.

However, the consequences of accident scenarios CH2 and CH3 are evaluated in Appendix E (Tables E-9, E-10, E-11, E-12, E-19, E-20, E-21, E-22, E-57, E-58, E-59, and E-60) assuming that the accidents involve highly loaded (1,100 PE-Ci) overpacked (untreated waste within a 55-gallon (208 L) drum overpacked within a SWB or TDOP) and (1,800 PE-Ci) solidified/vitrified waste containers. The consequences of CH2 and CH3 for solidified/vitrified waste, are discussed here due to the differences in breaching mechanisms, and the release fractions identified in Section 5.2.1.1. It is conservatively assumed that seven solidified waste containers are breached as a result of crane failure (CH2), and two are breached as a result of puncture (CH3), with one drum in each scenario at 1,800 PE-Ci. As discussed in Section 5.2.1.1, the damage ratio for CH2 scenario is conservatively assumed to be the same as for untreated waste (DR = 1E-02), and for CH3, DR = 1E-02. The ARF x RF for solids that undergo brittle fracture (e.g. aggregate, glass) due to crush-impact forces is given by Equation 5-1 of DOE-HDBK-3010-94.[5] Applying this equation for solidified waste forms to the drop of waste container from heights equal to or less than 10 ft ($5 \text{ ft} < h \leq 10 \text{ ft}$), the calculated ARF x RF = 1.64E-05. Comparing this factor with that obtained for contaminated noncombustible materials which are subjected to impact and breach of the waste container for solid that do not undergo brittle fracture (Section 5.2.1.1), solidification offers a two order magnitude reduction in respirable airborne radioactive material for the bounding scenarios analyzed in this SAR.

Substitution of these values into the consequence calculations for CH2 and CH3 (Tables E-9, E-11, E-19, E-21, E-57, and E-59), indicate worst-case consequences to the immediate worker for CH3, and are thus summarized here. The doses to the immediate worker (2.1 rem [21 mSv]), noninvolved worker (0.25 rem [2.5 mSv]), and MEI (0.03 rem [0.3 mSv]), are well within the risk evaluation guidelines (for the extremely unlikely range) <u>despite the higher PE-Ci loading</u>. Based on the data presented in Table A-5 of Appendix A, as a result of the conditional likelihood of receiving such a shipment, the risk evaluation guidelines for the extremely unlikely range are used for the consequence evaluation. Therefore, although a higher PE-Ci limit is allowed, the effects of vitrifying, or solidifying waste containers results in a significant reduction in the release of respirable airborne radioactivity and thus risk to the receptors of concern.

To determine the acceptability of overpacking a drum of untreated waste within a SWB, the radiological consequences of CH2 and CH3 are again evaluated assuming that multiple drums are breached, one in each scenario at 1,100 PE-Ci (Tables E-10, E-12, E-20, E-22, E-58, and E-60). As discussed in Section 5.2.1.1, the DR for overpacked noncombustible solids (drum within a SWB) for drops less than 10 ft is 2.5E-04, and the DR for punctures of overpacked noncombustible solids (drum within a SWB or TDOP) is 1E-02. CH3 therefore results in a worst-case source term and as such, the consequences of CH3 are analyzed here. The ARF and RF for noncombustible solids are 1E-03 and 1.0 respectively. Substitution of these values into the consequence calculations for CH3, indicate doses of approximately 9 rem (90 mSv) to the noninvolved worker, 1 rem (10 mSv) to the MEI, and 77 rem (770 mSv) to the immediate worker. The immediate worker, noninvolved worker, and MEI doses therefore remain well within the risk evaluation guidelines (for the extremely unlikely range). Based on the data presented in Table A-5 of Appendix A, as a result of the conditional likelihood of receiving such a shipment, the risk evaluation guidelines for the extremely unlikely range are used for the consequence evaluation.

The WAC Pu-239 Equivalent Activity Operations and Safety limits defined above, when analyzed in conjunction with conservative safety analysis assumptions, and existing stored waste information: (1) provides a reasonable degree of assurance that the safety envelop of the facility has been defined, and (2) ensures that the risk to immediate workers, noninvolved worker, and the MEI remain well within the risk evaluation guidelines.

WAC Revision 4.0 Immobilization Criteria

Section 3.3.1.6 of WAC Rev.4[50] stated that immobilization will minimize the quantity of radioactive material that is available for dispersion or inhalation in event of the failure of a waste package.

The types of accidents of SAR concern involve contaminated combustible and non-combustible material packaged in robust containers (drums and standard waste boxes), that are opened and/or fail due to drops and/or punctures. The release fractions for drops and/or punctures of drums used in the SAR analyses for the case of surface contamination on solid, noncombustible surfaces are obtained from DOE-HDBK-3010-94. Section 5.1, page 5-4 of DOE-HDBK-3010-94 states, "the airborne release fractions and respirable fractions for these types of accidents are based on reasoned judgement that suspension under these circumstances will be bounded by suspension postulated for debris impacting powders in cans."

Therefore, in conjunction with the use of conservative waste container radionuclide inventories and damage ratios for heterogeneous or uncategorized metals, conservatism is provided in the calculation of potential radiological consequences from untreated CH TRU waste to the MEI, onsite worker, and immediate worker. The estimated consequences were found to be within the accident risk evaluation guidelines for all receptors of concern. As such, based on the accident consequence analysis in this SAR, no additional criteria are required to immobilize **untreated** (not solidified or vitrified) waste forms (up to a maximum allowable value of 80 PE-Ci for drums and 130 PE-Ci for SWBs) to minimize the quantity of radioactivity available for release.

Section 5.0 of DOE-HDBK-3010-94[5] discusses the difficulty in characterizing the size distribution of deposited radionuclide contamination. The handbook states that for surface contamination of combustible and noncombustible materials, it is not expected that defensible bases exist for assuming an original source respirable fraction, as the WAC Rev 4 criteria required. Therefore, (1) since the use of 80 PE-Ci for a drum radionuclide inventory and the inherent conservatism in the derivation and use of the bounding release fractions produce acceptable dose consequences to the worker, noninvolved worker, and MEI, and (2) considering the difficulty in characterizing waste particle size distributions for the waste forms identified in the BIR, the elimination of the WAC immobilization criteria for "untreated waste" up to the values of 80 PE-Ci for drums and 130 PE-Ci for SWBs is warranted. As discussed in the preceding discussion on maximum allowable waste container radionuclide inventories, however, waste containers exceeding these values will be overpacked, solidified, or vitrified (thus immobilized) as a defense-in-depth approach to limiting the consequences of potential accidents. Immobilization is therefore based on a more readily quantifiable variable (PE-Ci) (i.e., it is measurable and verifiable in all waste forms) than on the percentage of respirable particulates.

References for Section 5.2

1. DOE-STD-3009-94, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports, July 1994.

2. DOE/WIPP 94-026, Waste Isolation Pilot Plant Land Management Implementation Plan, August 1994.

3. DOE Order, 6430.1A, U.S. Department of Energy, General Design Criteria, 1989.

4. Guidance for the Implementation of EPA's Standards for management and Storage of Transuranic Waste (40 CFR Part 191, Subpart A) at the Waste Isolation Pilot Plant ("WIPP Subpart A Guidance"), Draft, August 23, 1996.

5. DOE-HDBK-3010-94, Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities, December 1994.

6. WPS-88-001, Full-Scale Drop-Impact Tests with DOT Specification 7A Waste Containers, Rockwell International, Rocky Flats Plant, December 9, 1988.

7. SAND80-2517, Analysis, Scale Modeling, and Full-Scale Tests of Low-Level Nuclear Waste Drum Response to Accident Environments.

8. MLM-3245, U.S. DOE Evaluation Document for DOT Type A Packaging, EG&G Mound, March 1987.

9. WHC-SD-WM-TRP-231, Drum Drop Test Report, Westinghouse Hanford Corporation, February 27, 1995.

10. PLG-1121, Damage Assessment of Waste Containers Involved in Accidents at the Waste Isolation Pilot Plant, PLG, Inc., August, 1996.

11. PLG-1167, Analysis of Roof Falls and Methane Gas Explosions in Closed Rooms and Panels

12. TRUPACT-II SAR, Revision 16, Appendix 1.3.11, Description of Pipe Overpack Payload Container, February 1997.

13. DOE/EIS-0026-FS, Final Supplement Environmental Impact Statement, Waste Isolation Pilot Plant, U.S. Department of Energy, Carlsbad, N.M., 1990.

14. Nuclear Regulatory Commission Regulatory Guide 1.145, Rev 1, Atmospheric Dispersion Models for the Potential Accident Consequence Assessments at Nuclear Power Plants, United States Nuclear Regulatory Commission, Washington, DC, November 1982.

15. WHC-SD-GN-SWD-30002, GXQ Users Guide, Westinghouse Hanford Company, Rev 0., June 8, 1993.

16. ICRP Report No. 23, Report of the Task Group on Reference Man, International Commission on Radiological Protection, Pergamon Press, NY, 1974.

17. DOE/EH-0071, Internal Dose Conversion Factors for Calculation of Dose to the Public, July 1988.

18. Letter from R. Neill, Environmental Evaluation Group, New Mexico, to G. Dials, dated January 9, 1996.

19. ANSI/ANS-51.1-1983, American National Standards Institute, Standard Nuclear Safety Criteria for the Design of Stationary Pressurized Water Reactor Plants.

20. ANSI/ANS-52.1-1983, American National Standards Institute, Standard Nuclear Safety Criteria for the Design of Stationary Boiling Water Reactor Plants.

21. 10 CFR 835, Occupational Radiation Protection, December 14, 1993.

22. 10 CFR 100, Reactor Site Criteria.

23. DOE Emergency Management Guide for Hazards Assessment, June 2, 1996.

24. Craig, DK et al., Toxic Chemical Hazard Classification and Risk Acceptance Guidelines for the use in DOE Facilities, May 1993.

25. American Conference of Governmental Industrial Hygienists, Threshold Limit Values for Chemical Substances, ACGIH, Cincinnati, Ohio, ISBN:1-882417-06-2, 1994.

26. Federal Emergency Management Agency, Handbook of Chemical Hazards Analysis Procedures, 1989.

27. American Conference of Government Industrial Hygienists, Guide to Occupational Exposures Values-1993, ISBN:1-882417-07-0, 1994.

28. WCAP 14312, Hazard and Operability Study for CH TRU Waste Handling System, Waste Isolation Pilot Plant, Westinghouse Waste Isolation Division, April, 1995.

29. WIPP-DOE-069, Rev. 5, TRU Waste Acceptance Criteria for the Waste Isolation Pilot Plant, April 1996.

30. DOE/CAO-95-1121, U.S. Department of Energy Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report (BIR), Revision 03, December 1995.

31. DOE\WIPP 87-005, Waste Drum Fire Propagation at the WIPP, April 1987.

32. EEG-45, Preliminary Investigation Into the Explosion Potential of Volatile Organic Compounds in WIPP CH-TRU Waste, Environmental Evaluation Group, New Mexico, June, 1990.

33. EEG-48, An Assessment of the Flammability Potential of Transuranic Waste, Environmental Evaluation Group, New Mexico, June, 1991.

34. DOE/WIPP-91-018, Position Paper on Flammability Concerns Associated with TRU Waste Destined for WIPP, April, 1991.

35. DOE/NS-0013, Fire, Explosion, and High-Pressure Hazards Associated with Waste Drums and Containers, DOE Office of Nuclear Safety, Safety Notice Issue No. 93-1, February, 1993.

36. CAO-94-1010, Revision 0, Transuranic Waste Characterization Quality Assurance Program Plan, U.S. Department of Energy, Carlsbad, N.M., 1995.

37. ERDA 76-21, Energy Research and Development Administration, Nuclear Air Cleaning Handbook.

38. WIPP/WID-96-2196, Rev. 0, Waste Isolation Pilot Plant TRUDOCK Crane System Analysis, September, 1996.

39. WTSD-TME-063, Probability of a Catastrophic Hoist Accident at the Waste Isolation Pilot Plant, July, 1985.

40. DOE/WID-96-2178, Rev. 0, Waste Isolation Pilot Plant Waste Hoist Brake System Analysis, July, 1996.

41. EEG-59, An Analysis of the Annual Probability of Failure of the Waste Hoist Brake System at the Waste Isolation Pilot Plant, Environmental Evaluation Group, New Mexico, November, 1995.

42. UCRL-15910, Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards, June 1990.

43. Bechtel Interoffice Memorandum, J.J. Litehiser to H.G. Taylor, DOE Order 6430.1A Review of the WIPP Site, Job No. 20585-001, September 27, 1990.

44. NUREG-0800, U.S. Nuclear Regulatory Commission. Standard Review Plan, 3.5.1.6, Aircraft Hazards, Rev 2, July, 1981.

45. SMRP No. 155, A Site-Specific Study of Wind and Tornado Probabilities at the WIPP Site in Southeast New Mexico, Department of Geophysical Sciences, T. Fujita, University of Chicago, February 1978 and its Supplement of August 1978.

46. DOE/WIPP 93-033, The Current Basis for Roof Fall Prediction at WIPP and the Preliminary Prediction for SPDV Room II, August 1993.

47. DOE/WIPP-91-023, U.S. Department of Energy, Report of the Geotechnical Panel on the Effective Life of Rooms in Panel 1, DOE/WIPP 91-023, Waste Isolation Pilot Plant, Carlsbad, NM, 1991.

48. DOE/WIPP-94-2027, Westinghouse Electric Corporation, Waste Isolation Division, 1994 Panel 1 Utilization Plan, .WIPP/WID-94-2027.

49. DOE/WIPP-96-2180, Westinghouse Geotechnical Engineering, 1996 Long-Term Ground Control Plan for the Waste Isolation Pilot Plant, WIPP/WID-95-2180, June 1996.

50. WIPP-DOE-069, Rev. 4, TRU Waste Acceptance Criteria for the Waste Isolation Pilot Plant, December 1991.

51. 40 CFR 191, Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Wastes, Subpart A, Environmental Standards for Management and Storage.

52. 40 CFR 61, Environmental Protection Agency Regulations on National Emission Standards for Hazardous Air Pollutants, Subpart H, National Emission Standard for Radionuclide Emissions from Department of Energy (DOE) Facilities.

53. Working Agreement for Consultation and Cooperation, signed by the U.S. DOE and the State of New Mexico, July 1981 and subsequent revisions.

54. WP 12-9, WIPP Emergency Management Program

55. DOE/WIPP-91-005, Waste Isolation Pilot Plant RCRA Part B Permit Application, Revision 6, U.S. Department of Energy, Carlsbad, N.M.

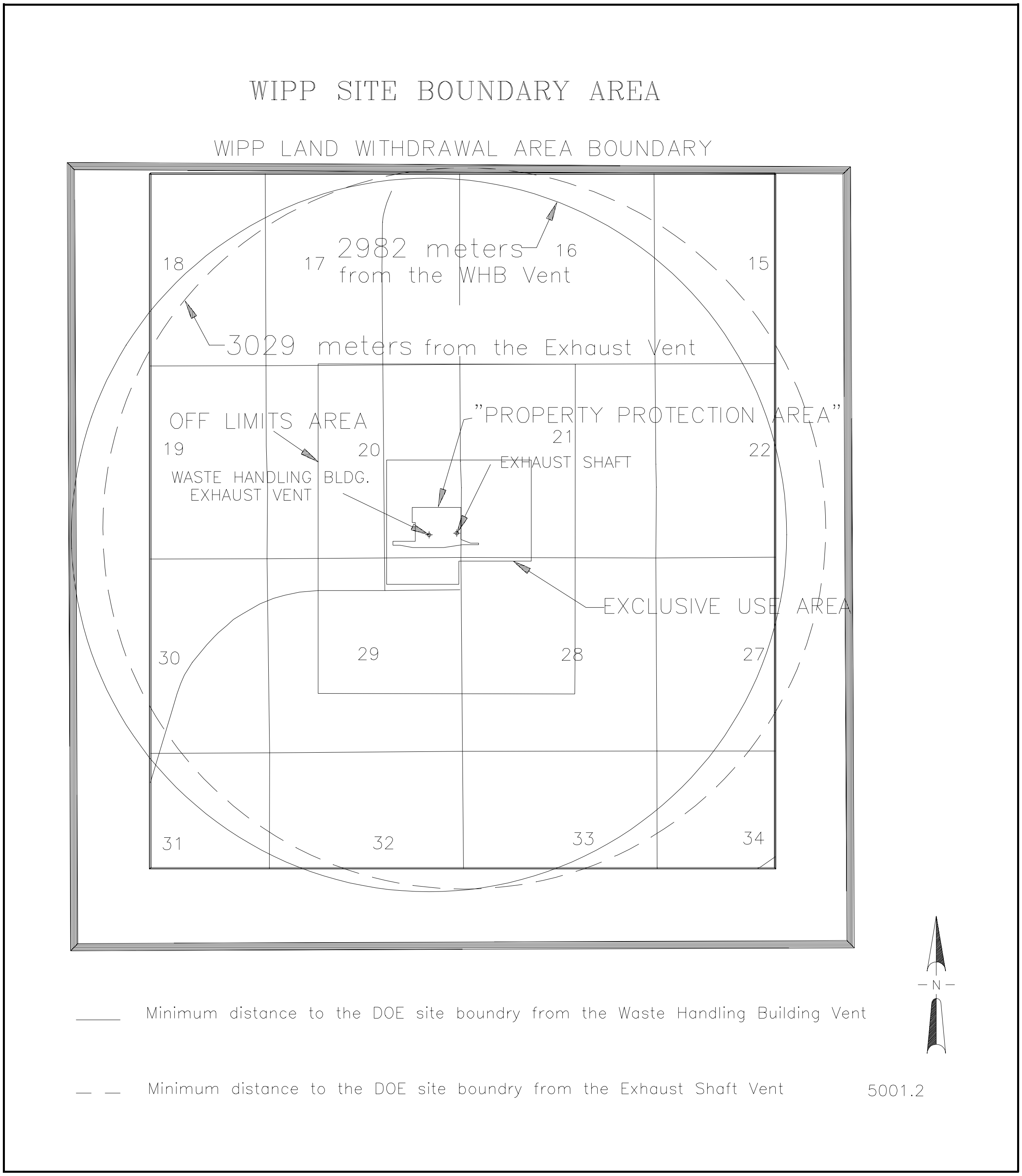


Figure 5.2-1, WIPP Site Boundary Area

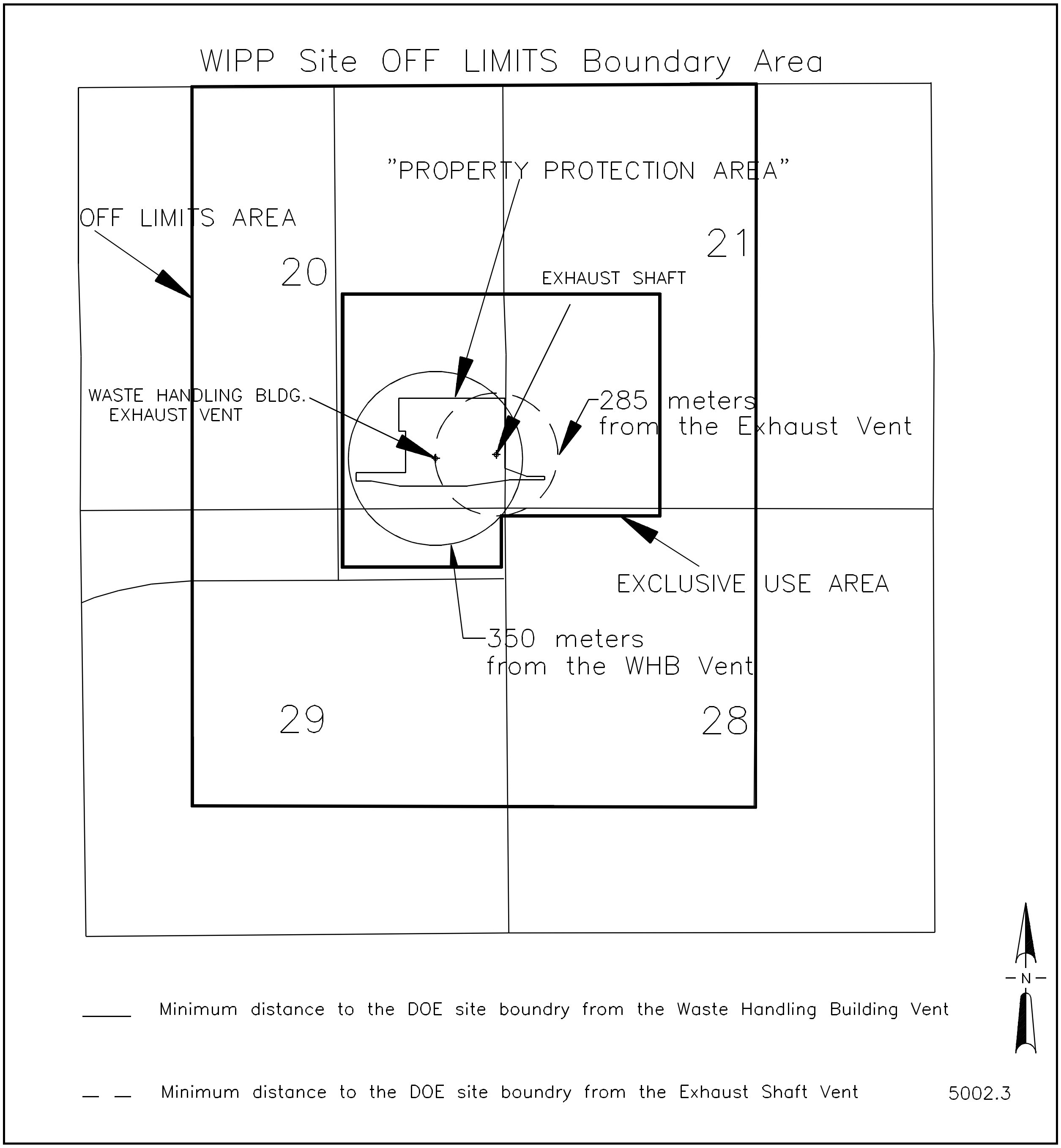


Figure 5.2-2, WIPP Site Off-Limits Boundary Area

Table 5.2-1a, MEI Risk Evaluation Guidelines

Description	Estimated Annual Frequency of Occurrence	Description	Radiological Guidelines	Nonradiological Guidelines
Normal operations	$1 \geq f\ 10^{-1}$			
Anticipated	$10^{-1} \geq f \geq 10^{-2}$	Incidents that may occur several times during the lifetime of the facility. (Incidents that commonly occur)	≤ 2.5 rem (25 mSv)	≤ PEL-TWA or TLV-TWA
Unlikely	$10^{-2} \geq f > 10^{-4}$	Accidents that are not anticipated to occur during the lifetime of the facility. Natural phenomena of this class include: Uniform Building Code-level earthquake, 100-year flood, maximum wind gust, etc.	≤ 6.5 rem (65 mSv)	≤ TOX-1[(1)]
Extremely Unlikely	$10^{-4} \geq f > 10^{-6}$	Accidents that will probably not occur during the life cycle of the facility.	≤ 25 rem (250 mSv)	≤ TOX-2[(2)]
Beyond Extremely Unlikely	$10^{-6} \geq f$	All other accidents.	No Guidelines	No Guidelines

(1) **TOX-1 Alternative** Guidelines
ERPG1
PEL-STEL
TLV-STEL
TLV-TWA*3

(2) **TOX-2 Alternative** Guidelines
ERPG2
EEGL (60 min.)
PEL-C
TLV-C
TLV-TWA*5

Table 5.2-1b, Noninvolved Worker Risk Evaluation Guidelines

Description	Estimated Annual Frequency of Occurrence	Description	Radiological Guidelines	Nonradiological Guidelines
Normal operations	$1 \geq f\ 10^{-1}$			
Anticipated	$10^{-1} \geq f \geq 10^{-2}$	Incidents that may occur several times during the lifetime of the facility. (Incidents that commonly occur)	≤ 5 rem (50 mSv)	TOX 1
Unlikely	$10^{-2} \geq f > 10^{-4}$	Accidents that are not anticipated to occur during the lifetime of the facility. Natural phenomena of this class include: Uniform Building Code-level earthquake, 100-year flood, maximum wind gust, etc.	≤ 25 rem (250 mSv)	TOX 2
Extremely Unlikely	$10^{-4} \geq f > 10^{-6}$	Accidents that will probably not occur during the life cycle of the facility.	≤ 100 rem (1 Sv)	TOX 3
Beyond Extremely Unlikely	$10^{-6} \geq f$	All other accidents.	No Guidelines	No Guidelines

(1) TOX-1 Alternative Guidelines
ERPG1
PEL-STEL
TLV-STEL
TLV-TWA*3

(2) TOX-2 Alternative Guidelines
ERPG2
EEGL (60 min.)
PEL-C
TLV-C
TLV-TWA*5

(3) TOX-3 Alternative Guidelines
EEGL (30 minute)
IDLH

Table 5.2-2, Toxicological Guidelines for Derivation of TOXs Page 1 of 2

Substance	TLV - TWA (mg/m^3)	TLV - STEL/C (mg/m^3)	PEL - TWA (mg/m^3)	PEL - STEL/C (mg/m^3)	IDLH (mg/m^3)	EEGL (mg/m^3)	ERPG 1 - 2 - 3 (mg/m^3)
Asbestos	2 f/cc	n/a	.2 f/cc	1 f/cc (30min)	n/a	n/a	n/a
Beryllium	0.002	n/a	0.002	0.005	10	n/a	1 - 0.005 2 - 25 3 - 100
Cadmium	0.002	n/a	0.005	n/a	50	n/a	n/a
Lead	0.15	n/a	0.05	n/a	700	n/a	n/a
Butyl Alcohol	n/a	152	300	150	24,640	n/a	n/a
Carbon Tetrachloride	31	63	12.6	n/a	1,917	n/a	1 - 95 2 - 159 3 - 1917
Mercury	0.025	n/a	0.05	0.1	28	.2 (24 hour)	1 - 0.15 2 - 0.2 3 - 28
Methyl Alcohol	262	328	260	310	33,250	266	1 - 266 2 - 266 3 - 532
Methylene Chloride	174	n/a	500	1,000	21,000	n/a	n/a
Chloroform	10	n/a	2	50	5,000	500	1-100 2-1,000 3-5,000
1,1,2,2-Tetrachloroethane	6.9	n/a	35	n/a	1,505	n/a	n/a
Trichloroethylene	n/a	n/a	50	200	1,000	n/a	1-100 2-500 3-1,000
Polychlorinated Biphenyl (PCB)	0.5	n/a	0.5	n/a	10	n/a	n/a

Notes to Table 5.2-2:

EEGL is a concentration of a substance in air that has been judged by the Department of Defense to be acceptable for the performance of specific tasks by military personnel during emergency conditions lasting 1 to 24 hours. EEGL dosages may produce transient central nervous system effects and eye or respiratory irritation, but nothing serious enough to prevent response to emergency conditions.

Threshold limit values (TLVs) have been defined to include various levels of exposure to worker populations. TLVs are published by the American Conference of Governmental Industrial Hygienists (ACGIHs).

TLV-TWA: Threshold limit value-Time-weighted average for a specific substance defines the limit of acceptable concentration to which most workers can be exposed for up to a normal eight-hour day and a 40-hour week without adverse effect. As with other TLV values, the population that comprises the general public differs from the population defined for TLVs in that the general public includes additional groups such as children, elderly persons, and hospitalized patients.

TLV-STEL: Threshold limit value-Short-term exposure limit is a time weighted average concentration to which workers should not be exposed for longer than 15 minutes and which should not be repeated more than four times per day, with at least 60 minutes between successive exposures. Whereas the TLV-TWA is useful for chronic exposure effects, the TLV-STEL addresses effects of Short-term, high-level exposures. As with other TLV values, the population that comprises the general public differs from the population defined for TLVs in that the general population includes additional groups such as children, elderly persons, and hospitalized patients.

Table 5.2-2, Toxicological Guidelines for Derivation of TOXs **Page 2 of 2**

TLV-C: Threshold Limit Value-Ceiling is the concentration in air that should not be exceeded during any part of the working exposure, for the work population. Ceiling limits may be used with other TLVs or independently. As for other TLV values, the population that comprises the general public differs from the working population since it includes additional groups such as children, elderly persons, and hospitalized patients.

PELs have been developed by the Occupational Safety and Health Administration (OSHA) as a measure for safe and healthful working conditions for men and women employed in any business engaged in commerce in the United States. As with other exposure limits developed for industrial applications, limitations exist with respect to applicability to the general population. PEL is an exposure limit established by OSHA. PEL-C is the concentration that shall not be exceeded during any part of the workday exposure.

SPEGL-Short-term Public Emergency Guidance Level is an acceptable ceiling concentration for a single, unpredicted short-term exposure to the public. The exposure period is usually calculated to be one hour or less and never more than 24 hours. Five SPEGLs have been developed by the USNRC Committee on Toxicology and are generally set at between 0.1 and 0.5 of EEGL values.

IDLH levels have been developed to define concentrations of materials from which workers should evacuate within 30 minutes without escape-impairing symptoms or any irreversible health effect. As IDLH values were developed by the National Institute for Occupational Safety & Health (NIOSH) for industrial application, their usefulness for application to the general population is limited. IDLH is a NIOSH definition.

ERPGs are published by the AIHA These are intended to provide airborne concentration levels to which most individuals (in a community) could be exposed for periods up to one hour without experiencing adverse effects as defined by the ERPG level. These guidelines are intended for emergency response applications. ERPG designations are:

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

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

ERPG-1: The maximum airborne concentration to which nearly all individuals could be exposed for up to one hour without experiencing or developing health effects (i.e., more severe than sensory perception or mild irritation, if relevant).

a. There is no IDLH identified for asbestos. TLV for asbestos is set by the number of asbestos fibers. The TLV-TWA (per OSHA permissible exposure limits) is 0.2 fibers longer than 5 micrometers and with a length to diameter ratio of at least 3:1.

b. Conversion to fibers/cc and calculation of fraction of TLV: The asbestos release is assumed to be chrysotile, the most common form of asbestos. The density of chrysotile is 1.55 gm/cc (or 1.55E+09 mg/m^3). Fibers of respirable size would be approximately 10 microns long by 3.3 microns in diameter. Using the expression that volume equals (π/4)x(diameter squared) x (length), the volume of a fiber is then 8.5E-17 m^3. The volume multiplied by the density gives the mass as 1.3E-07 mg per fiber. Using the concentration in mg/m^3 at each receptor and converting to fibers/cc will allow a comparison of the asbestos released to the appropriate TLV.

   Fibers/cc = (Asbestos concentration mg/m^3)(1 fiber/1.3 x 10^{-7}mg)(1m^3/1.0 x 10^6cc)

c. C denotes ceiling value.

1mg/m^3 * 1.6E7 = 1lb/ft^3

Table 5.2-3a, Summary of Noninvolved Worker and MEI Estimated Radiological Dose and Comparison to Guidelines[1] Page 1 of 1

Accident	No-mitigation Release Freq/yr[2]	Noninvolved Worker /MEI Guidelines (rem)	Type of Release	Receptor Dose (CEDE-rem)			Receptor Dose % of Guidelines [(Dose/Guidelines)*100]		
				On-site (Noninvolved Worker)	Exclusive Use Area Boundary (MEI)	Site Boundary	On-site (Noninvolved Worker)	Exclusive Use Area Boundary (MEI)	Site Boundary
CH2 Crane Failure in WHB	Extremely Unlikely	100/25	Drums/mitigated	2.7E-06	3.1E-07	2.1E-08	<1%	<1%	<1%
			Drums/no-mitigation	2.7E+00	3.1E-01	2.1E-02	2.7%	1.2%	<1%
			SWBs/mitigated	1.1E-06	1.3E-07	8.5E-09	<1%	<1%	<1%
			SWBs/no-mitigation	1.1E+00	1.3E-01	8.5E-03	1.1%	<1%	<1%
CH3 Puncture in WHB	Extremely Unlikely	100/25	Drums/mitigated	3.8E-06	4.4E-07	3.0E-08	<1%	<1%	<1%
			Drums/no-mitigation	3.8E+00	4.4E-01	3.0E-02	3.8%	1.8%	<1%
			SWBs/mitigated	1.3E-06	1.6E-07	1.1E-08	<1%	<1%	<1%
			SWBs/no-mitigation	1.3E+00	1.6E-01	1.1E-02	1.3%	<1%	<1%
CH4 Drop in WHB	Extremely Unlikely	100/25	Drums/mitigated	8.6E-07	1.0E-07	6.8E-09	<1%	<1%	<1%
			Drums/no-mitigation	8.6E-01	1.0E-01	6.8E-03	<1%	<1%	<1%
			SWBs/mitigated	1.3E-07	1.6E-08	1.1E-09	<1%	<1%	<1%
			SWBs/no-mitigation	1.3E-01	1.6E-02	1.1E-03	<1%	<1%	<1%
CH9 Drop in U/G	Extremely Unlikely	100/25	Drums/mitigated	2.7E-06	4.4E-07	2.1E-08	<1%	<1%	<1%
			Drums/no-mitigation	2.7E+00	4.4E-01	2.1E-02	2.7%	1.8%	<1%
			SWBs/mitigated	1.1E-06	1.8E-07	8.4E-09	<1%	<1%	<1%
			SWBs/no-mitigation	1.1E+00	1.8E-01	8.4E-03	1.1%	<1%	<1%

Notes: (1) Listed accidents are those whose no-mitigation frequency, as derived in Appendix D, is $>10^{-6}$/yr. The consequences of beyond extremely unlikely accidents may be found in the respective accident scenario.

(2) The no-mitigation release frequency is as derived from the event tree (Appendix D) and includes: (a) the likelihood of the initiating event, (b) the conditional likelihood of waste container damage/failure as derived from test data, and (c) the conditional likelihood of the worst-case CI from Table A-5 of Appendix A.

1 REM = .01 Sv **1mg/m^3 * 1.6E7 = 1lb/ft^3**

Table 5.2-3b, Summary of Immediate Worker Estimated Radiological Dose and Comparison to Guidelines[1] **Page 1 of 1**

Accident	No-Mitigation Release Freq/yr[2]	Type of Release	Noninvolved Worker Guidelines (rem)	Receptor Dose (CEDE-rem)	Receptor Dose % of Guidelines
CH2 Crane Failure in WHB	Extremely Unlikely	Drums/no-mitigation	100	1.1E+01	11.0%
		SWBs/no-mitigation	100	4.5E+00	4.5%
CH3 Puncture in WHB	Extremely Unlikely	Drums/no-mitigation	100	3.2E+01	32.0%
		SWBs/no-mitigation	100	1.1E+01	11.0%
CH4 Drop in WHB	Extremely Unlikely	Drums/no-mitigation	100	3.6E+00	3.6%
		SWBs/no-mitigation	100	5.6E-01	<1.0%
CH9 Drop in U/G	Extremely Unlikely	Drums/no-mitigation	100	2.2E+01	22.0%
		SWBs/no-mitigation	100	8.8E+00	8.8%

Notes: (1) Listed accidents are those whose no-mitigation frequency, as derived in Appendix D, is $>10^{-6}$/yr. The consequences of beyond extremely unlikely accidents may be found in the respective accident scenario.

(2) The no-mitigation release frequency is as derived from the event tree (Appendix D) for the associated scenario, and includes: (a) the likelihood of the initiating event, (b) the conditional likelihood of waste container damage/failure as derived from test data, and (c) the conditional likelihood of the worst-case CI from Table A-5 of Appendix A.

1 REM = .01 Sv

Table 5.2-4a, Summary of Noninvolved Worker and MEI Estimated Nonradiological Concentrations and Comparison to Guidelines

Accident	No-mitigation Release Freq./yr	Type of Release	Compound	Concentrations (mg/m3)			% of Guidelines	% of Guidelines
				Noninvolved Worker Area	Exclusive Use Area	Noninvolved Worker/MEI Guidelines (mg/m^3) (Table 5.2-2)	Noninvolved Worker Area	Exclusive Use Area
CH2 Crane Failure in WHB	Unlikely	Drums/no-mitigation	Methylene Chloride	7.3E+00	8.6E-01	21,000/870	<1.0%	<1.0%
			Carbon Tetrachloride	1.4E+01	1.6E+00	1,917/63	<1.0%	2.50%
			Chloroform	7.10E-01	8.3E-02	5,000/50	< 1.0%	<1.0%
			1,1,2,2-Tetrachloroethane	3.70E-01	4.34E-02	1,505/35	<1.0%	<1.0%
		SWBs/no-mitigation	Methylene Chloride	4.2E+00	4.9E-01	21,000/870	<1.0%	<1.0%
			Chloroform	4.1E-01	4.7E-02	5,000/50	<1.0%	<1.0%
			1,1,2,2-Tetrachloroethane	2.12E-01	2.5E-02	1,505/35	<1.0%	<1.0%
			Carbon Tetrachloride	7.7E+00	9.0E-01	1,917/63	<1.0%	1.40%
CH3 Puncture in WHB	Unlikely	Drums/no-mitigation	Methylene Chloride	4.2E+00	4.9E-01	21,000/870	<1.0%	<1.0%
			Carbon Tetrachloride	7.8E+00	9.0E-01	1,917/63	<1.0%	1.40%
			Chloroform	4.10E-01	4.7E-02	5,000/50	<1.0%	<1.0%
			1,1,2,2-Tetrachloroethane	2.10E-01	2.5E-02	1,505/35	<1.0%	<1.0%

Page 2 of 2

Table 5.2-4a, Summary of Noninvolved Worker and MEI Estimated Nonradiological Concentrations and Comparison to Guidelines

Accident	No-mitigation Release Freq./yr	Type of Release	Compound	Concentrations (mg/m3)			% of Guidelines	% of Guidelines
				Noninvolved Worker Area	Exclusive Use Area	Noninvolved Worker/MEI Guidelines (mg/m³) (Table 5.2-2)	Noninvolved Worker Area	Exclusive Use Area
		SWBs/no-mitigation	Methylene Chloride	8.4E+00	9.8E-01	21,000/870	<1.0%	<1.0%
			Chloroform	8.1E-01	9.5E-02	5,000/50	<1.0%	<1.0%
			1,1,2,2-Tetrachloroethane	4.2E-01	4.9E-02	1,505/35	<1.0%	< 1.0%
			Carbon Tetrachloride	1.6E+01	1.8E+00	1,917/63	<1.0%	2.9%
CH4 Drop in WHB	Unlikely	Consequences same as CH3	-	-	-	-	-	-
CH9 Drop in U/G	Unlikely	Drums/no-mitigation	Methylene Chloride	7.3E+00	1.2E+00	21,000/870	<1.0%	<1.0%
			Chloroform	7.1E-01	1.2E-01	5,000/50	<1.0%	<1.0%
			1,1,2,2-Tetrachloroethane	3.7E-01	6.1E-02	1,505/35	<1.0%	<1.0%
			Carbon Tetrachloride	1.36E+01	2.2E+00	1,917/63	<1.0%	3.5%
		SWBs/no-mitigation	Methylene Chloride	4.2E+00	6.9E-01	21,000/870	<1.0%	<1.0%
			Chloroform	4.1E-01	6.7E-02	5,000/50	<1.0%	<1.0%
			1,1,2,2-Tetrachloroethane	2.1E-01	3.5E-02	1,505/35	<1.0%	<1.0%
			Carbon Tetrachloride	7.7E+00	1.3E+00	1,917/63	<1.0%	2.1%

NOTE: No credit is taken for mitigation of solid, liquid chemicals or VOCs by HEPA filtration.

$1 mg/m^3 * 1.6E7 = 1 lb/ft^3$

Table 5.2-4b, Summary of Immediate Worker Estimated Nonradiological Dose and Comparison to Guidelines Page 1 of 1

Accident	No-mitigation Freq/yr	Compound	Noninvolved Worker Guidelines (mg/m^3)	Drum Concentration (mg/m^3)	Drum % 0f Guidelines	SWB Concentration (mg/m^3)	SWB % of Guidelines
CH2	Unlikely	Methylene Chloride	21,000	5.49E+00	<1.0%	3.14E+00	<1.0%
		Chloroform	5,000	5.30E-01	<1.0%	3.03E-01	<1.0%
		Carbon Tet	1,917	1.01E+01	<1.0%	5.79E+00	<1.0%
		1,1,2,2-Tetrachlor.	1,505	2.78E-01	<1.0%	1.58E-01	<1.0%
CH3 Puncture in WHB	Unlikely	Methylene Chloride	21,000	3.14E+00	<1.0%	6.27E+00	<1.0%
		Chloroform	5,000	3.03E-01	<1.0%	6.06E-01	<1.0%
		Carbon Tet	1,917	5.79E+00	<1.0%	1.16E+01	<1.0%
		1,1,2,2-Tetrachlor.	1,505	1.59E-01	<1.0%	3.16E-01	<1.0%
CH4	Unlikely	Same as CH3		Same as CH3		Same as CH3	
CH9	Unlikely	Methylene Chloride	21,000	5.99E+01	<1.0%	3.42E+01	<1.0%
		Chloroform	5,000	5.78E+00	<1.0%	3.30E+00	<1.0%
		Carbon Tet	1,917	1.11E+02	5.8%	6.31E+01	3.3%
		1,1,2,2-Tetrachlor.	1,505	3.03E+00	<1.0%	1.73E+00	<1.0%

1mg/m^3 * 1.6E7 = 1lb/ft^3

This page intentionally left blank

5.3 Remote Handled (RH) Transuranic (TRU) Hazard Analysis

TBD

This page intentionally left blank

5.4 RH TRU Accident Analysis

TBD

This page intentionally left blank

5.5 Long-Term Waste Isolation Assessment

Applicable regulations require the DOE to demonstrate the ability of the WIPP repository to isolate TRU wastes for a 10,000-year period (40 CFR 191[1]). To evaluate the long-term performance of the disposal system, the DOE uses a technique developed especially for predicting the behavior of geologic repositories over the thousands of years required for waste isolation. This technique is performance assessment. Performance assessment is a multi disciplinary, iterative, analytical process that begins by using available information that characterizes the waste and the disposal system (the design of the repository, the repository seals, and the natural barriers provided by the host rock and the surrounding formations). The DOE uses performance assessment to estimate the releases of radionuclides, based on the probabilities of these relevant features, events, and processes (FEPs) occurring. Sensitivity analyses are used by the DOE to determine which characteristics of the disposal system exert the greatest effect on performance. The results of performance assessment are used by the DOE in the 40 CFR Part 191 compliance program to assess the disposal system's behavior and the possible environmental releases.

The DOE's methodology for performance assessment uses relevant information about the disposal system and the waste to simulate performance over the regulatory time periods. This process is schematically represented by the flow diagram in Figure 5.5-1, which shows how information describing the disposal system is used by the DOE to develop scenarios, scenario probabilities, and the consequence models used to estimate performance. The WIPP performance assessment methodology has been reviewed by the NAS, the EEG, and experts in and outside the United States. Initially, the DOE used the process in Figure 5.5-1 with a feedback line from the Uncertainty Analysis block to the System Description block. In this way, the DOE used performance assessment to identify important parameters and the programs needed to better define the parameters and to obtain relevant information.

Uncertainty and how it is handled in the analysis plays a major role in the formulation of a performance assessment strategy. The EPA anticipates that uncertainty in long-term predictions will be inevitable and substantial (see 40 CFR § 191.13(b)). Because of this, the Agency applies a reasonableness test to the outcome of performance assessments. In other words, the uncertainty that is inherent in modeling the behavior of natural and engineered system is such that there is likely no single correct set of models and assumptions. Instead, there are those models and assumptions that lead to a "reasonable expectation" that compliance will be achieved.

The DOE has addressed uncertainty associated with the WIPP disposal system through careful site, facility, and waste characterization. Uncertainty remaining after these characterizations is incorporated into the performance assessment through the use of reasonable assumptions about models and parameter distributions.

In general, the DOE has not attempted to bias the performance assessment toward a conservative outcome. The mean complimentary cumulative distribution function (CCDF) represents a best estimate of the expected, and in the case of human intrusion, prescribed performance of the disposal system. However, where realistic approaches to incorporating uncertainty are unavailable or impractical, and where the impact of the uncertainty on performance is small, the DOE has chosen to simplify the analysis by implementing conservative assumptions. The conservatism in the analysis does not significantly affect the location of the mean CCDF in Figure 5.5-2 (DOE/CAO-1996-2184, Title 40 CFR Part 191, Compliance Certification Application for the Waste Isolation Pilot Plant, October 1996[2]).

References for Section 5.5

1. 40 CFR 191, Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Wastes, Subpart A, Environmental Standards for Management and Storage.

2. DOE/CAO-1996-2184, Title 40 CFR Part 191, Compliance Certification Application for the Waste Isolation Pilot Plant, October 1996.

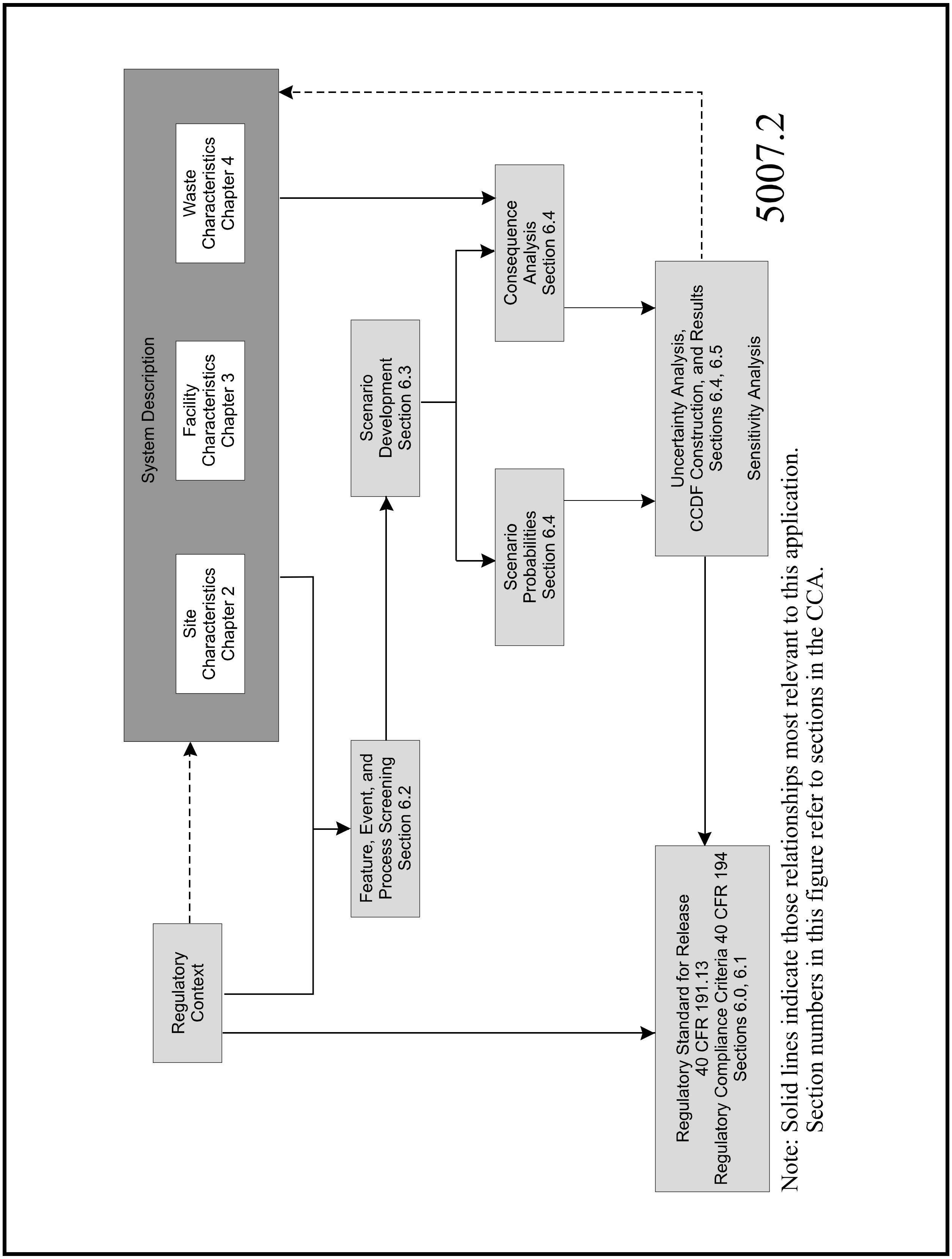
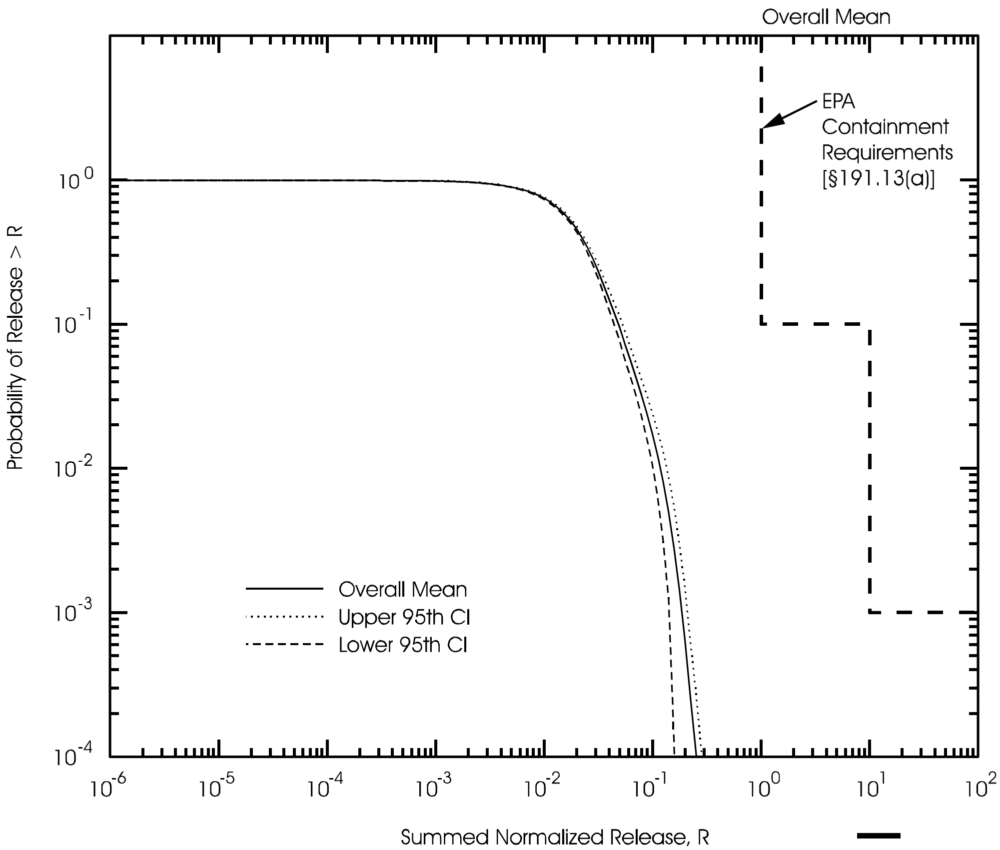


Figure 5.5-1 Methodology for Performance Assessment for the WIPP



Fugure 5.5-2 Final WIPP CCDF

5.6 Conclusions

The analyses in this chapter provide a detailed review of the potential hazards associated with CH TRU waste handling operations. The methodologies used in this process included a qualitative hazard analysis and a quantitative evaluation of the potential consequences of postulated accidents. The hazard analysis process indicated that eleven potential accident scenarios required further review and quantitative evaluation. Based on bounding container inventory and release estimates, the calculated accident consequences were compared to accident risk evaluation guidelines for the public and found to be significantly below the guidelines.

Additionally, (1) the analysis indicated safety class or safety significant SSCs are not required for the WIPP to mitigate any accident radiological and nonradiological consequence to below risk evaluation guidelines, and (2) per the discussion in Section 4.4.1, secondary confinement is not required. SSCs while not required to prevent or to mitigate the consequences of an accident from exceeding the risk evaluation guidelines support the WIPP defense-in-depth philosophy.

This page intentionally left blank

DERIVATION OF TECHNICAL SAFETY REQUIREMENTS
TABLE OF CONTENTS

DERIVATION OF TECHNICAL SAFETY REQUIREMENTS
LIST OF TABLES

TABLE **TITLE** **PAGE NO.**

DERIVATION OF TECHNICAL SAFETY REQUIREMENTS

This section provides the basis for deriving the WIPP Technical Safety Requirements (TSRs) in accordance with the requirements of DOE Order 5480.22, *Technical Safety Requirements*.[1] This section provides the link between the Hazards and Accident Analysis in Chapter 5 and the WIPP TSR document, DOE/WIPP-95-2125 (current revision), *Waste Isolation Pilot Plant Technical Safety Requirements* (Attachment 1 to this SAR). DOE Order 5480.22[1] provides detailed criteria for the selection of TSR Safety Limits (SLs), Limiting Control Settings (LCSs), Limiting Conditions for Operations (LCOs), Surveillance Requirements (SRs), and Administrative Controls (ACs).

The Chapter 5 Hazards and Accident Analyses indicate that SLs, LCSs, LCOs, and SRs are not required for the WIPP facility as derived below. As discussed in Chapter 5, Design Class I Systems, Structures or Components (SSCs) are not required for the WIPP to mitigate any accidental radiological and non-radiological off-site Maximally Exposed Individual (MEI) or noninvolved worker consequences to acceptable levels. WIPP TSRs in the form of ACs are derived in this chapter. These ACs provide TSRs covering the WIPP defense-in-depth approach developed in Chapter 5.

6.1 Requirements

Requirements for the derivation of TSRs are specified in DOE 5480.22.[1]

This page intentionally blank

6.2 TSR Coverage

ACs impose administrative requirements necessary to control operation of the facility such that all TSR requirements are met. Since no SLs, LCSs, LCOs, or SRs are defined for the WIPP, WIPP specific ACs impose administrative requirements necessary to ensure operation of the facility consistent with the design that was shown to be safe in chapter 5. These administrative requirements are defined in Section 6.4.5.

This page intentionally blank

6.3 Derivation of Facility Modes

Operations at the WIPP consist mainly of waste handling, storage, and disposal operations. The following is a definition of the modes of operations. The mode of operation is defined such that the Waste Handling Building and the Underground may be in different modes. Prior to receiving waste, the facility is required to be in one of the modes of operation.

6.3.1 Waste Handling Mode

The Waste Handling Building (WHB) and/or the Underground is configured for waste handling, and all required defense-in-depth SSCs are operated as required. Maintenance, repair activities, and inspections are allowed as long as they do not prevent the functions of the SSCs required for the Waste Handling Mode. The required SSCs described in Table 6-2 ensure that the defense-in-depth features identified in Chapter 5 as consequence mitigators or additional preventative features are available during those activities (waste handling) that introduce the potential for significant accidents.

6.3.2 Waste Storage/Disposal Mode

Waste handling operations are not being conducted in the WHB and/or in the Underground. WHB and/or the Underground is configured for waste storage or disposal. After receipt of waste, the facility retains its inventory of radioactive and hazardous material. No waste handling operations are allowed during Waste Storage/Disposal Mode except as required to safely complete a waste handling evolution interrupted by SSC malfunction or unavailability, and in accordance with the applicable procedure. Maintenance, repair activities, and inspections are allowed, provided the SSCs required in Table 6-2 for Waste Storage/Disposal Mode are restored to operation in a timely manner, and SSCs are not intentionally removed from service during waste handling completion.

This page intentionally blank

6.4 Derivation of WIPP TSRs

6.4.1 Safety Limits (SLs)

As defined in DOE Order 5480.22,[1] Technical Safety Requirements, SLs are limits on process variables associated with those physical barriers, generally passive, that are necessary for the intended facility function and that are found to be required to guard against the uncontrolled release of radioactivity and other hazardous material. "Process Variables" refers to observable, measurable parameters such as temperature and pressure. "Passive physical barriers" refers to those barriers that constitute the primary process material boundary.

Based on the analysis presented in Chapter 5, no SLs are identified for the WIPP facility.

6.4.2 Limiting Control Settings (LCSs)

As defined in DOE Order 5480.22,[1] LCSs are settings on safety systems that control process variables to prevent exceeding SLs. More precisely, an LCS is the set point for an instrument or device monitoring a process variable that, if exceeded, initiates actions to prevent exceeding an SL.

The WIPP facility has no SLs identified, therefore, no LCSs are required.

6.4.3 Limiting Conditions for Operations (LCOs)

DOE Order 5480.22,[1] Attachment 1, Section II.2.3.h, provides that "LCOs should be written only for systems and equipment which meet one (or more) of the following descriptions," and prescribes five selection criteria, h.(1) through h.(5). The order also emphasizes that "Maintaining the LCOs at the minimum number necessary will emphasize the importance of the LCOs and better ensure the compliance with them." All five criteria clearly tie the LCOs to the facility accident or transient analyses.

The LCO selection criteria interpretations define TSR content based on key nuclear safety analysis requirements. Specifically, three of the five TSR LCO selection criteria are understood to restrict TSR LCOs to only those requirements that are under the direct control of the facility's operators, and are of primary importance for: **prevention** (Criterion h.(1)), **mitigation** (Criterion h.(2)), and **initial conditions** (Criterion h.(3)) of credible, unmitigated accident scenarios. Additionally, Criterion h.(4) involves the application of criteria h.(1), h.(2), and h.(3) to experiments and experimental facilities, and Criterion h.(5) to systems and equipment that are used for handling fissile material. The specifics of each criterion as applied to the WIPP facility are as follows:

- Criterion h.(1) - Prevention:

  A basic concept in the protection of the public is the prevention of accidents that have the potential for an uncontrolled release of radioactive material. Criterion h.(1) is intended to ensure that TSRs be selected to identify instrumentation that is used to detect, and to indicate in the control room or other control location, a significant degradation of the physical barriers which prevent the uncontrolled release of radioactive or other hazardous materials. For example, instrumentation installed to detect significant degradation of a reactor coolant pressure boundary enables the operator to correct the degraded condition prior to accident initiation or to place the facility in a condition that reduces the likelihood of the accident.

Instrumentation at the WIPP, such as the Continuous Air Monitors (CAMs), Effluent Monitors, Area Radiation Monitors (ARMs), and installed instrumentation to control differential pressure, is not required to prevent accidents as analyzed in the SAR from occurring, or to facilitate the Central Monitoring Room (CMR) operator placing the facility in a condition reducing the likelihood of an accident from occurring. Therefore, Criterion h.(1) has no application to the WIPP.

- Criterion h.(2) - Mitigation:

Criterion h.(2) provides that "Structures, systems, and components that are relied upon in the Safety Analyses to function or actuate to prevent or mitigate accidents, or transients that either involve the assumed failure of, or present a challenge to, the integrity of a physical barrier that prevents the uncontrolled release of radioactive materials ... intended to include only those structures, systems, and components that are part of the primary success path of a safety sequence analysis and those support and actuation systems necessary for them to function successfully."

The "primary success path of a safety sequence analysis" is defined as "the sequence of events assumed by the Safety Analyses, which leads to the conclusion of a transient or accident with consequences that are acceptable. Hence, any structure, system, or component in that assumed sequence should be included in the LCO."

Consistent with the primary intent of DOE Order 5480.22[1] establishing requirements for the protection of the public, the existing practice is: 1) to evaluate the unmitigated radiological and non-radiological consequences to members of the MEI and noninvolved worker as the result of an accident; 2) to compare the radiological and non-radiological consequences to established accident risk evaluation guidelines; and 3) if the consequences of the accident exceed the established accident consequence risk evaluation guidelines, to define SSCs and associated TSR LCOs mitigating or reducing those consequences to acceptable levels below the established criteria.

The unmitigated MEI and noninvolved worker radiological and non-radiological consequences and risk evaluation guidelines, as documented in Chapter 5, Tables 5.2-3, and 5.2-4. are used as the basis for applying this criterion.

Application of DOE Order 5480.22[1] TSR LCO Selection Criterion h.(2) to the WIPP:

The WIPP SSCs that are assumed to function in the SAR accident analysis mitigating an accident's radiological and non-radiological consequences to acceptable levels (to within the accident risk evaluation guidelines) satisfy Criterion h.(2).

The unmitigated radiological and non-radiological accident consequences were estimated and compared to the risk evaluation guidelines in Chapter 5. The unmitigated radiological and non-radiological accident consequences are below the consequence risk evaluation guidelines therefore; 1) mitigating SSCs are not required, and 2) TSR LCOs are not required. Tables 5.2-3 and 5.2-4 of Chapter 5 of the SAR list the analyzed accidents, and the mitigated and unmitigated MEI and noninvolved worker radiological consequences. All of the radiological and non-radiological accident consequences are well below the applicable risk evaluation guidelines.

- Criterion h.(3) - Initial Condition:

  Process variables as initial conditions of accidents or transients that are monitored and controlled during operations so the parameter remains within the analysis bounds satisfy this selection criterion. The WIPP is not a process facility, therefore process variables are not considered in the SAR accident analysis as initial conditions for accidents. Thus, Criterion h.(3) is not applicable to the WIPP.

- Criterion h.(4):

  Criterion h.(4) involves applying criteria h.(1), h.(2), and h.(3) to experimental activities involving radioactive or other hazardous materials. There are currently no planned experimental or test activities at the WIPP. Therefore, Criterion h.(4) is not applicable to the WIPP.

- Criterion h.(5):

  Criterion h.(5) applies to fissile material handling facilities and is only related to inadvertent criticality protection. Inadvertent criticality is not a credible hazard at the WIPP. Inadvertent criticality is controlled through the ACs Criticality Program in conjunction with the Waste Characteristics program which conforms to the WIPP Waste Acceptance Criteria (WAC).[2] Therefore, Criterion h.(5) is not applicable to the WIPP.

6.4.4 Surveillance Requirements (SRs)

As defined in DOE Order 5480.22,[1] SRs relate to testing, channel calibration, channel operational testing, or inspection to maintain the operability, quality, and safety of SSCs and their support systems. SRs are defined as the requirements necessary to maintain facility operation within the SLs, LCSs, and LCOs. Selection criteria for SRs are defined in DOE Order 5480.22.[1]

Without SLs, LCSs, and LCOs for the WIPP facility, SRs are not required.

6.4.5 Administrative Controls

As discussed in Section 2.4 of Attachment 1 of DOE Order 5480.22,[1] ACs impose necessary requirements controlling operation of the facility to meet all TSR requirements. Without SLs, LCSs, LCOs, and SRs, WIPP specific ACs impose administrative and operational requirements supporting the WIPP defense-in-depth concept. Basic elements and requirements defined for TSR AC programs are enforced by the associated implementing WIPP procedures.

Supporting the first layer of defense-in-depth (the prevention of accidents) as defined in Section 5.1.6, WIPP TSR ACs are established as follows:

- To maintain the design, quality, testability, inspectability, operational capability, maintainability, and accessibility of the facility, TSR ACs are required relating to: (1) configuration and document control, (2) maintenance, (3) quality assurance, and (4) geotechnical monitoring. These ACs are important to ensure the frequency of events and the availability of the operating and design conditions remain as analyzed in Section 5.2.3.

- To ensure that the facility operations are conducted by trained and certified/qualified personnel in a controlled and planned manner, TSR ACs are required relating to: (1) facility operations chain of command and responsibilities, (2) facility staffing requirements, (3) procedures, (4) staff qualifications, (5) conduct of operations, and (6) training. These ACs are important to ensure the low frequency of the accidents analyzed in Section 5.2.3, in particular to those waste handling accidents where human error is the major contributor to the likelihood of the accident initiating event (CH3, CH4, and CH9).

- To ensure that hazards are limited within the bounds assumed in Section 5.2, or that the occurrence of a deviation from the assumed hazard bounds are at an acceptably low frequency, TSR ACs are required relating to: (1) waste characteristics (Waste Acceptance Criteria), (2) waste container integrity, and (3) criticality safety. The TSR AC for waste characteristics limits the radionuclide content of each waste container, restricts the fissile content of the containers, and restricts the presence of waste characteristics unacceptable for management at the WIPP facility. Container integrity ensures the robustness reflected in the waste release analyses, while criticality safety is a designed in-storage and handling configuration that ensures (in conjunction with waste characteristics) that active criticality control is not required.

Supporting the second and third layers of defense-in-depth, WIPP TSR ACs are identified which establish programs for radiation protection of workers and the environment (including radiation monitoring equipment and airborne radioactivity monitoring), and mitigation of off-normal events though emergency management.

6.4.5.1 SSCs Required to Support Defense-In-Depth

Specific SSCs identified for each accident in Section 5.2.3 that fulfill a defense-in-depth safety function, or considered essential for waste handling, storage and/or disposal operations are as follows: (1) Waste Handling Building (WHB) Heating, Ventilation and Air Conditioning (HVAC) (excluding RH area ventilation unless the RH area is used for CH storage or handling), and Underground Ventilation and Filtration System (UVFS) (including underground shift to filtration); (2) Waste Hoist Equipment (including Brake System); (3) Waste Handling Equipment (including the TRUDOCK Bridge Crane, forklifts, transporters, etc., as required), (4) WHB structure including tornado doors, (5) Central Monitoring System (to support underground shift to filtration only); and (6) Radiation Monitoring System, active waste disposal room exit alpha CAM (for underground shift to filtration). The applicability of the important defense-in-depth SSCs to each accident analyzed in Section 5.2.3, is listed in Table 6-1. The above SSCs are classified as "Defense-In-Depth SSCs," and are applicable to each mode as shown in Table 6-2.

As shown in Section 6.4.3, based on the criteria for assigning Technical Safety Requirement (TSR) Limiting Conditions for Operation (LCOs), defense-in-depth SSCs are not assigned TSR LCOs. The facility has no complex system requirements to maintain an acceptable level of risk. The WIPP Waste Acceptance Criteria for transuranic wastes and the design of the waste handling process and its supporting facilities provide assurance that the immediate consequences of an accident will be limited and allow the WIPP facility to isolate and contain releases while maintaining a high assurance that no additional releases will occur. The facility is designed to minimize the presence and impact of other energy sources that could provide the heat or driving force to disperse hazardous materials. The magnitude of hazardous materials that can be involved in an accident leading to a release is very limited. The radioactive material is delivered to the site in sealed containers, and the waste handling operations are designed to maintain that integrity throughout the entire process required to safely emplace those containers in the site's underground waste disposal rooms. Inventory limits on individual containers ensure that heat generated by radioactive decay can be easily dissipated by passive mechanisms. Finally, only a limited number of waste containers have the possibility of being breached as a result of any one accident initiating event. As a result, the consequences of unmitigated releases from all accidents hypothesized in Chapter 5, including those initiated by human error, do not produce significant offsite health consequences.

When something unusual happens during normal operations (such as defense-in-depth SSCs becoming unavailable), **waste handling can be simply stopped** until an acceptable operating condition is reestablished. The facility is designed to minimize the presence and impact of other energy sources that could provide the heat or driving force to disperse hazardous materials. Should an accident involving the breach of a container occur, **the plant design permits the immediate cessation of activity and isolation of the area where the breach occurs**. Once isolation is achieved, there is no driving force within the waste or waste handling area that could result in a further release of the waste material. The absence of energy sources that can disperse the radioactive waste allows the immediate termination of all activities, evacuation of personnel, and isolation of the area without the threat of additional consequences. This will enable WIPP personnel to then proceed with detailed planning to meet the unique circumstances of any accidental release prior to initiating decontamination and the execution of recovery actions, while assuring that the health and safety of both workers and the public is protected. The controls necessary to maintain safety during the recovery and cleanup can be documented in the recovery plans, its associated Radiological Work Permit, and the USQ process. In order to ensure protection during recovery from an event that breaches a waste container, the Defense-In-Depth SSCs for the waste handling mode will be required during the period of time that waste may be exposed.

Based on SAR Section 5.2.4.1, Evaluation of the Design Basis, specific functional requirements are not assigned here for the Defense-In-Depth SSCs, rather, the SSCs shall be operated as required in Table 6-2. Detailed design descriptions for the Defense-In-Depth SSCs may be found in Chapter 4, and the applicable Systems Design Descriptions.

6.4.5.2 Defense-In-Depth SSC Operation

Defense-in-depth SSCs are listed in Table 6-1. The applicable System Design Descriptions define defense-in-depth SSCs, describe their intended safety functions, and specify the requirements for design, operation, maintenance, testing, and calibration. WP 04-AD3001, Facility Mode Compliance, shall be implemented, and maintained to ensure that defense-in-depth SSCs are operated as required during each facility mode as described in Table 6-2.

If any of the Defense-In-Depth SSCS fails to operate (when required), or becomes unavailable during waste handling operations, or must be taken out of service for maintenance or repair, Waste Handling operations shall be stopped, and the area shall be placed in the Waste Storage/Disposal Mode. Waste Handling operations shall not resume until all of the required Defense-In-Depth SSCs required for waste handling mode are capable of being operated, as required.

The Defense-In-Depth SSCs operational requirements ensure that important defense-in-depth SSCs are operated as required during Waste Handling Mode in the Surface or Underground, to provide protection for the "most likely" waste handling accidents identified in Section 5.2.3: (1) CH2, Crane Failure in the Waste Handling Building (WHB); (2) CH3, Puncture of Waste Containers in the (WHB); (3) CH4, Drum Drop in WHB; and (4) CH9, Drum Drop in the Underground; for natural phenomenon events: (1) CH6, Design Basis Earthquake; and CH10, Design Basis Tornado; and for less likely operational accidents evaluated to be beyond extremely unlikely identified in Section 5.2.3: (1) CH1, Spontaneous Ignition in a Drum in the WHB; (2) CH5, Waste Hoist Failure; (3) CH7, Spontaneous Ignition in a Drum in the Underground; and (4) CH11, Roof Fall.

As discussed above, if any of the Defense-In-Depth SSCs fail to operate (when required), or become unavailable during Waste Handling operations, Waste Handling operations shall be stopped, and the facility shall be placed in the Waste Storage/Disposal Mode. Waste Handling operations shall not resume until the required SSCs are capable of being operated as required.

During Waste Storage/Disposal Mode in the WHB, the Defense-In-Depth SSCs operational requirements ensure that important defense-in-depth SSCs are operated as required during temporary storage operations (for waste temporarily stored in the WHB prior to transfer to the underground) to provide protection for less likely operational accidents identified in Section 5.2.3: (1)CH1, Spontaneous Ignition in a Drum in the WHB; and for natural phenomenon events: (1) CH6, Design Basis Earthquake, and CH10, Design Basis Tornado.

During Waste Storage/Disposal Mode in the Underground, the Defense-In-Depth SSCs operational requirements ensure that important defense-in-depth SSCs are operated as required (for waste disposed in the underground), to provide protection for less likely operational accidents identified in Section 5.2.3: (1) CH7, Spontaneous Ignition in a Drum in the Underground; and (2) CH11, Roof Fall.

It should be noted that the likelihood of CH1, CH7, and CH11 were evaluated in Section 5.2.3 to be beyond extremely unlikely. As such for the Waste Storage/Disposal Mode, if any of the required Defense-In-Depth SSCs fail to operate (when required), or become unavailable, no specific actions are identified, other than to perform corrective maintenance on the affected equipment in a timely manner.

A summary of the applicability of defense-in-depth SSCs in relation to the mode definitions is presented in Table 6-2.

6.5 Design Features

The Design Features of the WIPP Facility are described in Chapter 4 of the SAR.

This page intentionally blank

6.6 Interface TSRs

The WIPP Facility does not have interfacing TSRs from other facilities.

References for Chapter 6

1. DOE Order 5480.22, Technical Safety Requirements, September 15, 1992.

2. WIPP-DOE-069, Waste Acceptance Criteria for the Waste Isolation Pilot Plant, Rev. 5, February 1996.

Table 6-1, Summary of Defense-In-Depth Functions and Defense-in-Depth Features Important to Accident Scenarios Page 1 of 8

Accident	Defense-In-Depth Function	Defense-in-Depth Feature	TSR Control (AC)	Type of Feature (SSC or Administrative Control (AC))
CH1 Spontaneous Ignition in WHB	• Primary Confinement	• Vented DOT Type A, or equivalent, Waste Container	5.9.12	SSC (Passive)
	• Secondary Confinement	• Waste Handling Building Structure (WHB) • WHB CH HVAC System • WHB HEPA Filters	5.1 5.1 5.1	SSC (Passive) SSC (Active) SSC (Passive)
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	5.9.12	AC
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	5.9.8	AC

Table 6-1, Summary of Defense-In-Depth Functions and Defense-in-Depth Features Important to Accident Scenarios **Page 2 of 8**

Accident	Defense-In-Depth Function	Defense-in-Depth Feature	TSR Control (AC)	Type of Feature (SSC or Administrative Control (AC))
CH2 Crane Failure in WHB	• Primary Confinement	• Vented DOT Type A, or equivalent, Waste Container	5.9.12	SSC (Passive)
	• Secondary Confinement	• Waste Handling Building Structure (WHB) • WHB CH HVAC System • WHB HEPA Filters	5.1 5.1 5.1	SSC (Passive) SSC (Active) SSC (Passive)
	• TRUDOCK Crane designed to prevent failure resulting in a dropped load • Adjustable Center of Gravity Lift Fixture (ACGLF) designed to prevent load from swinging	• TRUDOCK Crane Design, ACGLF Design • Configuration Control • Quality Assurance	5.1 5.9.1/5.9.13 5.9.4	SSC (Active) AC AC
	• TRUDOCK Crane maintained to prevent failure resulting in a dropped load • Adjustable Center of Gravity Lift Fixture maintained to prevent load from swinging	• Preventative Maintenance	5.9.3	AC
	• TRUDOCK Crane operated to prevent failure resulting in a dropped load • Adjustable Center of Gravity Lift Fixture operated to prevent load from swinging	• Pre-op Checks/Inspections (Conduct of Ops) • Operator Training and Qualifications • Waste Handling Procedures • Hoisting and Rigging Practices • Operations performed with spotter present • Document Control	5.9.7 5.9.6 5.9.5 5.9.6 5.9.6 5.9.2	AC AC AC AC AC AC
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	5.9.12	AC
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	5.9.8	AC

Table 6-1, Summary of Defense-In-Depth Functions and Defense-in-Depth Features Important to Accident Scenarios Page 3 of 8

Accident	Defense-In-Depth Function	Defense-in-Depth Feature	TSR Control (AC)	Type of Feature (SSC or Administrative Control (AC))
CH3 Puncture in WHB	• Primary Confinement	• Vented DOT Type A, or equivalent, Waste Container	5.9.12	SSC (Passive)
	• Secondary Confinement	• Waste Handling Building Structure (WHB) • WHB CH HVAC System • WHB HEPA Filters	5.1 5.1 5.1	SSC (Passive) SSC (Active) SSC (Passive)
	• Waste Handling Equipment (Forklift and Attachment Design, and Facility Pallet) designed to prevent failure resulting in a punctured waste container	• Forklift and Attachments Design, Facility Pallet Design • Configuration Control • Quality Assurance	5.1 5.9.1/5.9.13 5.9.4	SSC (Active) AC AC
	• Waste Handling Equipment maintained to prevent failure resulting in a punctured waste container	• Preventative Maintenance	5.9.3	AC
	• Waste Handling Equipment operated to prevent failure resulting in a punctured waste container	• Pre-op Checks/Inspections (Conduct of Ops) • Operator Training and Qualifications • Waste Handling Procedures • Hoisting and Rigging Practices • Operations performed with spotter present • Document Control	5.9.7 5.9.6/5.9.4 5.9.5 5.9.6 5.9.6 5.9.2	AC AC AC AC AC AC
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	5.9.12	AC
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	5.9.8	AC

Table 6-1, Summary of Defense-In-Depth Functions and Defense-in-Depth Features Important to Accident Scenarios Page 4 of 8

Accident	Defense-In-Depth Function	Defense-in-Depth Feature	TSR Control (AC)	Type of Feature (SSC or Administrative Control (AC))
CH4 Drop in WHB	• Primary Confinement	• Vented DOT Type A, or equivalent, Waste Container	5.9.12	SSC (Passive)
	• Secondary Confinement	• Waste Handling Building Structure (WHB) • WHB CH HVAC System • WHB HEPA Filters	5.1 5.1 5.1	SSC (Passive) SSC (Active) SSC (Passive)
	• Waste Handling Equipment (Forklift and Attachments, Facility Pallet) designed to prevent failure resulting in a dropped waste container	• Forklift and Attachments Design, Facility Pallet Design • Configuration Control • Quality Assurance	5.1 5.9.1/5.9.13 5.9.4	SSC (Active) AC AC
	• Waste Handling Equipment maintained to prevent failure resulting in a dropped waste container	• Preventative Maintenance	5.9.3	AC
	• Waste Handling Equipment operated to prevent failure resulting in a dropped waste container	• Pre-op Checks/Inspections (Conduct of Ops) • Operator Training and Qualifications • Waste Handling Procedures • Hoisting and Rigging Practices • Operations performed with spotter present • Document Control	5.9.7 5.9.5 5.9.5 5.9.6 5.9.6 5.9.2	AC AC AC AC AC AC
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	5.9.12	AC
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	5.9.8	AC

Table 6-1, Summary of Defense-In-Depth Functions and Defense-in-Depth Features Important to Accident Scenarios Page 5 of 8

Accident	Defense-In-Depth Function	Defense-in-Depth Feature	TSR Control (AC)	Type of Feature (SSC or Administrative Control (AC))
CH5 Waste Hoist Failure	• Primary Confinement	• Vented DOT Type A, or equivalent, Waste Container	5.9.12	SSC (Passive)
	• Secondary Confinement	• Underground Ventilation Exhaust System • Underground Ventilation Exhaust HEPA Filters • Central Monitoring System (for actuation of underground shift to filtration only)	5.1 5.1 5.1	SSC (Active) SSC (Passive) SSC (Active)
	• Waste Hoist System designed to prevent failure resulting in an uncontrolled movement of the hoist	• Waste Hoist and Brake System Design • Configuration Control • Quality Assurance	5.1 5.9.1/5.9.13 5.9.4	SSC (Active) AC AC
	• Waste Hoist System maintained to prevent failure resulting in an uncontrolled movement of the hoist	• Preventative Maintenance	5.9.3	AC
	• Waste Hoist System operated to prevent failure resulting in an uncontrolled movement of the hoist	• Pre-op Checks/Inspections (Conduct of Ops) • Operator Training and Qualifications • Waste Handling Procedures • Hoisting and Rigging Practices • Operations performed with spotter present • Document Control	5.9.7 5.9.6/5.9.4 5.9.5 5.9.6 5.9.6 5.9.2	AC AC AC AC AC AC
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	5.9.12	AC
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	5.9.8	AC

Table 6-1, Summary of Defense-In-Depth Functions and Defense-in-Depth Features Important to Accident Scenarios Page 6 of 8

Accident	Defense-In-Depth Function	Defense-in-Depth Feature	TSR Control (AC)	Type of Feature (SSC or Administrative Control (AC))
CH6 DBE	• Primary Confinement	• Vented DOT Type A, or equivalent, Waste Container	5.9.12	SSC (Passive)
	• WHB structure (includes structure and structural components) designed and maintained to prevent failure during a DBE resulting in waste container breach	• Waste Handling Building DBE design • Configuration Control • Quality Assurance • Preventative Maintenance	 5.9.1/5.9.13 5.9.4 5.9.3	SSC (Passive) AC AC AC
	• WHB 6-ton bridge crane and waste hoist designed and maintained to prevent failure during a DBE resulting in waste container breach	• Waste Handling Building 6-ton bridge crane and waste hoist DBE design • Configuration Control • Quality Assurance • Preventative Maintenance	5.1 5.9.1/5.9.13 5.9.4 5.9.3	SSC (Passive) AC AC AC
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	5.9.12	AC
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	5.9.8	AC
CH 7 Spontaneous Ignition in U/G	• Primary Confinement	• Vented DOT Type A, or equivalent, Waste Container	5.9.12	SSC (Passive)
	• Secondary Confinement	• Underground Ventilation Exhaust System • Underground Ventilation Exhaust HEPA Filters • Radiation Monitoring System (active waste disposal room exit alpha CAM for underground shift to filtration) • Central Monitoring System (for actuation of underground shift to filtration only)	5.1 5.1 5.1 5.1	SSC (Active) SSC (Passive) SSC (Active) SSC (Active)
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	5.9.12	AC
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	5.9.8	AC

Table 6-1, Summary of Defense-In-Depth Functions and Defense-in-Depth Features Important to Accident Scenarios Page 7 of 8

Accident	Defense-In-Depth Function	Defense-in-Depth Feature	TSR Control (AC)	Type of Feature (SSC or Administrative Control (AC))
CH9 Drop in U/G	• Primary Confinement	• Vented DOT Type A, or equivalent, Waste Container	5.9.12	SSC (Passive)
	• Secondary Confinement	• Underground Ventilation Exhaust System • Underground Ventilation Exhaust HEPA Filters • Radiation Monitoring System (active waste disposal room exit alpha CAM for underground shift to filtration) • Central Monitoring System (for actuation of underground shift to filtration only)	5.1 5.1 5.1 5.1	SSC (Active) SSC (Passive) SSC (Active) SSC (Active)
	• Waste Handling Equipment (Forklift and Attachments, Facility Pallet) designed to prevent failure resulting in a dropped waste container	• Forklift and Attachments Design, Facility Pallet Design • Configuration Control • Quality Assurance	5.1 5.9.1/5.9.13 5.9.4	SSC (Active) AC AC
	• Waste Handling Equipment maintained to prevent failure resulting in a dropped waste container	• Preventative Maintenance	5.9.3	AC
	• Waste Handling Equipment operated to prevent failure resulting in a dropped waste container	• Pre-op Checks/Inspections (Conduct of Ops) • Operator Training and Qualifications • Waste Handling Procedures • Hoisting and Rigging Practices • Operations performed with spotter present • Document Control	5.9.7 5.9.6/5.9.4 5.9.5 5.9.6 5.9.6 5.9.2	AC AC AC AC AC AC
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	5.9.12	AC
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	5.9.8	AC

Table 6-1, Summary of Defense-In-Depth Functions and Defense-in-Depth Features Important to Accident Scenarios Page 8 of 8

Accident	Defense-In-Depth Function	Defense-in-Depth Feature	TSR Control (AC)	Type of Feature (SSC or Administrative Control (AC))
CH10 DBT	• WHB structure (includes structure and structural components) designed and maintained to prevent failure during a DBT resulting in waste container breach	• Waste Handling Building DBT design • Configuration Control • Quality Assurance • Preventative Maintenance	5.1 5.9.1/5.9.13 5.9.4 5.9.3	SSC (Passive) AC AC AC
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	5.9.12	AC
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management Program	5.9.8	AC
CH11 Roof Fall	• Primary Confinement	• Vented DOT Type A, or equivalent, Waste Container	5.9.12	SSC (Passive)
	• Secondary Confinement	• Underground Ventilation Exhaust System • Underground Ventilation Exhaust HEPA Filters • Radiation Monitoring System (active waste disposal room exit alpha CAM for underground shift to filtration) • Central Monitoring System (for actuation of underground shift to filtration only)	5.1 5.1 5.1 5.1	SSC (Active) SSC (Passive) SSC (Active) SSC (Active)
	• Underground disposal areas designed to prevent failure resulting in a breached waste container	• Underground disposal area design • Configuration Control • Quality Assurance	 5.9.1/5.9.13 5.9.4	SSC (Passive) SSC (Passive) AC
	• Underground disposal areas maintained to prevent failure resulting in a breached waste container	• Ground Control/Inspections and Assessments • Geomechanical Monitoring	5.9.14 5.9.14	AC AC
	• Limitations on waste container radionuclide and fissile inventory and waste characteristics	• WIPP Waste Acceptance Criteria	5.9.12	AC
	• Provide facility emergency response to the event (notification, evacuation, direct response)	• WIPP Emergency Management	5.9.8	AC

Table 6-2 Summary of Applicability of Defense-In-Depth SSCs to WIPP Modes **Page 1 of 1**

Defense-In-Depth SSCs	**Waste Handling Mode**		**Waste Storage/Disposal Mode**	
	WHB	**Underground**	**WHB**	**Underground**
WHB HVAC System	**X**		**X***	
Waste Hoist (when required to transport waste)	**X**	**X**		
Waste Handling equipment (including the TRUDOCK Bridge Crane, forklifts, facility pallets, underground transporters, etc.) as required during waste handling operations only.	**X**	**X**		
WHB structure including tornado doors	**X**		**X***	
Underground Ventilation and Filtration System		**X**		**X**
Radiation Monitoring System (active waste disposal room exit alpha CAM for underground shift to filtration)		**X**		**X**
Central Monitoring System to support underground shift to filtration		**X**		**X**

*Note that no defense-in-depth operational requirements apply to the WHB when no WASTE is present.

Following failure of a required SSC, the facility will be placed in the WASTE Storage/Disposal Mode. During the time required to effect the required repairs, the facility is not in violation of the TSR.

This page intentionally blank

RADIOLOGICAL AND HAZARDOUS MATERIAL PROTECTION
TABLE OF CONTENTS

SECTION **TITLE** **PAGE NO.**

RADIOLOGICAL AND HAZARDOUS MATERIAL PROTECTION
TABLE OF CONTENTS

SECTION **TITLE** **PAGE NO.**

RADIOLOGICAL AND HAZARDOUS MATERIAL PROTECTION
LIST OF TABLES

This page intentionally left blank

RADIOLOGICAL AND HAZARDOUS MATERIAL PROTECTION

7.1 Radiological Protection

This section discusses (1) the radiological hazards to the worker and off-site public as a result of normal (routine) CH and RH TRU waste handling and emplacement activities, (2) the WIPP radiological control program and organization, and (3) the WIPP "As Low As Reasonably Achievable" (ALARA) policy and program. Waste containers accepted for disposal at the WIPP are surveyed prior to release from the generator sites, and are required to meet the 10 CFR 835[1] external contamination limits. Therefore, WIPP normal operations do not involve or entail any planned or expected releases of airborne radioactive materials to the workplace or the environment.

The radiological control philosophy at the WIPP is "Start Clean - Stay Clean," which emphasizes the prevention of radioactive contamination. This philosophy dictates the immediate securing of any radiological work, when radioactive contamination above established levels is found, or a release of radioactive contamination is known or suspected. Normal work will not resume until the area, including personnel and equipment, has been released in accordance with contamination control procedures, and approval from the Radiological Control Manager has been obtained.

As part of normal operations activities, the waste containers, although having met the 10 CFR 835[1] limits prior to shipping, are closely inspected for damage and surveyed for radiation and radioactive contamination prior to unloading and transfer to the underground for disposal. Decontamination or overpack (waste containers damaged during waste handling operations) will be undertaken, if required, and as approved by management as discussed in Section 4.3.1. Decontamination and operations involving overpack of damaged containers are considered abnormal activities, and the risk to workers and the public is addressed qualitatively through the hazards analysis process in Chapter 5.

7.1.1 Radiological Control Program and Organization

7.1.1.1 Radiological Control Program Objectives

The objective of the radiological control program is to ensure the exposure of employees and the general public to radiation and radioactive materials is within the guidelines of 10 CFR 835[1]; 40 CFR Part 191, Subpart A;[2] 40 CFR 61, Subpart H;[3] DOE Orders 5400.5,[4] and 6430.1A[5] respectively, and that such exposures are kept ALARA. These objectives are met by ensuring that:

- Shipments of radioactive material are handled in accordance with WIPP Waste Acceptance Criteria (WAC)[8] limitations, DOT regulations,[9] and internal operating procedures.

- Shielding, posting, and access control may be employed to reduce direct radiation exposures.

- Engineering controls are designed to reduce exposures during normal operations.

- Areas where the radioactive waste is unloaded are monitored with alarm capabilities for airborne radioactivity.

- Personnel receive a level of radiation protection training appropriate to their assignments.

- Appropriate access/egress control techniques and radiological surveys of personnel and equipment are used to prevent the spread of external contamination.

- A source control program is in place to minimize the potential for the spread of contamination, unnecessary exposure to personnel, loss, theft, sabotage, or improper disposal of radioactive sources.

- A respiratory protection program is in place, and respiratory protective equipment will be used during abnormal activities (decontamination and overpack operations).

- Instruments and equipment are properly calibrated so that accurate radiation, contamination, and airborne radioactivity surveys can be performed.

- Radiological work procedures and instructions provide for an ALARA review prior to commencement of work, for jobs in which radiation and/or radioactive contamination are expected to exceed trigger levels established by the WP 12-5, WIPP Radiation Safety Manual.[10]

- Appropriate personnel dosimetry devices are supplied, and a radiation exposure record system is maintained.

- An internal dose-assessment program (whole-body counting and bioassay) is in place.

- Radiological Protection management is notified of any unusual or unexpected radiological conditions.

- Every radiological worker is given the authority to stop radiological work if there is evidence that radiological controls are being compromised.

- An effluent and environmental monitoring and/or sampling program is in place to detect releases to the environment, and to verify that facility releases are maintained at a minimum.

- The radiological control program is conducted in accordance with written and approved procedures.

7.1.1.2 Administrative Organization

Radiological Control is a functional part of the Environment, Safety and Health (ES&H) Department. The Sections of the ES&H Department are Industrial Safety and Hygiene, Emergency Management, RCRA Permitting, Environmental Compliance and Support, Environmental Monitoring, Nuclear Compliance, WIPP Laboratories, and Radiological Control. The management organization described in the following paragraphs implements the radiological control program.

Environment, Safety and Health (ES&H) - The Manager of ES&H has responsibility for all activities concerning industrial safety and radiation protection of employees and the general public. With regard to Radiological Control, the ES&H Manager is responsible for the training of radiation workers and Radiological Control technicians, emergency planning, and the ALARA program. The ES&H Manager is also responsible for coordinating these activities with cognizant governmental agencies. Within the organization of the Management and Operating Contractor, the Radiological Control Manager reports to the Manager of ES&H. The Radiological Control Manager approves radiological control procedures.

Radiological Control- The Radiological Control Manager is responsible for maintaining radiological safety of the plant by regularly evaluating and assessing surface contamination, radiation levels, and airborne radioactivity concentrations in radiological work areas with respect to approved limits.

The Radiological Control Manager is also responsible for directing operational health physics activities; performing surveillance of routine and special WIPP facility operations; establishing training programs for qualification and re-qualification of radiological control technicians; and approving other radiological training programs consistent with 10 CFR 835,[1] and applicable DOE Orders. The Radiological Control Manager is required to review radiological control procedures annually to determine their adequacy.

The Radiological Control Manager and designees have the authority to stop operations when an actual or impending loss of radiological safety control is identified. In addition, because of the importance of radiation safety, the Radiological Control Manager has a direct line of communication to the General Manager in matters of radiation safety.

Minimum qualifications for radiological control program personnel are in accordance with applicable DOE Orders and Guidance.

Dosimetry - The Radiological Control Manager is responsible for operating and maintaining a personnel dosimetry program to determine radiation exposure to employees and visitors. In addition, the Radiological Control Manager is responsible for implementing and operating the internal dosimetry program. The Radiological Control Manager has the authority to remove from further exposure, employees who have either reached or exceeded the established administrative radiation exposure limits or not demonstrated their continuing understanding of, or compliance with, the WIPP radiological control program.

7.1.2 ALARA Policy and Program

7.1.2.1 Policy Considerations

It is the firm commitment of the WIPP management that occupational radiological exposures are kept ALARA. This policy, as reflected in administrative programs and procedures established in accordance with 10 CFR 835,[1] and DOE/EV/1830-T5,[11] ensures that the design basis of the WIPP facility will maintain individual occupational radiation exposures to an ALARA level of less than 1 rem (10 mSv) per year, per person. A site-specific administrative control level may be established at less than 1 rem (10 mSv) per year, per person, in accordance with WP 12-5, WIPP Radiation Safety Manual.[10]

7.1.2.2 Design Considerations

The ALARA techniques applied to the WIPP facility design were based on DOE exposure guide DOE/EV/1830-T5,[11] as appropriate for this first-of-a-kind facility. Future design modifications will be in accordance with 10 CFR 835,[1] DOE Orders O 420.1,[6] Facility Safety, and O 430.1,[7] Life-Cycle Asset Management, and other codes, standards, and orders applicable at the time of modification. Chapter 4 presents details of plant design and operations.

The ALARA criteria were applied during the design of the plant through a series of design reviews by nuclear and health physics specialists from the responsible Architect-Engineer organization. During the operational disposal-phase, the responsibility for ensuring that exposures are kept ALARA is the responsibility of all levels of management. Operationally, the manager responsible for waste handling will develop and implement procedures and operation of equipment to ensure waste handler exposures are maintained ALARA.

7.1.2.3 Operational Considerations

Radiological exposure to plant personnel will be kept ALARA by continued review of operations and training. The WIPP ALARA Program is described in the WIPP ALARA Manual, WP 12-2.[12]

The Manager of ES&H, or designees, will monitor performance of the waste handling operations by reviewing exposures, procedures, and incident reports, and recommending corrective action, when required. The DOE and the Management and Operating Contractor (MOC) will supplement this program through periodic audits of exposure records and procedures, as well as investigations of all incidents.

7.1.3 Radiological Exposure Control

7.1.3.1 Radiological Protection Design Features

7.1.3.1.1 Plant Arrangement Designs for Keeping Exposures ALARA

Facility Arrangement - For radiological control purposes, the areas in the WIPP facility to which access is managed to protect individuals from exposure to radiation and/or radioactive materials are identified as Controlled Areas, and are administrated in accordance with the WIPP Radiation Safety Manual.[10] The Controlled Areas are segregated from other operating areas by physical barriers (e.g., fences, walls, bulkheads). The Controlled Areas on the surface are primarily located in and around the Waste Handling Building (WHB), and are separated from other areas by a fence and walls (Figure 4.1-2).

A Controlled Area will be established in the underground disposal area during disposal operations. Engineering control features are incorporated in the arrangement of the underground disposal area. The disposal area is isolated from the construction area by physical barriers and separate ventilation flow paths discussed in Chapter 4. The disposal areas are normally excavated in groups of rooms called panels, as indicated in Figure 4.1-3.

Access control and personnel traffic patterns are considered in the plant layout to minimize the potential for spreading contamination, and to minimize personnel radiation exposure.

Waste Handling Building - General Arrangement - A Controlled Area will be established in the WHB, as required to support Waste Handling operations. Personnel access into the operating areas of the building is through a controlled access corridor from the TRUPACT Maintenance Facility.

Air locks are located between areas with either different levels of contamination potential or large pressure differentials. The ventilation system and air locks act to mitigate the spread of contamination by maintaining pressure differentials between radiological areas. This is done to ensure that any leakage is directed into areas with higher potentials for contamination.

CH TRU Waste Handling Area Arrangement - The surface waste handling equipment and facilities in the CH TRU waste handling area are arranged so that waste handling flow patterns are as direct as possible from TRUPACT II unloading to hoist loading.

RH TRU Waste Handling Area Arrangement - The RH TRU waste handling area is arranged for efficient handling of shielded road casks and waste canisters, and includes an area for shielded road cask preparation and decontamination, as required. The enclosed Cask Unloading Room is located below the hot cell. Here, a ventilation barrier provided by an inflatable seal between the cask and hot cell floor, provides the means for controlling the potential spread of contamination during cask unloading. The hot cell is arranged to allow inspection, and, if required, over packing of the canisters before they are lowered into the canister transfer cell and subsequently transferred to the Facility Cask.

A Crane Maintenance Room and a Manipulator Repair Room are provided next to the hot cell, behind shielding, to allow removing hot cell equipment to areas with a lower radiation background for repair. This reduces the need to enter the hot cell.

Personnel access into the hot cell is through air locks from the main operating gallery. A room below the hot cell operating gallery houses the hot cell HEPA filters.

Radiation sources and shield penetrations are arranged to prevent radiation streaming, and to reduce radiation levels in accessible areas.

7.1.3.1.2 Equipment and Component Designs for Keeping Exposures ALARA

This section summarizes the design features used for general classes of equipment and major components. These classes of equipment are common to many of the plant systems. Therefore, the features employed to maintain exposures ALARA for each system are similar.

Waste Handling Equipment - Features to facilitate decontamination, such as smooth cleanable surfaces and the elimination of square corners and crevices, are incorporated in the handling equipment design, where practicable. Mechanical handling equipment is designed for easy replacement for decontamination and/or repair.

Remote handling equipment in the hot cell includes the hot cell crane and the master/slave manipulators. The hot cell crane can be moved into the Crane Maintenance Room using manual override, if crane failure occurs in the hot cell. This allows maintenance in a separate area, and minimizes the need for access into the hot cell. The master/slave manipulators can be removed from the operating gallery side of the hot cell for maintenance and brought into the manipulator repair room, an area with a lower radiation background.

Forklifts and transporters are designed to expedite the loading and unloading of waste packages while minimizing the potential for accidents. They also ensure the effective securing of waste packages to minimize waste handling time.

Instruments - Whenever practical, instrumentation and control devices are located in low radiation areas and away from radiation sources.

Instruments, that for functional reasons are located in areas with a relatively high radiation background, are designed for easy removal to areas with a lower radiation background for calibration or repair.

Lighting - Multiple electric lights are provided. Sufficient illumination is provided so that the loss of a single lamp does not require immediate entry and replacement of the defective lamp.

HVAC Equipment - The environmental control systems for areas with a potential for contamination are designed for contamination-free replacement of filter elements.

7.1.3.1.3 Radiation Shielding

7.1.3.1.3.1 Design Objectives

The objective of radiation shielding is to minimize the exposure of personnel to the radiation sources described below. Radiation shielding is one of the methods utilized to maintain the exposure of personnel to radiation ALARA.

7.1.3.1.3.2 Direct Radiation Sources

The direct radiation sources that are the bases for shielding design are categorized from CH TRU waste. The direct radiation sources described in this section use maximum expected values and conservative assumptions to ensure a conservative basis for radiation shielding design. The representative characteristics of these radiation sources are described below and summarized in Table 7.1-1.

CH TRU Waste - CH TRU waste will primarily be received in standard waste boxes (SWBs) and 55-gallon drums. Because of higher anticipated activity density, the 55-gallon drum is used as the reference CH TRU waste radiation source for shielding analysis. The CH TRU waste source container used for this analysis is 24 inches in diameter, and 35 inches long (the approximate dimensions of a DOT 17C 55-gallon drum). These drums can be stacked in the underground no more than three high, due to the limited height of the disposal drift. Some space remains above the stack, for emplacement of backfill material and airflow over the waste packages during the disposal operations.

Although the CH TRU waste contains alpha and beta emitting nuclides, the primary radiation of interest in shielding calculations is gamma rays. Alpha and beta particles are completely shielded by the waste containers, and do not contribute to the external dose, with the possible exception of a beta-generated bremsstrahlung contribution to the gamma spectrum. For shielding design calculations, a spectrum representing typical waste containing TRU nuclides and fission products was derived. The gamma spectrum selected as representative of the CH TRU waste is characterized by a RH TRU radionuclide distribution, with a reduced photon source. The selected RH TRU spectrum is believed to yield conservative results since the photon energies are greatly skewed to the higher energies. Photon energies for CH TRU radionuclides are typically much lower.

The average and maximum gamma source strengths used in the CH TRU waste shielding calculations are based on a design average CH TRU waste surface exposure rate of 10 mrem/h (0.10 mSv/h), and the maximum CH TRU waste surface exposure rate of 200 mrem/h (2 mSv/h). The resultant design basis CH TRU waste gamma source strengths are shown in Table 7.1-1. Although, some components of CH waste produce neutrons by spontaneous fission, the contribution to the total dose rate is less than a few percent.

7.1.3.1.3.3 Design Description

To meet the shielding design objectives, the following general guidelines are used:

- Radiation shield thicknesses must ensure that the dose rate due to uncollided and scattered radiation through the shield are less than the maximum levels specified for each design radiation zone. Shield wall thicknesses are shown in plant arrangement drawings.

- Principal shielding materials are ordinarily concrete/rebar, lead, steel, or salt. Shielding materials for viewing windows include leaded glass and oil. Temporary shielding, such as lead blankets, bricks, or other materials may also be employed, as required, during maintenance or other operations.

- Temporary shielding for openings such as doors, hatches, windows, ventilation ducting, and piping should be designed to prevent radiation streaming. Penetrations through primary shielding are placed so that they do not provide a direct line through the shield wall to the radiation source. Design features such as offset piping connections, stepped doors or hatches, shadow shields, and labyrinths are incorporated in the shielding design, wherever applicable. Shielding for large diameter penetrations is provided by additional concrete or steel around a penetration. Shielding can also be provided by the addition of shield collars or leaded grout around pipes and penetrations.

- Access to potentially high radiation areas involves passage through shield doors or labyrinth walls. This prevents direct radiation streaming into adjacent areas. Labyrinth shielding is designed so that the exposure due to uncollided and scattered radiation is less than the maximum levels specified for the adjacent area.

The <u>CH TRU Waste Handling Area</u> is arranged for efficient handling of the CH TRU waste containers. Traffic flow and adequate space for waste transfer activities are considered in the layout of this area. A separate enclosed area, located in the southeast corner of the CH Bay and shielded by concrete walls, is provided for temporary holding of discrepant shipments of CH TRU wastes that cannot be immediately emplaced.

Within the <u>RH TRU Waste Handling Area</u>, RH TRU waste canisters are handled within shielded casks, or by remote means within the shielded hot cell enclosure. The primary shielding in the hot cell complex is provided by the shipping cask shields or the hot cell walls. The hot cell complex is designed for a 45 rem/h (450 mSv/hr) neutron surface dose rate and a gamma surface dose rate of 400,000 rem/h (4,000 Sv/hr).

The <u>hot cell</u> is an integral part of the Waste Handling Building. The shield walls are primarily constructed of reinforced concrete. Remote operations using the hot cell crane and master slave manipulators are observed through closed circuit television and shielded viewing windows at hot cell work stations. A shielded pass-through drawer is utilized to introduce supplies into the hot cell, to remove waste materials from the cell, and to transfer swipes. An interlocked shielded door and labyrinth shield walls at the personnel access to the hot cell reduce radiation levels from sources in the cell. The shipping cask unloading room, crane maintenance room, facility cask loading room, manipulator repair room, and canister transfer room are separate functional areas integrated with the hot cell.

A <u>Shielded Room</u> for hot cell crane maintenance is provided next to the hot cell. Normally, personnel are not permitted in the crane maintenance room during hot cell operations. However, in the event of a crane failure requiring maintenance, the crane can be moved into the crane maintenance room, where a steel shield gate reduces the dose rates from within the hot cell. Under most conditions, dose rates during these maintenance activities will be less than 0.5 mrem/h (5E-03 mSv/hr) in the maintenance room. Under no conditions are personnel allowed in the crane maintenance room when a canister is raised above a position on top of the cask unloading room.

The <u>Facility Cask</u> provides shielding while the RH TRU waste canisters are moved from the canister transfer cell to the disposal locations underground. Figure 4.3-16 shows the facility cask shielding.

The facility cask provides a cylindrical steel and lead shield enclosure around one RH TRU canister, and has shield valves at either end. The cask design includes sufficient shielding to reduce gamma radiation levels to less than 200 mrem/h (2 mSv/hr) at the surface of the cask, for wastes meeting the WIPP WAC. Design and operation of the facility cask will be reviewed should a significant RH TRU neutron contribution be identified.

Within the Underground Disposal Areas, no permanent shielding is required. The facility cask construction provides shielding for operators and helps maintain doses ALARA. When transferring a RH TRU canister from the facility cask to the disposal location in the underground salt, horizontal emplacement and retrieval equipment shielding overlap with the facility cask to minimize radiation streaming paths.

7.1.3.1.3.4 Method of Shielding Analysis

The radiation sources used for shielding design are based on maximum values expected during plant operations. Shielding thicknesses ensure that the sum of the dose rates due to uncollided and scattered radiation through the shield wall during waste canister handling are within the limits of the radiation zone specified for the area.

Shielding analysis was performed by the Architect-Engineer for the WIPP Project by use of the QAD-P5A computer code and input parameters.[13,14] This code is a multi-group, multi-region point kernel, general purpose shielding code for estimating the effects of gamma rays originating in a volume distributed source. The point kernel method utilized by the code involves representing the source volume by a number of point sources, and computing the line of sight distance from each point source to the detector point. Using the distance the gamma ray travels through the shielding and the attenuating characteristics of the shielding materials, the geometric attenuation and material attenuation are determined. The point kernel representing the energy transferred by the uncollided photon flux along a line of sight path is combined with an appropriate buildup factor to account for the contribution from the scattered photons.

Gamma scattering calculations are used to estimate dose rates around labyrinth and shadow shielding. The G^3 computer code and input parameters are used for gamma scattering calculations.[15] The code calculates gamma scattering from a point source to a series of point detectors. The code evaluates the uncollided flux at specified scatter points, and multiplies it by the product of the differential cross section for scattering toward the detector point and the number of electrons in the elemental volume associated with the scatter point (the center of the elemental volume).

The ANISN computer code, with the Cask 40-group neutron/gamma cross section library, is used for neutron and secondary gamma calculations to confirm adequate shield thicknesses.[16,17] This code is a multi-group, multi-region, one dimensional, discrete ordinates transport code that solves the Boltzmann transport equation in slab, cylindrical, or spherical geometries for neutron and gamma radiation.

These computer codes are used to calculate dose rates for various shielding thicknesses. The radiation sources in the computer code are modeled as closely as possible to the actual geometries, dimensions, and physical conditions. The RH waste handling area shielding is designed to comply with the design radiation dose rates. In the CH TRU waste handling area, the interim holding area shielding thicknesses are based on storing drums that contain the average gamma source strengths, as described in Section 7.1.3.1. The separate shielded holding area shielding is based on the full-capacity holding of drums that contain the maximum gamma source strength.

Shielding Integrity and Verification - The integrity of the shielding and its design features is ensured by the adherence to the requirements and recommended practices described in ANSI N101.6-1972,[18] with the following additional criteria:

- In addition to the applied loads requirements listed in Section 4.3.3 of ANSI N101.6-1972,[18] the concrete radiation shield structural analysis also considers steady-state and transient thermal loads.
- Detailed thermal stress analysis in the design of reinforcement for controlling thermal cracking (temperature reinforcement) in specific concrete radiation shields is included in determining variables used in equations for bending moment and tensile stress, as described in Section 6.4 of ANSI N101.6-1972.[18]
- Reinforcing steel or other means are provided for transferring shear and other forces through a construction joint, as described in Section 8.8.7 of ANSI N101.6-1972.[18]

7.1.3.2 Radiological Practices

7.1.3.2.1 Radiation Safety Training

Radiation safety training is conducted at the WIPP facility to ensure that each worker understands: (1) the general and specific radiological aspects of their assignment, (2) their responsibility to their co-workers and the public for safe handling of radioactive materials, and (3) their responsibility for minimizing their own radiation exposure. The level of training for each employee is commensurate with the requirements of their job category.[10]

7.1.3.2.2 Radiological Control Procedures

The following procedures are established by policy to help ensure that radiation exposures to the general public, operating personnel, and the environment are within regulatory limits and ALARA. These procedures also support the "Start Clean - Stay Clean" philosophy, which emphasizes the prevention of radioactive contamination as well as its movement or spread.

Radiation and Contamination Surveys - Health physics personnel perform routine radiation and contamination surveys of all accessible areas of the facility, surveys of the waste packages upon receipt, and various other types of surveys to detect contamination and its potential spread and expected radiation dose rates. Routine survey areas and frequencies are established in accordance with health physics procedures and manuals, and are based upon the probability of contamination and changes in radiation level, and upon personnel occupancy. These surveys consist of measurements for dose rate and contamination, as appropriate, for the specific area. The records of the survey results are retained in a permanent file by the Operational Health Physics section, and are reviewed shortly after survey performance, so that trends indicative of problem areas are identified as early as possible. Radiation and contamination surveys and associated records are described in Chapter 5 and Chapter 7 of the WIPP Radiation Safety Manual,[10] respectively.

Access Control - Access to radiological areas of the facility is controlled in accordance with 10 CFR 835[1] Only personnel who have successfully completed the requirements specified in Chapter 3 of the WIPP Radiation Safety Manual[10] will be allowed unescorted entry to the radiological areas of the site. All other personnel will require an escort.

Personnel monitoring will be in accordance with WP 12-3, Dosimetry Program Manual,[19] and Chapter 5 of the WIPP Radiation Safety Manual.[10]

The WIPP policy addressing visitors is described in Chapter 3 of the WIPP Radiation Safety Manual.[10]

Personnel entering a Controlled Area are required to obtain General Employee Radiological Training (GERT) prior to entering. Personnel performing radiological work in a radiological area are required to sign-in on an access control log or access control computer in addition to signing in on a Radiological Work Permit (RWP), issued in accordance with Chapter 3 of the WIPP Radiation Safety Manual.[10]

The RWP specifies the controls necessary for the planned entry, and may require additional monitoring devices, protective clothing, respiratory equipment, etc. The necessity for these control items may be based exclusively on radiation level, a combination of surface contamination and radiation level, an area of airborne radioactivity, or the potential for occurrence of any of these conditions. When required, these additional control items will be prescribed, and personnel will be properly equipped prior to entering the work area.

Exposure control is accomplished by identifying areas containing sources of radiation and/or contamination, and controlling personnel access into these areas.

Radiological areas are designated and defined in 10 CFR 835[1] and in the WIPP Radiation Safety Manual,[10] as follows:

- Controlled Area - Any area to which access is controlled in order to protect individuals from exposure to radiation and radioactive materials.

- Radiological Buffer Area (RBA) - An intermediate area established to prevent the spread of potential radioactive contamination. The area may surround Contamination Areas, High Contamination Areas, and Airborne Radioactivity Areas.

- Radioactive Material Area (RMA) - An area or structure where radioactive material is used, handled, or stored.

- Radiation Area - An area, accessible to personnel, in which the dose rate is greater than 0.005 rem/hr (0.05 mSv/hr), but less than or equal to 0.1 rem/hr (1mSv/hr), at 11.8 inches (30 centimeters) from the source, or from any surface that the radiation penetrates.

- High Radiation Area - An area, accessible to personnel, in which the dose rate is greater than 0.1 rem/hr (1 mSv/hr) at 11.8 inches (30 centimeters), but less than or equal to 500 rad/hr (5 Gy/hr), at 39.4 inches (100 centimeters) from the radiation source, or from any surface that the radiation penetrates.

- Very High Radiation Area - An area, accessible to personnel, in which the dose rate is greater than 500 rad/hr (5 Gy/hr) at 39.4 inches (100 centimeters) from a radiation source or from any surface that the radiation penetrates.

- Contamination Area - Area where contamination levels are greater than the values specified in Appendix D of 10 CFR 835,[1] but less than or equal to 100 times those levels.

- High Contamination Area - Area where contamination levels are greater than 100 times the values specified in Appendix D of 10 CFR 835.[1]

- Airborne Radioactivity Area - Area where the measured concentration of airborne radioactivity, above natural background, exceeds, or is likely to exceed :

  10 percent of the Derived Air Concentration (DAC) values listed in 10 CFR 835

Personnel Monitoring Program - Personnel at the WIPP facility are monitored for both internal and external exposure as described in Section 7.1.3.2.6.

A routine external exposure monitoring program at the WIPP facility measures the radiation dose received by personnel. The external dose measurement program is described in Chapter 5 of the WIPP Radiation Safety Manual,[10] and WP 12-3, Dosimetry Program Manual.[19]

Internal exposure measurement is described in Chapter 5 of the WIPP Radiation Safety Manual,[10] and the Dosimetry Program Manual.[19] The WIPP program for internal exposure measurement may use the techniques of in-vitro bioassay examination (e.g., urinalysis, and/or fecal analysis) and in-vivo bioassay examination (whole-body counting and chest counting). Bioassay will be performed on a routine basis. Baseline bioassay will be performed on workers who handle radioactive materials as a normal function of their job.

Personnel dosimetry records are maintained by Dosimetry, which ensures that occupational exposure records are maintained in a readily retrievable data base, to permit ready accounting of employees' accumulated radiation exposure. Maintenance of personnel radiation exposure records is described in WP 12-3, Dosimetry Program Manual.[19]

Airborne Radioactivity Monitoring Program - The airborne radioactivity monitoring program complies with 10 CFR 835,[1] and verifies that the survey program described above is detecting contamination control problem areas, and those problem areas are corrected before loose surface contamination becomes airborne. The equipment used for air sampling and monitoring is described in Section 7.1.3.2.6. The airborne monitoring program is described in Chapter 5 of the WIPP Radiation Safety Manual.[10]

Respiratory Protection Program - A variety of types of respiratory protection equipment for non-routine operations such as maintenance, emergency use, and mine rescue is available at the WIPP facility.

Only respiratory protection equipment approved for use by the National Institute of Occupational Safety and Health is used at the WIPP facility.

Workers who may be required to wear respiratory protection equipment must attend a training program on the equipment use during abnormal and emergency conditions. They are fitted for the devices they are required to wear, and are given a special medical examination to ensure that there is compatibility with wearing the devices.

The respiratory protection program meets the requirements of ANSI Z88.2-1992.[20] Respiratory protection is addressed in Chapter 5 of the WIPP Radiation Safety Manual,[10] and WP 12-IH.02, WIPP Industrial Hygiene Program.[22]

Radioactive Material Control - There are two facets to the control of radioactive material. The first is radioactive source control. Radioactive sources are used to test, calibrate, and check the operation of radiation detection instrumentation. Radioactive sources are also brought on-site by external organizations for testing, radiography, and soil density operations. The radioactive source control program ensures that proper control, including leak testing, inventory, transfer, and disposal of these sources are maintained at all times to prevent loss/theft, spread of contamination, and other abnormal occurrences involving radioactive sources.

The second facet of the radioactive material control program is the control of radioactive material produced from radiological work processes performed on-site. Any item used in a process that involves known or suspected presence of radioactive contamination or radioactive materials is surveyed prior to release from a radiological area. If the survey indicates the presence of radioactive material on the item, then the item is either decontaminated or disposed of as site-derived waste, as directed by the Radiological Control Manager.

7.1.3.2.3 Radiological Control Facilities

Control Points - All personnel leaving RBA's, RMA's, Contamination, High Contamination, and Airborne Radioactivity Areas (ARA) are required to check out. Personnel leaving RBAs, Contamination, High Contamination, and ARAs are also required to perform a personnel survey prior to exit.

Personnel Access Control Points - As discussed in Section 7.1.3.2.2, access to the areas at the WIPP facility where radioactive materials are handled is controlled and limited to personnel who have successfully completed the requirements of Chapter 6 of the WIPP Radiation Safety Manual.[10]

Personnel decontamination will be performed in accordance with approved procedures.

Laboratory Facilities - Radiological analysis facilities are located in the Safety and Emergency Services Building, and the WHB. The counting equipment located in the laboratories is described in Section 7.1.3.2.6. A sample preparation facility, which is used to prepare samples for analysis, is also located near the Safety and Emergency Services Building. The sample preparation facility has appropriate equipment for radiochemical separation of radionuclides in the samples for counting.

Calibration Facilities - The dose rate instrument calibration facility is located in the Shielded Calibration Room of the Support Building. Contamination survey instruments are calibrated in the area of the health physics office. Calibration equipment is described in Section 7.1.3.2.6.

Equipment Decontamination Stations - Decontamination or overpacking of major equipment will be conducted as discussed in Section 4.3.1. Decontamination can be accomplished in place, according to established procedures.

Dosimetry Laboratory - The laboratory is located in the Safety and Emergency Services Building. The TLD equipment in the laboratory is described in Section 7.1.3.2.6. No radioactive materials, other than those used for calibration purposes, are permitted in the Dosimetry Laboratory.

Plant Clothing Facility - Plant clothing will be obtained from the clothing issue room in the Support Building. Plant clothing items, which are assumed or have been shown by survey to be contaminated, will be disposed of as site-generated waste.

7.1.3.2.4 Radiological Control Equipment

Various types of protective clothing and equipment are stocked at the WIPP facility to protect personnel from contamination. Protective clothing is provided for body, head, hand, and foot protection.

Contamination control equipment is used to prevent or limit the spread of radioactive contamination, and to assist in its removal. The equipment is stored and routinely inventoried in cabinets in or near areas where it is normally used.

7.1.3.2.5 Radiological Posting

When required, areas within the WIPP facility, including the underground disposal area, are posted in accordance with 10 CFR 835,[1] and the WIPP Radiation Safety Manual,[10] to specify the actual or potential radiological hazard. Posting provides necessary information and access control for minimizing personnel radiation exposures and the potential spread of contamination, as described in Section 7.1.3.2.2.

7.1.3.2.6 Radiation Protection Instrumentation

The instrumentation used by the health physics personnel can be divided into four categories:

- Fixed radiation counting instruments (laboratory type)
- Portable radiation survey instruments
- Area radiation monitoring instruments
- Airborne radioactivity sampling and monitoring instruments

Instruments are repaired and calibrated by health physics personnel. In some cases, specialized instruments may be returned to the manufacturers for repair and calibration.

<u>Fixed Radiation Counting Instruments</u> - Fixed radiation counting instruments are located in the counting laboratories, and are used primarily for analyzing process monitoring samples and environmental samples taken in and around the WIPP facility. The instruments selected for use in the laboratories possess the sensitivities required for performing environmental and operational activities.

These instruments are periodically calibrated with standard sources, traceable to the National Institute of Science and Technology (NIST). Instrument background and response to calibrated check sources are determined before each operating day to verify that the instrument background and calibration have not changed.

The instruments in the counting laboratories include gross radioactivity counters and spectrographic systems.

When required, samples are prepared for counting in the sample preparation facility. Sample preparation for counting may include evaporation, ashing, partitioning, grinding, chemical separation, or placing samples in containers that conform the sample to a defined geometry.

<u>Portable Radiation Survey Instruments</u> - The portable radiation detection instruments are used to perform radiation and contamination surveys in the field.

Portable dose rate instruments are normally calibrated in the calibration room using a shielded calibrator and/or other smaller NIST traceable sources and approved procedures. Portable contamination instruments are calibrated in the area of the health physics office with NIST traceable sources and approved procedures. Prior to use, these instruments are checked for response with a check source containing a nominal amount of radioactivity. Those instruments that cannot be calibrated at the WIPP are sent to a calibration facility that has been approved by WIPP Q&RA.

Portable instruments include alpha contamination detectors, beta contamination detectors, gamma survey meters, and neutron survey meters.

Personnel Monitoring Instruments and Service - The WIPP facility has a personnel dosimetry program that conforms to the requirements of 10 CFR 835.[1] The program is certified by the Department of Energy Laboratory Accreditation Program for Personnel Dosimetry (DOELAP), and is conducted in accordance with the WP 12-3,[19] WIPP Dosimetry Program Manual.

Digital dosimeters are used when a dose rate above background is expected or exists. These dosimeters are used to keep track of exposure in between TLD readouts. The TLD reading is the record of exposure. Personnel monitoring for external contamination is performed using the survey instruments previously discussed. Portal Monitors are placed at the WIPP site security gate to monitor personnel for radiation sources.

It is the intent of the radiological control program to qualify all employees who handle waste to perform contamination surveys on their clothing and body. In addition, when special operations are conducted, contamination surveys of personnel are performed by or under the direction of a qualified Radiological Control Technician. Bioassay and in-vivo programs will be administrated in accordance with WP 12-3, Dosimetry Program Manual.[19]

A radiation monitoring system supplements the personnel and area radiation survey provisions of the plant radiological control program to ensure that radiation exposures are maintained ALARA. The radiation monitoring system includes area radiation monitors, continuous air monitors for radioactive particulate and fixed air samplers (FASs). The radiation monitoring alarms give visual and/or audible signals that annunciate locally, and, for select systems, in the Central Monitoring Room (CMR). These alarms require operator response and corrective actions. Most of the radiation monitoring system instruments are supplied with an Uninterruptible Power Supply (UPS) in the event of a power outage.

Calibration of Radiation Survey Instruments - All calibrations of radiological instruments shall be traceable to NIST or other equivalent recognized standards. The portable dose rate instruments are calibrated with a shielded calibrator that minimizes radiation exposure to the calibration technician. Portable sources are used to calibrate fixed instruments such as the area radiation monitors and continuous air monitors (CAMs). Radiation survey instrument calibration records are maintained for the life of the facility.

Instruments receive periodic electronic calibration using NIST traceable, calibrated electronic sources.

Area Radiation Monitoring - Area radiation monitors are provided, as needed, in normally accessible areas to provide indications of changes in the surrounding operational environment within the plant.

Area radiation monitors continuously monitor gamma radiation. The monitors activate local and remote alarms upon the detection of radiation levels higher than the limits specified for a given work area. Separate alarms are activated by the failure of a monitor.

Each monitor is periodically calibrated using sources certified by or traceable to the NIST. Detector operation is checked using radioactive sources. Instrument failure alarms are provided locally and in the CMR.

Airborne Radioactivity Monitoring - Occupied radiological areas on the surface and underground are monitored, when required, by CAM equipment per 10 CFR 835. CAMs must be located in occupied areas that may have the potential to equal or exceed one DAC of the radionuclides of interest, and other areas as deemed appropriate by WIPP management.

The design features of the airborne monitoring equipment depend on their function. The monitors continually collect and measure airborne particulates by pulling air through a filter in proximity to an integral beta-gamma or alpha detector. The airborne radioactivity monitor provides a local and, in some locations, a remote readout and alarm in the CMR. Meters, audible and visual alarms provide a clear and unambiguous indication of alarm conditions. As appropriate, each monitoring system is set to alarm within acceptable levels of the limits in 10 CFR 835.[1]

FASs are installed to collect airborne particulates on a fixed filter medium. The fixed air sampler filters are removed and counted periodically to evaluate cumulative radioactive particulate concentrations.

In addition to the above permanently installed equipment, portable CAMs and portable air samplers are provided. The portable air samplers and portable CAMs are similar to those described above. Portable samplers normally are used for sampling routine/non-routine operations, for emergency air sampling, or to temporarily replace inoperable equipment.

The CAMs are calibrated periodically and after repairs, using standards that are traceable to the NIST. The source and detector geometry during calibration are the same as the sample and detector geometry in actual use.

7.1.4 Dose Assessment for Normal Operations

7.1.4.1 On-site Dose Assessment

This section provides a summary of the dose assessments for the primary, occupationally exposed groups involved in waste handling operations at the WIPP facility. The results are representative values, determined by estimating dose rates based on shielding analyses, the characterization of the waste forms (see Chapter 5), time and motion/manpower studies for the handling of the waste, and the estimated quantities of waste received. The time and motion/manpower information used is based on the current concept of staffing levels and the organization planned for WIPP facility operations. This assessment considers normal waste handling operations only. Abnormal operations, such as decontamination and overpack operations (of waste containers damaged during the waste handling process) are addressed in Appendix C, HAZOP Session Summary Table.

Waste containers accepted for disposal at the WIPP are expected to meet the 10 CFR 835[1] external contamination limits. Therefore, WIPP normal operations do not involve or entail any planned or expected releases of airborne radioactive materials. As such, the projected occupational worker dose from normal operations is a result of direct radiation from waste containers only, with no contribution from internal dose (CEDE) to airborne radiological materials.

Table 7.1-2 provides the estimated annual external exposure to workers during normal CH TRU waste handling operations. The exposure is based on an initial disposal rate of five shipments per week, per the National TRU Waste Management Plan.[21] Upon receipt of waste, the actual annual external exposure will be monitored and controlled per the WP 12-5, WIPP Radiation Safety Manual,[10] and Table 7.1-2 will be updated as necessary.

7.1.4.1.1 Radiation and Contamination Zones and Radiological Areas

For design purposes, waste handling and disposal areas were divided into radiation and contamination zones. Each zone was designed to minimize and confine both direct radiation and potential contaminants if they occur, using static barriers, such as permanent and temporary walls and shielding, and by the dynamic controls provided by the ventilation systems. The design objective was to provide the ability to operate with an administrative control level of 1.0 rem/year (10 mSv) per person or less.

For operational purposes, designated radiological areas are dynamic and subject to frequent change depending on activities and radiological conditions in the areas.

7.1.4.1.2 Normal Operations Dose Estimates

Normal operations encompass the transfer of CH TRU transporters and containers from the point of receipt to the disposal area without an abnormal occurrence.

The following items are inputs to the analysis of the dose estimates included in Table 7.1-2:

- The average dose rate for a CH TRU waste drum is estimated based on information provided by waste generators and reflected in WIPP Radiation Safety Paper 96-01,[25] entitled "Dose Estimation, Radiological Area Posting and Access Control Policy for Initial Waste Receipt."

The number of people who could receive radiation exposure in a given area is based on manpower studies for the CH TRU areas both aboveground and underground at the facility. The primary occupationally exposed groups considered in the dose assessment are waste handling personnel and radiation control personnel. Estimated exposure times are based on time and motion analyses of the functional steps constituting the preoperational checkouts. In unshielded areas, estimated exposure rates are based on the exposure rates from waste containers and the expected range of distances between radiation sources and personnel. The data used in this analysis is conservative compared to the actual waste handling operation anticipated.

7.1.4.2 Off-site Dose Assessment

As discussed in Section 7.1.4.1, waste containers accepted for disposal at the WIPP are expected to meet the 10 CFR 835[1] external contamination limits. Therefore, WIPP normal operations do not involve or entail any planned or expected releases of airborne radioactive materials. The WIPP will be operated in compliance with the release standards of 40 CFR 191 Subpart A[2] and 40 CFR 61 Subpart H.[3] Once operations begin, confirmatory measurements will be performed as discussed below.

7.1.4.2.1 Effluent Sampling/Monitoring and Environmental Monitoring

7.1.4.2.1.1 Effluent Sampling Systems

The effluent sampling system consists of FASs for the confirmation of the presence or absence of airborne particulate radioactivity releases.

Samplers are installed near each release point to collect the particulate samples from a representative fraction of the total volume of air being discharged. The samplers consist of a sampling probe, a filter holder, and a vacuum supply.

Other design features are included to improve sampling efficiency.

The FAS filter holder is designed to prevent in-leakage of ambient air, and to support the filter under the design pressure of the vacuum supply. Furthermore, the holder is designed so that particulate matter is uniformly deposited on the filter.

The data from the FASs provide a method for quantifying total airborne particulate radioactivity discharged. This is done to demonstrate compliance with the mandated regulatory requirements contained in 40 CFR 191, Subpart A,[2] and 40 CFR 61, Subpart H.[3] These regulations place stringent requirements on the allowable annual dose equivalent to any member of the public. The sampling period and sample volume are maximized to provide a reasonable lower limit of detection.

The Department of Energy (DOE), Westinghouse Waste Isolation Division (WID), New Mexico Environment Department (NMED), and Environmental Evaluation Group (EEG) have signed a protocol[23] that is an agreement for WID to provide NMED and EEG with routine and non-routine (radiation alarm) effluent sample filters for independent analysis. The methods for sample filter transfer to NMED and EEG are described in the protocol[23] and in WP 12-HP3500, Airborne Radioactivity.[24]

7.1.4.2.1.2 Effluent Monitoring Systems

Radiation Effluent Monitoring System (REMS) may be located near the release points in the effluent airstreams. These instruments monitor the extracted air from the effluent ventilation stream for radioactive particulates to provide an alarm in case of a significant accidental release.

The effluent monitoring systems are designed and environmentally qualified to withstand the effects of the Design Basis Earthquake, and are installed with backup power to allow monitoring in the event of a power failure.

References for Section 7.1

1. 10 CFR 835, Occupational Radiation Protection, January, 1993.

2. 40 CFR 191, Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Wastes, Subpart A, Environmental Standards for Management and Storage.

3. 40 CFR 61, Environmental Protection Agency Regulations on National Emission Standards for Hazardous Air Pollutants, Subpart H, National Emission Standard for Radionuclide Emissions from Department of Energy (DOE) Facilities.

4. DOE Order 5400.5, Radiation Protection of the Public and the Environment, June, 1990.

5. DOE Order 6430.1A, General Design Criteria Manual, December 12, 1983.

6. DOE Order O 420.1, Facility Safety, October 1995.

7. DOE Order O 430.1A, Life-Cycle Asset Management, August 1995.

8. WIPP-DOE-069, TRU Waste Acceptance Criteria for the Waste Isolation Pilot Plant, Rev. 5, February 1996.

9. U.S. Department of Transportation, Title 49, Code of Federal Regulations.

10. WP 12-5, WIPP Radiation Safety Manual, Revision 3, March 1997.

11. DOE/EV/1830-T5, A Guide to Reducing Radiation Exposure to As Low As Reasonably Achievable (ALARA), April 1984.

12. WP 12-2, WIPP ALARA Manual, Revision 3, September 1998.

13. ORNL-4181, Modifications of the Point-Kernel Code QAD-P5A: Conversion to the IBM-360 Computer and Incorporation of Additional Geometry Routines, July 1968.

14. LA-3573, QAD: A Series of Point - Kernel General-Purpose Shielding Programs, April 1967.

15. LA-5176, G^3: A General Purpose Gamma-Ray Scattering Program, June 1973.

16. Union Carbide Corp., Report No. K-1693, A User's Manual for ANISN: A One Dimensional Discrete Ordinates Transport Code with Anisotropic Scattering, June 1973.

17. ORNL-RSIC-CLC23, Cask-40 Group Coupled Neutron and Gamma-Ray Cross Section Data, Revision D, March 12, 1974.

18. ANSI N101.6-1972, Concrete Radiation Shields.

19. WP 12-3, Dosimetry Program Manual, Revision 7, March, 1999.

20. ANSI Z88.2-1992, American National Standard for Respiratory Protection.

21. DOE/NTP-96-1204, The National Transuranic Waste Management Plan, September 1996.

22. WP 12-IH.02, WIPP Industrial Hygiene Program, Rev. 0, December 5, 1997.

23. Protocol for Providing Effluent Monitoring System Filters to the New Mexico Environment Department and the Environmental Evaluation Group, November 1992.

24. WP 12-HP3500, Airborne Radioactivity, Rev. 2, April 28, 1995.

25. WIPP Radiation Safety Paper 96-01 entitled "Dose Estimation, Radiological Area Posting and Access Control Policy for Initial Waste Receipt."

26. WIPP Radiological Control Position Paper, No. 97-05, *"Dose Assessment for Hand Emplacement of MgO Sacks Around CH Waste 7 Packs at the Waste Isolation Pilot Plant,"* April, 1997.

Table 7.1-1, CH TRU Waste - Gamma Source Strength

Energy (MeV)	Average* Source Strength (MeV/cc-sec)	Maximum** Source Strength (MeV/cc-sec)
0.10	5.33E - 3	1.07E - 1
0.15	9.11E + 0	1.82E + 2
0.30	3.51E + 0	7.02E + 1
0.45	5.48E + 0	1.10E + 2
0.70	7.49E + 1	1.50E + 3
1.00	7.33E + 1	1.47E + 3
1.50	6.12E + 2	1.22E + 4
2.00	5.10E + 0	1.02E + 2

* Calculated exposure rate at surface of drum - 10 mrem/h (0.10 mSv/h)
** Calculated exposure rate at surface of drum - 200 mrem/h (2.00 mSv/h)

Table 7.1-2, Normal CH TRU On-site Annual External Radiation Dose Estimates

Operation	Personnel	Total Dose* rem/person-yr (mSv/person-yr)
CH TRU Waste Handling	Waste Handlers	** 14.6 (146)
	Radiological Control	3.6 (36)

* Assumes 15 TRUPACTs/week (5 shipments) and 50 weeks/year. Total dose indicated is not per individual, but that shared among a number of workers, e.g., 14.6 rem/yr ÷ 20 workers (waste handlers at full throughput = .73 rem/yr/individual (7.3 mSv/yr/individual.)

** Worker dose associated with the emplacement of MgO sacks around the perimeter of a 7-Pack was evaluated, and found to be in the range of 70-90 μrem per 7-Pack (105-135 mrem annually).[26]

This page intentionally left blank

7.2 Hazardous Material Protection

This section (1) provides an assessment of the potential for occupational and public exposure to nonradiological hazardous materials as a result of normal operations during the WIPP disposal phase, and (2) describes the WIPP programs in place for control of nonradiological hazards, and for protection of the worker and the public. An assessment of the potentials for nonradiological exposure as the result of abnormal operations and accidents is included in Chapter 5, Hazards and Accident Analysis.

Hazardous material protection, as implemented by the WIPP Industrial Hygiene Program, is an integral part of the overall WIPP Industrial Safety program, as developed and implemented in WP 12-IH.02, WIPP Industrial Hygiene Program.[1] The organization responsible for implementation is the WIPP ES&H Industrial Safety and Hygiene (IS&H) section. Implementation of the defined program elements will ensure control of occupational health hazards originating from chemical, biological, and physical (excluding ionizing radiation) agents.

Requisition, procurement, use, handling, and storage of non-TRU waste hazardous materials are controlled by WP 02-RC.01, Site Generated Non-Radioactive Hazardous Waste Management ,[3] and implementing procedures. Implementation of this program will ensure compliance with the Toxic Substances Control Act[4] (TSCA); the Superfund Amendments and Re-authorization Act[5] (SARA); the Occupational Safety and Health Act[6] (OSHA); the Comprehensive Environmental Response, Compensation, and Liability Act[7] (CERCLA), the Mine Safety and Health Act[8] (MSHA), and the U.S. Code of Federal Regulations (CFR).

7.2.1 Hazardous Material Sources

The primary occupational, nonradiological hazard to both the worker and the public during normal operations is from the airborne release of volatile organic compound (VOC) gases from TRU mixed waste containers during waste handling and emplacement operations. Lead and other heavy metals are present in TRU mixed waste, but pose hazards to workers and the public only under accident conditions, as discussed in Chapter 5. Exposure assessments for workers and the off-site public in the following sections are based on the releases of the average drum headspace VOC concentrations into the waste handling building and the underground via diffusion through the drum vent filters.

7.2.2 Hazardous Material Exposure Assessment for Normal Operations

The exposure assessments presented in this section are summarized from, or based on the environmental impacts analysis provided in the WIPP RCRA Permit Application.[15]

7.2.2.1 Off-site Exposure Assessment

The potential environmental and public impacts associated with the airborne release of VOCs during normal operations, summarized in this section, are assessed in detail in the WIPP RCRA Permit Application.[15] Based on the most recent headspace sampling of TRU mixed waste and toxicity data, nine VOCs were identified as the most prevalent and, of these, carbon tetrachloride, methylene chloride, and chloroform are considered potential carcinogens.

The average void volume was used to calculate the total grams of a VOC in the gas phase of each TRU mixed waste drum. The "void volume" or "headspace" is the total volume of a drum occupied by gases. The average void volume within a drum was calculated to be 5.2 cubic feet (147 liters, 6.56 moles at STP).

The compliance point relevant to air emissions for the RCRA Permit Application[15] for off-site exposure assessment is the WIPP site boundary. The RCRA Permit Application[15] assessment uses conservative assumptions, which tend to overestimate the consequences of releases. Table 7.2-1 lists the maximum public exposure concentration at the site boundary from VOC air emissions from both the waste handling building and from the underground, calculated assuming a 35-year operational and decommissioning/closure period. As shown in the table, the largest projected carcinogen health risk to a hypothetical member of the public residing at the WIPP Site boundary would be for carbon tetrachloride, at about 100 times below the public exposure health-based levels. The total risk from contributions from all nine emissions is considerably less than the acceptable risk level.

7.2.2.2 On-site Exposure Assessment

The potential occupational exposures associated with the airborne release of VOCs during normal operations, are also shown in Table 7.2-1. The highest occupational exposure concentrations from WHB and underground VOC air emissions are from methylene chloride, which are well below Occupational Safety and Health Administration (OSHA) 29 CFR 1910.1000[9] 8-hour time weighted average (TWA) permissible exposure limits (PELs).

7.2.3 Industrial Hygiene Program

The WIPP Industrial Hygiene Program encompasses the comprehensive aspects of Industrial Hygiene defined by DOE Order 440.1,[10] excluding ionizing radiation, physical safety, fire prevention, medical examinations, and formal training, which are addressed by other programs.

The WIPP Industrial Hygiene Program acts to protect WIPP workers by anticipating, recognizing, evaluating, and controlling chemical, physical, biological, and ergonomic factors and/or stressors in the workplace. The permissible exposure limits used in hazard evaluation and hazard communication shall not exceed those in the mandatory standards of DOE Order 5480.4,[11] Attachment 2.

7.2.3.1 ALARA Policy

The WIPP Industrial Hygiene Program seeks to ensure that employee exposures to hazardous materials are ALARA. The program uses the following controls to meet this goal:

- The use of approved and controlled procedures that provide administrative or engineering controls that minimize or eliminate exposure to hazardous materials
- Furnishing employees the necessary personal protective equipment
- Training employees to recognize potential hazards, take safety precautions, understand consequences of an accident, and know the actions to take in case of an accident
- Monitoring the work environment to obtain personnel and area exposure data

- Review and approval of all chemical use and storage at the WIPP
- Maintain Material Safety Data Sheets (MSDS)

7.2.3.2 Hazard Identification, Evaluation, and Elimination

WIPP (IS&H) identifies, defines, and evaluates controls in the occupational environment for those stresses which could be detrimental to employee health and safety. These stresses, whether chemical (e.g., liquid, particulate, vapor, or gas); physical (e.g., electromagnetic radiation, noise, vibration, extremes of temperature or pressure); biological (e.g., agents of infectious disease); or ergonomic (e.g., body position in relation to task) are recognized by familiarization with the work environment, review of first aid records, and hazard control.

IS&H uses methods available, either by laboratory analysis or instrument monitoring, to define environmental conditions of the workplace. The following activities are included, but not limited to: hearing conservation, dust sampling, characterization of mine gases, control of toxic fumes and vapors, sanitation inspections and potable water supply sampling, evaluating OSHA and MSHA compliance for on-site activities, review of proposed project facilities, and evaluation of other hazards by periodic monitoring of work areas. With respect to these activities, assurance of equipment calibration and maintenance and record keeping of inspections are maintained. These methods are outlined in WP 12-IS.01, Industrial Safety Program[2] and WP 12-IH.02, WIPP Industrial Hygiene Program.[1]

An on-site industrial hygiene laboratory calibrates and prepares sampling equipment for personnel exposure measurements, to analyze mine atmospheres, water potability, and chemical exposure hazards. Respirator fit testing and maintenance are also an industrial hygiene responsibility.

The WIPP Hazard Communication Program is discussed in detail in WP 12-IH.02, WIPP Industrial Hygiene Program.[1] The program includes material hazard training, Material Safety Data Sheet (MSDS) management, inventory/listing of hazardous materials on-site, control of hazardous material purchase requisitions by IS&H prior to purchase, material container labeling requirements, on-the-job training requirements, and employee responsibility requirements concerning hazardous materials used in the work area.

The Industrial Hygiene Program is outlined in WP 12-IH.02, WIPP Industrial Hygiene Program.[1]

7.2.3.3 Chemical Management

Management of hazardous materials is implemented by guidance contained in WP 02-EC.04.[12] Guidelines are provided for procurement, receipt, distribution, tracking, storage, transportation, use, recycling, and disposal of hazardous materials.

Each WIPP employee receives as part of the General Employee Training (GET), hazard communication training and hazard recognition training. All employees who work with hazardous materials receive hazard communication training and Resource Conservation and Recovery Act (RCRA) training.

As an overview of site chemical usage purchase requisitions, MSDS, and Action Requests are reviewed. This minimizes use of hazardous materials by allowing for substitution of materials and maintains an ALARA approach to carcinogens and very toxic materials. During the review, availability of appropriate storage, personal protective equipment, and the need for personnel training are also evaluated.

Hazardous Materials are logged into the warehouse upon arrival. IS&H receives copies of all MSDS for materials brought on the site whether by Westinghouse or by subcontractors. Copies of MSDS are available to all employees during all shifts. Training on the Occupational, Safety and Health Administration (OSHA) Hazard Communication Standard is a requirement of all personnel who work with or enter areas where hazardous materials are used.

Periodic inspections of work and storage areas are performed to evaluate safe work conditions, proper storage, and effectiveness of engineering controls.

7.2.3.4 Air Monitoring

7.2.3.4.1 Nonradioactive Air Contaminants

WP 12-828[13] implements the WIPP Air Quality Monitoring Program. To ensure compliance with American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLV), administrative or engineering controls are determined and implemented whenever possible. When such conditions are not feasible to achieve full compliance, protective equipment and/or other protective measures are used to keep employee exposures to air contaminants within prescribed limits. Any equipment and/or technical measures used must be approved by WIPP IS&H personnel.

IS&H monitors or tests the air in areas where hazardous chemicals are stored, and in areas where workers may be exposed to concentrations of airborne fumes, mists, or vapors. All surveys are recorded; records contain the location, time, job description, or occurrences that may be associated with the contaminants and instruments used. All available inventories, reports and monitoring data are available to the Health Services personnel in order to assist the medical monitoring program.

In the WIPP underground, airborne concentrations of mists, fumes, or vapors will be monitored and sampled on a periodic basis, or upon request, by suitable devices such as Draeger pumps or other portable grab sample monitors. If relevant air concentrations are found in excess of the TLVs, immediate corrective actions will be taken as determined by IS&H, and the air will be periodically tested until in compliance.

Air quality monitoring equipment is calibrated per manufacturers' recommendations, with an accurate record kept of pre-calibration conditions of the instrument. Functional tests are performed daily. Competency of individuals required to use air monitoring equipment is verified. Functional testing competency requires a formal training program.

7.2.3.4.2 Diesel Emissions

Vehicle emissions of underground equipment are periodically monitored in accordance with WP 12-IH.02, Industrial Hygiene Program,[1] to assure the health and safety of personnel. Incomplete combustion of diesel fuels causes contaminants of carbon monoxide, carbon dioxide, and nitrogen dioxide. The air in the underground is monitored for these contaminants, to ensure compliance within TLV limits. Vehicles are checked for carbon monoxide and nitrogen dioxide after preventive maintenance checks and during scheduled overview inspections.

7.2.3.5 Workplace Monitoring

IS&H surveys are a means of evaluating and maintaining a safe and healthful workplace. Examples of items surveyed are drinking water potability; local exhaust ventilation systems; and chemical, physical, and biological hazards. Sampling of the environment involves calibration of equipment, actual sampling, and recording the results in terms of the actual stress. Surveys are conducted in accordance with the WIPP Industrial Hygiene Program.[1]

7.2.3.6 Occupational Medical Program

The occupational medical site personnel, as defined in the Occupational Health Program Plan,[14] work in close cooperation and coordination with other departments to optimize the maintenance of a healthful work environment. Pre-employment, periodic, return to work, and termination health examinations are coordinated with the Human Resources Department. Diagnosis and treatment of occupational injuries and illnesses are coordinated with all departments where these incidents may occur. Health maintenance and preventive medical activities are coordinated with IS&H.

The program overview is performed by an occupational medical physician, who works part-time under contract to the WIPP facility. The physician is assisted by an on-site occupational health nurse, emergency service technicians (ESTs), and fire protection technicians (FPTs). The ESTs/FPTs provide 24-hour emergency medical coverage on the site.

The occupational medical program is designed to accomplish the following:

- Ensure the health and safety of employees in their work environments, through the application of occupational health principles

- Determine the physical fitness of employees to perform job assignments without undue hazard to themselves, fellow employees, or the public at large

- Ensure the early detection and treatment of employee occupational illness, or injuries, by means of scheduled periodic health evaluations and a wellness awareness program

7.2.4 Radiological Soil Monitoring

Radiological soil monitoring has been implemented to establish baseline parameters. Samples have been collected and analyzed from a total of 37 locations within a 50 mi (80 km) radius of the WIPP facility. At each location, samples from three depths have been collected and either analyzed for 19 different radionuclides or archived for future reference.

The sampling activities have been divided into three geographic areas. These include the WIPP site group, which has the smallest scale and consists of eight locations at the cardinal compass directions from the center of the Property Protection Area (PPA). Because of the proximity to the WIPP facility, this group is perhaps of the most interest in identifying potential radiological releases from operations. The next area is the Five Mile Ring, at a radius of approximately 5 mi (8 km) from the center of the PPA, with 16 locations. The last area is the Outer Sites, with 13 locations representing a variety of habitats, soil types, and land uses in southeastern New Mexico. The data and analytical results from each of these sampling locations have been presented in the Statistical Summary of the Radiological Baseline Program for the Waste Isolation Pilot Plant.[16]

7.2.5 Hydrologic Radioactivity Monitoring

The hydrologic radioactivity monitoring program has been designed to measure characteristic radiological levels in surface-water bodies, bottom sediments, and groundwater. Water samples have been collected and analyzed for 18 different radionuclides. The resulting data from the surface-water and groundwater sampling programs have been analyzed independently. Bottom sediments have been analyzed for 17 different radionuclides. The baseline results of these programs were presented in the Statistical Summary of the Radiological Baseline Program for the Waste Isolation Pilot Plant.

7.2.6 Surface-Water and Sediment Monitoring

Much like the soil-sampling programs, the surface-water and sediment-monitoring programs serve as measures of confirmatory monitoring for the detection of atmospheric radionuclide releases. As a release to the atmosphere is the only release scenario considered credible for the operational life of the facility, data are compared to the previously established baseline. During the Disposal Phase, statistically significant changes will be studied to evaluate if the WIPP programs are a contributor to an increase in the radionuclides detected.

Data collected as part of the nonradiological groundwater surveillance program has been used to develop a database to support the background water quality characterization report. By the end of 1990, the groundwater of interest had been characterized, and the objective of the program shifted from characterization to surveillance. Collection of groundwater quality data continues to assist the DOE in meeting performance assessment, regulatory compliance, and permitting requirements. The data also provide radiological and nonradiological water quality input to the WIPP Environmental Monitoring Program; a means to comply with future groundwater inventory and monitoring regulations; and, input for making land-use decisions.[15]

Because of the absence of surface waters in the vicinity of the WIPP facility, the geographic sampling group that could provide the data of most interest is the stock tanks. These are typically man-made catchment basins, five of which were chosen because of their location with respect to the WIPP facility. In addition to these five stock tanks, the WIPP effluent water (sewage lagoons) and influent water have been sampled and analyzed annually. The results are provided in Appendix D4 of DOE/WIPP 91-005.[15]

7.2.7 Volatile Organic Compound Monitoring

The VOC monitoring program activities have focused on the air pathway since 1991. The airborne emission of VOCs is the only credible release pathway from the WIPP facility during disposal operations, and the final closure design basis requires this pathway to be eliminated upon final closure. With over two and one-half years of data, a credible basis for determining the WIPP's background levels of the targeted VOCs has been established.

The DOE has prepared a VOC monitoring plan which describes the aspects of a VOC monitoring strategy. The plan has been prepared so that the DOE can show that the assumptions and predictions used to demonstrate compliance to the environmental performance standards are valid. Validity is shown when observed emissions are equal to or less than those predicted. The VOC Confirmatory Monitoring Plan (VCMP) is provided in Appendix D20 in DOE/WIPP 91-005.[15] The VCMP includes monitoring design, sampling and analysis procedures, and quality assurance objectives.

This VCMP describes a sampling and analysis program to confirm the theoretical calculations. The monitoring program is capable of quantifying VOC concentrations in the ambient mine air at the WIPP. The VCMP addresses the following information requirements:

- Rationale for the design of the monitoring program, based on possible pathways, operations, engineered and natural barriers, and monitoring locations optimized for detection.

- Descriptions of the specific elements of the monitoring program including the type of monitoring, the location of stations, the frequency of sampling, the target analytes, the schedule for implementation, the equipment used, the sampling and analytical techniques, and the data recording and reporting procedures.

The design of the VCMP used the results of background VOC monitoring activities at the WIPP. These data are presented in Appendix D21 of DOE/WIPP 91-005.[15] These data represent the anticipated background levels of VOCs during operations at the WIPP.

The DOE's intent is to collect air samples upstream and down stream of Panel 1, beginning just prior to waste emplacement, and proceeding until at least six months following completion of panel closure. The DOE will continue monitoring until the criterion for terminating monitoring are met. These criterion are established in Appendix D20 of DOE/WIPP 91-005[15] for each target analyte.

The current VOC monitoring program uses EPA Compendium Method TO-14. The DOE has had success with TO-14 at the WIPP if care is taken in placing samplers to avoid high dust, and if stringent cleaning requirements are imposed for the clean canisters. This is necessary because of the extremely low concentrations that are being monitored. The DOE is evaluating the use of the Fourier Transform Infra-Red (FTIR) technique for monitoring VOCs at WIPP. This method is being used successfully at other locations, and has recently been approved by the EPA for measuring the concentration of VOCs in the headspace gases of drums of TRU waste. If FTIR becomes viable, the monitoring plan will be revised, and the revisions will be submitted to the NMED for approval prior to implementation.

The VCMP will be run under a Quality Assurance Plan that conforms to the document entitled EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations,[17] (EPA 1994). Quality Assurance criteria for the target analytes are presented in Table D-10 of DOE/WIPP 91-005.[15] Definitions of these criteria are given in Appendix D20 of DOE/WIPP 91-005,[15] along with a discussion of other aspects of the Quality Assurance Program including sample handling, calibration, analytical procedures, data reduction, validation and reporting, performance and system audits, preventive maintenance, and corrective actions.

References for Section 7.2

1. WP 12-IH.02, WIPP Industrial Hygiene Program, Rev. 0, August, 1998.

2. WP 12-IS.01, Industrial Safety Program, Rev. 1, March, 1999.

3. WP 02-RC.01, Site Generated Non-Radioactive Hazardous Waste Management, Rev.0, April 1996.

4. 40 CFR 702-799, Toxic Substances Control Act.

5. 40 CFR 300-399, Superfund Amendments and Re-authorization Act.

6. 29 CFR 1900-1999, Occupational Safety and Health Act.

7. 40 CFR 300-372, Comprehensive Environmental Response, Compensation, and Liability Act.

8. Title 30, Code of Federal Regulations, Subchapter N, Metal and Non-Metal Mine Safety and Health, 9th Edition, July 1997.

9. 29 CFR 1910.1000, Air Contaminants, July 1993.

10. DOE Order 440.1, Worker Protection Management for DOE Federal and Contractor Employees, September 30, 1995.

11. DOE Order 5480.4, Environmental Protection, Safety, and Health Protection Standards, May 1984.

12. WP 02-EC.04, Hazardous Material Management Plan, Revision 1, December 1998.

13. WP 12-828, Air Quality Monitoring Procedure, Revision 0, February 1998.

14. WP 15-HS.02, Occupational Health Program Plan, Revision 1, March 1999.

15. DOE/WIPP 91-005, Resource Conservation and Recovery Act Part B Permit Application, Revision 6.

16. DOE/WIPP 92-037, Statistical Summary of the Radiological Baseline Program for the Waste Isolation Pilot Plant, 1992.

17. EPA QA/R-5, EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations, 1994.

Table 7.2-1, Maximum Occupational and Public Exposure From Underground Waste VOC Emissions

Indicator Volatile Organic Compounds (ppmv)	Worker Receptor Concentration		OSHA 8 Hour TWA[b] (ppmv)	Estimated Risk for Carcinogens and Hazard Quotients for Non-Carcinogens for Public Exposure to Waste Emissions	Acceptable Level of Risk[f]
	Surface	Underground			
Carbon Tetrachloride	3.0E-04	1.2E-02	10	3E-08	1E-06
Chlorobenezene[a]	6.9E-04	2.9E-02	75	4E-06[e]	1
Chloroform	2.7E-04	1.0E-02	50[c]	2E-09	1E-06
1,1-Dichloroethylene	1.2E-03	4.7E-02	5[d]	2E-09	1E-05
1,2-Dichloroethane	3.8E-04	1.5E-01	100	8E-10	1E-06
Methylene Chloride	4.5E-03	1.6E-02	25	6E-10	1E-06
1,1,2,2-Tetrachloroethane	3.2E-04	1.3E-02	5	3E-09	1E-05
Toluene[a]	1.6E-03	6.7E-02	200	3E-07[e]	1
1,1,1-Trichloroethane	4.0E-03	1.6E-01	350	2E-08	1E-05

a. Non-Carcinogen (all others are class B2 or C carcinogens)
b. 8 hour time weighted averages (TWA) except for chloroform
c. TWA for up to a 10 hour day in a 40 hour workweek
d. TWA from ACGIH
e. Non-Carcinogen hazard quotient
f. Acceptable level of risk for carcinogens is the probability of developing cancer, and for non-carcinogens is a hazard quotient less than or equal to 1

This page intentionally blank

INSTITUTIONAL PROGRAMS
TABLE OF CONTENTS

SECTION TITLE PAGE NO.

INSTITUTIONAL PROGRAMS
TABLE OF CONTENTS

INSTITUTIONAL PROGRAMS
TABLE OF CONTENTS

SECTION	TITLE	PAGE NO.

INSTITUTIONAL PROGRAMS
LIST OF FIGURES

INSTITUTIONAL PROGRAMS
LIST OF TABLES

SECTION	TITLE	PAGE NO.

This page left intentionally blank

INSTITUTIONAL PROGRAMS

This chapter discusses additional institutional programs at WIPP which fulfill the objectives of DOE Order 5480.23, Nuclear Safety Analysis Reports.[1] A description of the requirements and their implementation is provided for the following programs:

- Management, Organization, and Institutional Safety
- Procedures and Training
- Initial Testing, In-Service Equipment Monitoring, and Maintenance
- Operational Safety
- Emergency Preparedness Program

8.1 Management, Organization, and Institutional Safety Provisions

8.1.1 Introduction

The WIPP facility is managed by Westinghouse Electric Company (WELCO), Government and Environmental Services Company (GESCO), Waste Isolation Division (WID). GESCO includes other Government facilities operated by Westinghouse, and the WID draws on these resources as a result of this arrangement.

8.1.2 Requirements

The requirements and guidelines for developing the WID Management, Organization, and Institutional Safety program are provided in DOE Order 4700.1, Project Management Systems[2] and DOE/WIPP 103,[3] DOE Management Directives for the WIPP.

8.1.3 Organizational Structure, Responsibilities, and Interfaces

Westinghouse Electric Company has managed and operated the WIPP facility for the DOE since October 1985. Westinghouse, as the Management and Operating Contractor (MOC), provides the management staff, sets the safety culture, issues policies, and implements programs.

Several committees have been formed to integrate information regarding environment, safety, health, and radiation protection activities at the various facilities served by the Business Unit (BU). These committees facilitate the sharing of solutions to common problems and issues. The BU management team is supportive of WID activities by participating in Corporate reviews and audits of WIPP activities, and by providing management attention, as needed.

Additionally, the WID has access to Corporate expertise in several disciplines including waste management, risk assessment, safety analysis, environmental services, technical and analytical services, regulatory compliance, transportation, legal, quality assurance (QA), and others, as required.

The Westinghouse Corporate Audit Organization Charter allows for review of GESCO facility operations, which include the WIPP, to evaluate compliance with applicable policies, plans, procedures, laws and regulations. Westinghouse policy is to conduct all operations so that the health and safety of the employees, the public, and the environment remain protected. This commitment extends to all levels of management, and is reflected in the goals and objectives established for operating facilities.

The corporation has no specific authority regarding the engineering and design, construction, QA, testing, operation, and other activities beyond those carried out by the WID, as specified in the contract with the DOE. Corporate resources are available and will be committed, as needed, to ensure that WID activities are conducted safely, correctly, and efficiently. Corporate management plays a vital role in providing appropriate direction for WID activities by selecting the WID General Manager (GM).

8.1.3.1 Organizational Structure

Responsibility for operating the WIPP facility has been assigned to the MOC organization. Figure 8.1-1 shows the chain of command by which the Assistant Secretary for Environmental Restoration and Waste Management exercises responsibility for the operational safety of the WIPP.

While responsible for all aspects of the WIPP facility, DOE has contracted these scopes of work to various organizations. The MOC is responsible for managing the current and future construction contracts, and to operate the WIPP facility, including all day-to-day operations.

The GM is responsible for the design, operation, maintenance, and modification of the WIPP facility, including the health and safety of employees, and the protection of the environment. The GM has issued policies exercising this responsibility to manage these activities directly, or by delegation of authority. Management functions are performed according to management policies and requirements defined in the operating contract.

8.1.3.2 Organizational Responsibilities

The GM has delegated specific responsibilities to managers for the following WIPP functions:

1. Radiation safety, industrial safety, environmental protection, and regulatory compliance;

2. Operation, control, and maintenance of all surface structures, including the Waste Handling Building and associated equipment; handling and storing radioactive waste on site; transporting hazardous material off-site; transporting salt aboveground; monitoring and operating site utilities including HVAC, power distribution, water and sewer; operating the Central Monitoring System; underground operations including mining, transporting salt underground, hoisting, operating key facility experimental programs; and equipment maintenance;

3. Design of equipment, systems, and facilities for special operations; review of designs proposed by other major Project Participants; design of new or necessary facilities; resolution of technical and operational problems; and maintenance of design configuration;

4. Identification, development and definition of applicable requirements; assistance to management in interpreting and implementing QA program elements; provide performance-based and improvement-oriented independent assessment activities specific to quality improvement; review Federal Registers; review DOE Orders; perform field audits; evaluate audits of other departments; and, act as the Defense Nuclear Facilities Safety Board (DNFSB) point of contact;

5. Planning and scheduling; integration of technical programs, program development and program reporting, strategic planning and long term budget development; programmatic performance; recommend work-scope priorities; and, conduct contingency analyses;

6. Financial resources, accounting, computer services, material and property control, document and procedure review, and procurement services;

7. Coordination of all personnel-related functions supporting facility operations, planning and implementing the general employee technical training programs, and certifying/qualifying the operating staff;

8. Public information programs, governmental affairs, technical outreach and communications; public displays, handouts and brochures, interaction with the electronic and print media, visitor's program at the WIPP, Speaker's Bureau activities, identification and resolution of issues between the WIPP Project and outside institutions, maintain contacts with individual representatives from outside institutions, public relations efforts, and the States and Tribal Education Program (STEP), which is aimed at preparing emergency response personnel bordering the WIPP transportation routes.

8.1.3.3 Staffing and Qualifications

The GM has a Bachelors or advanced degree in engineering or business, or equivalent, and at least 15 years of diverse nuclear plant operations experience, including at least 5 years of department-level management or equivalent experience.

8.1.4 Safety Management Policies and Programs

8.1.4.1 Safety Review and Performance Assessment

Facility safety elements are reviewed annually. The WIPP MOC ensures that applicable environment, safety, and health requirements are met according to DOE Order 5480.23, *Nuclear Safety Analysis Reports*.[1] The review focuses on the functional areas within the safety program including: industrial safety, fire protection, and hazardous material elements.

WID procedure WP02-AR3001, *Unreviewed Safety Questions Determination*,[6] implements the requirements of DOE Order 5480.21, *Unreviewed Safety Questions*.[7] The procedure includes the screening criteria to determine if a proposed activity requires further evaluation and exemptions for activities that require no screening; the safety evaluation criteria for detailed evaluation of proposed activities and potential issues, including examples to aid the evaluators; identification of the training and appointment requirements for screeners, evaluators, and independent reviewers; documentation requirements and forms; and, identification of the authorization basis documents. Proposed engineering changes, operating procedures and certain controlled document changes, as well as discovered issues are screened and/or evaluated by qualified personnel. A limited number of personnel are trained and designated by department managers to perform the safety evaluations; all independent reviewers are designated by the manager of ES&H. Positive USQ determinations identified by safety evaluators and independent reviews are reviewed by the Nuclear Review Board (NRB) who are also trained safety evaluators.

8.1.4.2 Configuration and Document Control

The facility is designed to the requirements of DOE Order 6430.1A, General Design Criteria,[8] and design modifications are controlled by the Engineering Change Order (ECO) process, as implemented by WP 09-9 WID Operational Configuration Management Plan.[11] The ECO is used to implement and control changes to approved engineering design documents.

WIPP Technical Procedures and Emergency and Alarm Response Procedures are written using guidance provided in WP 15-PS.2, *Technical Procedure Writer's Guide.*[4] WP 15-PS.2 references the basic steps for procedure writing found in DOE-STD-1029-92, *DOE Writer's Guide for Technical Procedures.*[5] Modifications to operating procedures resulting from an ECO are controlled through the Procedure Change Notice (PCN) process. Procedure changes are implemented through procedure WP 15-PS3002, WID Controlled Document Processing,[12] which provides the process for review, approval, and cancellation of WID documents controlled by Document Services.

Temporary or permanent changes proposed to the facility are measured against criteria specified in the Unreviewed Safety Question Determination procedure, WP 02-AR3001.[4] USQs are reviewed against the SAR and Technical Safety Requirements (TSR). A safety evaluation documents any change, as mandated by DOE Order 5480.21.[7]

8.1.4.3 Occurrence Reporting

The Occurrence Reporting Process at the WID is directed by DOE Order 232.1A, Occurrence Reporting and Processing of Operations Information.[13] The WID occurrence reporting implementing procedure is WP 12-ES3918, Reporting Occurrences In Accordance With DOE Order 232.1A.[14] This occurrence reporting procedure provides for reporting events to the Facility Manager (FM) or his designee for categorization.

Examples of events that should be reported include, but are not limited to the following: events that could endanger or adversely affect personnel safety or operations, or are contrary to DOE requirements. In addition, the procedure requires the event to be investigated to determine the direct cause, root cause and contributing causes, and to develop corrective actions to prevent recurrence.

The WIPP Lessons Learned Program was established as required by DOE Order 5480.19, Conduct of Operations Requirements for DOE Facilities,[15] and is implemented by WID Management Charter MC 9.20, Rev. 1, *Lessons Learned Working Group*.[16] WID Management Charter MC 9.20 empowers the Lessons Learned Working Group to administer the Lessons Learned Program, which was implemented to ensure a continuing improvement in plant safety and reliability. Lessons Learned bulletins are developed from information obtained from DOE Safety Notices, Nuclear Regulatory Commission Bulletins, external occurrence reports, internal occurrence reports, internal investigative reports, and other pertinent industry documents. Lessons Learned bulletins are distributed to the WIPP managers for inclusion into their required reading, as applicable.

8.1.4.4 Safety Culture

A safe working environment is the priority at the WIPP. Individuals responsible for performing work are continually evaluating the safety of themselves, the environment, and the facility. This philosophy is directed from the top down within the organization.

The Management approach to Occupational Health and Safety at the WIPP emphasizes the integration of safety into all aspects of the facility mission. WIPP management has communicated its expectations of site personnel and subcontractors regarding safety through policies, procedures, programs, and recognition as discussed in the Westinghouse Electric Company, WID, Voluntary Protection Program Application, 1994.[17] Senior management infuses the principles of safety to mid-management, mid-management to line management, and this continues until every employee incorporates safety principles into their job.

Top management is "visibly" involved in safety and health programs by establishing goals, approving management policies, providing accountability mechanisms, implementing site tracking systems, participating in employee communications, reviewing injury/illness trends, reviewing Industrial Safety and Hygiene (IS&H) summaries, and providing resources to perform jobs safely. Management support is evidenced by the Westinghouse Electric Company, WID, Voluntary Protection Program Application, 1994,[17] and application for recertification in 1997.

The DOE Voluntary Protection Program (VPP) Star Status recognition was awarded to the WID because of their comprehensive health and safety program. The VPP program encourages recognition of successful leading- industry injury and illness prevention programs that result in reducing workplace hazards. The WIPP Safety program elements including training, employee involvement, management commitment, and hazard prevention and controls were reviewed during the VPP application process. The WIPP Safety program annual re-evaluation maintains the appropriate focus on safety to retain VPP Star status.

8.1.4.5 Operational Systems Safety

This aspect of Operational Systems Safety deals with operational controls whose purpose is to detect and control hazards in operational activities. The program is carried out through independent safety review, inspection, and analysis by the Environment, Safety, and Health organization. Specific features of Operational Systems Safety include:

- Design review - Formal, documented design reviews of facilities and equipment are attended by IS&H, as required, in addition to construction packages review, and design specifications. Comments generated are formally resolved, with sign off/concurrence required in the final issued package.

- Procedures review - Operations and maintenance procedures are formally reviewed, and approved, by IS&H personnel, as required, to ensure that hazards inherent in the work are properly controlled. In the process, proper personal protective equipment and other precautions are reviewed.

- Operational readiness analysis - As part of the formal startup process for new facilities and components, IS&H participates in formal readiness analysis, to ensure that safety-related personnel (qualifications and training), equipment, and procedures are in place prior to initial operations.

- Procurement and subcontract reviews - IS&H reviews of purchase orders, as required, are performed to ensure that purchases of hazardous/toxic substances are known to IS&H, and to ensure that no prohibited materials are purchased. These reviews also ensure that any necessary use precautions are issued to the user when the materials are brought on the site. Subcontract reviews are performed to ensure that DOE and other safety regulations are specified as contract requirements.

- Inspections - Actual compliance with safety requirements is periodically evaluated through scheduled and unannounced inspections, appraisals, and walkthroughs of the workplace by IS&H personnel.

- Fitness-for-Duty - This policy is applicable to all WID personnel, and is relative to the ability of any employee to perform his/her job in a safe and healthful manner. The Fitness-for-Duty Program includes the identification and disposition of substance or alcohol use or abuse problems, and physical or psychological impairment problems of any kind.[18]

References for Section 8.1

1 DOE Order 5480.23, Nuclear Safety Analysis Reports, April 10, 1992.

2 DOE Order 4700.1, Project Management Systems, March 6, 1987 (For reference only, superceded by DOE O 430.1A).

3 DOE/WIPP 103, DOE Management Directives for WIPP.

4 WP 15-PS.2, *Technical Procedure Writer's Guide*, Rev. 0, March 1997.

5 DOE-STD-1029-92, *DOE Writer's Guide for Technical Procedures*

6 WP02-AR3001, Unreviewed Safety Questions Determination, Rev. 0, March 1998.

7 DOE Order 5480.21, Unreviewed Safety Questions, December 24, 1991.

8 DOE Order 6430, General Design Criteria Manual for DOE Facilities (draft), June 10, 1981 (For reference only, superceded by DOE O 420.1 and DOE O 430.1A).

9 DOE Order O 420.1, Facility Safety, October 1995.

10 DOE Order O 430.1, Life-Cycle Asset Management, August 1995.

11 WP 09-9, Configuration Management Plan, Rev. 3, February 25, 19996.

12 WP 15-PS3002, WID Controlled Document Processing, February 1999.

13 DOE Order 232.1A, Occurrence Reporting and Processing of Operations Information, August 1997 .

14 WP 12-ES3918 , Reporting Occurrences in Accordance with DOE Order 232.1A, Rev.1 , April 1999.

15 DOE Order 5480.19, Conduct of Operations Requirements for DOE Facilities, July 9, 1990.

16 WID Management Charter MC 9.20, Rev. 1, *January 1997, Lessons Learned Working Group*.

17 Westinghouse Electric Corporation, Waste Isolation Division Voluntary Protection Program Application, 1994.

18 WP 15-078, Fitness for Duty, Rev. 0, May 29, 1992.

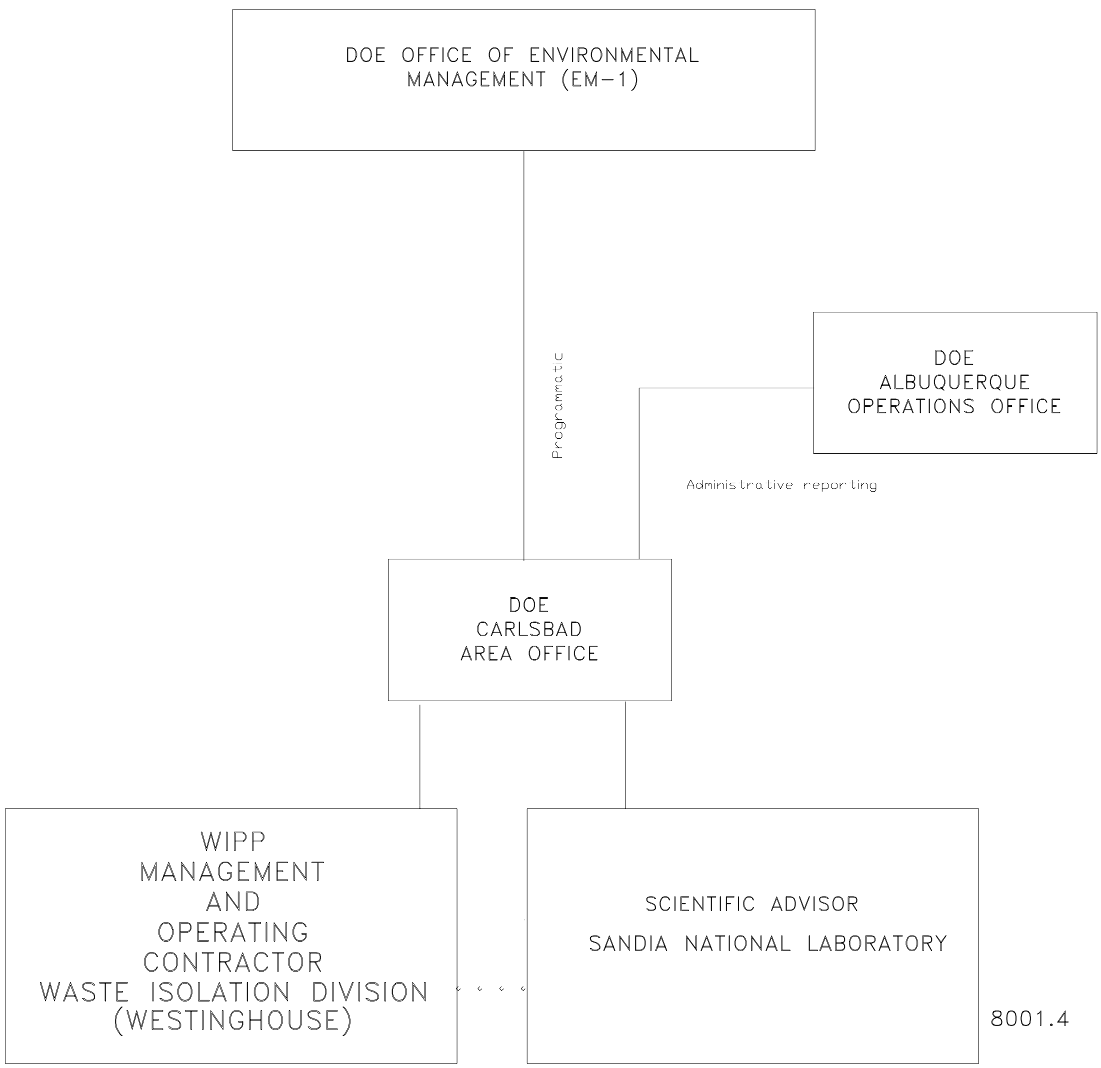


Figure 8.1-1, WIPP Facility Operations Responsibility

This page intentionally blank

8.2 Procedures and Training

8.2.1 Introduction

The WIPP training program is organized and managed to facilitate planning, directing, evaluating, and controlling a systematic training process that fulfills job-related needs and regulatory requirements. The MOC is responsible for establishing and administering the overall training program for WIPP personnel. Operations procedures are provided to ensure the facility is operated within its safety basis.

8.2.2 Requirements

Minimum requirements for the selection, qualification, and training of personnel at the WIPP are specified in DOE Order 5480.20A, Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities.[4] The minimum requirements for procedures are specified in DOE Order 5480.19, Conduct of Operations Requirements for DOE Facilities.[5]

8.2.3 Procedures Program

Formal written operating procedures are prepared for all developments and modifications that would affect the safety and/or the design purpose of the facility as defined in the SAR. Procedures govern configuration control of the facility and those systems designated Defense-in-Depth in Chapter 5. In addition, maintenance and calibration procedures are used to insure compliance with the safety basis of the site, as defined in this Safety Analysis Report. Work on Defense-in-Depth Structures, Systems, and Components (SSCs) is controlled procedurally.

Procedures are established to ensure the satisfactory preparation and thorough review of the operating procedures and any modifications to the procedures that may be necessary.

A master file of operating procedures is kept current, and controlled copies are available. The QA requirements for procedures are discussed in Chapter 9.

8.2.3.1 Development of Procedures

Procedure selection or need is required when a defined task or activity is to be performed, which meets one of the following criteria: (1) accomplishes work or activities defined in the WID QAPD, or creates quality records, (2) provides specific direction for the operating equipment and/or systems included in the configuration management process, (3) provides specific direction for physical activities that require repeatability and documented results, as described in WP 15-PS.2.[7] . The cognizant organization manager assigns a technically competent person, as defined in WP 13.1, WIPP *Quality Assurance Program Description,*[2] to develop the technical content of the document. Additionally, the cognizant organization manager determines which organizations will review the procedure, verifying its technical content and requirements, and the validation process, to determine if the procedure can be performed as written. An Unreviewed Safety Question (USQ) screening is performed by a qualified individual per WP 02-AR3001, *Unreviewed Safety Question Determination*.[3]

Revisions to procedures are processed according to WP 15-PS3002, *WID Controlled Document Processing*.[1] According to WP 15-PS3002, a proposed revision is prepared and processed by the cognizant organization. A review of the changes by all affected groups is the minimum requirement for revisions. Processing through USQ screening is required for all but minor changes.

Following successful completion of the technical review and validation process, the document package is sent to the Document Review Committee for final review, then the procedure is approved for use by a cognizant organization manager.

8.2.3.2 Maintenance of Procedures

Procedures undergo a periodic review during which a technically competent person must review the procedure for any new or existing requirements, cancellations, deletions, or additions. The change process allows for procedure changes that require immediate correction. Changes to the procedures mandate a technical review that must be signed off by the cognizant organization manager and a technically competent person before issuance as an approved change.

8.2.4 Training Program

The training program for employees, visitors, and subcontractors at the WIPP facility is a formally organized and continuing program. Training programs address the training of WIPP personnel and any site subcontractors in job-related training subjects spanning all levels of the organization, from fundamental technical skills and speciality training, to supervisory and management skills training. A formal Training Program for the WIPP facility operation staff and technical support personnel has been established. Training program policies and procedures define job function, responsibility, authority, and accountability of WID personnel involved in managing, implementing, and conducting training.

The primary objective of the WIPP facility training program is to prepare personnel to operate the WIPP in a safe and environmentally sound manner. To achieve this objective, the training program provides all employees with training relevant to their positions. Full-time employees at the WIPP, regardless of employer, and including those not directly involved in waste handling activities, receive an introduction to the Resource Conservation and Recovery Act (RCRA) and emergency preparedness within 30 days of employment as part of the General Employee Training (GET). In this way, everyone at the WIPP is given a basic understanding of regulatory requirements and emergency procedures. Employees in hazardous or mixed waste management positions receive additional classroom and on-the-job training designed specifically to teach them how to perform their duties safely, and to ensure the facility's compliance with the regulations. Hazardous/mixed waste management personnel receive the required training before being allowed to work unsupervised.

8.2.4.1 Development of Training

The training program is organized and managed to facilitate planning, directing, evaluating, and controlling a systematic training process that fulfills job-related needs and considers regulatory requirements. Implementation of training at the WIPP is a shared effort between the functional groups and the training section. WIPP training and qualifications programs are included in the following areas:

- Operations (Facility Operations, Waste Operations, Underground Operations)
- Maintenance Mining Operations
- Environmental and Radiological Control
- Industrial Safety and Health
- Engineering
- Quality and Regulatory Assurance
- Technical Training

Training to support qualification programs is based on a systematic approach to training (SAT). A graded approach has been used to tailor the training program to the needs of the WIPP site. The WIPP application of the SAT methodology is described in detail in the WIPP Training Program, WP 14-TR.01.[6] A product of this process is a training program designed to meet the skill and knowledge needs for the evaluated task or job. Through this process, the final program elements will be defined, including training frequency. Each training program is carefully developed and periodically re-evaluated to ensure relevance to the course objectives, compliance with the regulations, and support of the goal of safe and environmentally sound operations at the WIPP. This process is useful because it compels managers and training staff to look critically at each position, and to determine the necessary training program for each employee to fully develop their necessary expertise. If regulatory guidelines require, or task performance should dictate continuing or recurrent training, it is established at this point.

The Technical Training Section is responsible for administering training programs, for complying with training standards affecting both regular and contract personnel, and for maintaining current and accurate records reflecting the training of each employee. Records activities follow an approved "Records Inventory and Disposition Schedule," reviewed and updated at least annually, to comply with federal codes, policies, or directives concerning training records administration.

8.2.4.2 Maintenance of Training

Training programs are periodically reviewed, focusing on changes in job scope, task, performance, procedure, and regulation. Training programs are approved and authorized by appropriate line management and WIPP Training management before being implemented or revised.

Because changes are anticipated, to maintain qualifications, a qualified employee will requalify on applicable qualification cards every two years in order to maintain their qualification. Radiation Control Technician (RCT) requires that the employee requalify only on infrequent or abnormal tasks. This requalification focuses on continuing training in tasks that are critical to safety, or are difficult, or infrequently performed. This commitment to refresher training ensures a proficient and safe workforce.

8.2.4.3 Modification of Training Materials

When it is decided that existing programs require revision, a formal process is implemented to ensure program quality is maintained and enhanced.

Using the combined efforts of WIPP training and cognizant personnel, programs are revised and updated. These updates may be due to changes in task performance, modifications to equipment or noted human factors deficiencies. At the completion of program modification, cognizant line management and WIPP training must approve any revision before implementation. The amount and type of training required in the permits will be maintained, and additional training is at the discretion of the WIPP.

References for Section 8.2

1 WP 15-PS3002, *WID Controlled Document Processing, Rev. 3, February 1999*

2 WP 13.1, WIPP *Quality Assurance Program Description*

3 WP 02-AR3001, *Unreviewed Safety Questions Determination*

4 DOE Order 5480.20A, Personnel Selection, Qualification, Training Requirements for DOE Nuclear Facilities, November 15, 1994.

5 DOE Order 5480.19, Conduct Of Operations Requirements For DOE Facilities, July 9, 1990.

6 WP 14-TR.01, Rev. 1, *WIPP Training Program*, March 21, 1997.

7 WP 15-PS.2, Technical Procedure Writer's Guide, Rev. 0, March 1997

8.3 Initial Testing, In Service Equipment Monitoring , and Maintenance

8.3.1 Introduction

The MOC is responsible for testing and maintaining the equipment and systems at the WIPP.

8.3.2 Requirements

The plans and provisions for initial and in-service surveillance, are provided in DOE Order 5480.23, Nuclear Safety Analysis Reports.[1] The requirements for maintaining DOE property is provided in DOE Order 4330.4B, Maintenance Management Program.[2]

8.3.3 Initial Test Program

8.3.3.1 Start-up Testing & Preoperational Checkout

Equipment and systems important for continued and safe operation of the WIPP facility shall undergo start-up testing before operation. The testing shall verify established design criteria, prove functional requirements, and safe operation, or post modification retest, after changes are made to equipment or systems. The WIPP Start-Up Test Program, WP 09-SU.01[3] includes a program covering initiating, executing, revising, and canceling start-up test procedures; start-up documents/records control; and qualification requirements for start-up testing personnel.

8.3.3.2 Start-up Testing Program Objective

The basic objective of the Start-up Testing Program is to verify that the plant's equipment and systems operate safely, according to established plant design and approved test procedures.

8.3.3.3 Administrative Procedures for Conducting the Start-up Testing Program

Administrative procedures are established to ensure that the test procedures, before their execution, are prepared, reviewed and approved by qualified personnel. Testing shall be performed by certified individuals, and test results shall be documented and evaluated for adequacy using start-up program procedures. Test procedure changes are controlled and evaluated to ensure that changes do not adversely impact the intent of the test. Plant modifications shall be tested in the same manner as the original design. Implementation of such modifications/changes, including retesting, shall be accomplished by the latest approved applicable project and start-up program procedures.

8.3.3.4 Vendor Testing

Some equipment or system tests may be conducted at the vendor's facility according to contractual specifications; however, it is recognized that often equipment and systems can only be adequately tested after they are installed and integrated with other systems at the WIPP facility. Equipment and systems that fail vendor tests are rejected until repairs, adjustments, or modifications are completed, and failed equipment or systems are retested. Nonconformances may be authorized after evaluation by responsible engineering and management personnel.

8.3.3.5 Preoperational Checkout

Beyond vendor and start-up testing, preoperational waste handling demonstration checkouts shall be conducted using simulated waste. Simulated waste handling operations shall be performed in sequence, from receipt through final emplacement. The checkouts listed in Table 8.3-1 shall be done according to the latest approved operating procedures and preoperational checkout demonstration procedures. Preoperational checkout objectives include:

- Demonstrating that WIPP personnel can safely handle CH TRU waste packages, including unloading an internally contaminated TRUPACT
- Demonstrating the satisfactory operation of WIPP waste handling equipment
- Demonstrating that the WIPP operating procedures are comprehensive, and sufficiently detailed to perform normal waste handling operations, and to recover from off-normal occurrences encountered during waste handling operations
- Establishing the aggregate time estimate for WIPP waste handling operations
- Providing the basis for estimating the dose to be received by WIPP waste handling personnel

8.3.4 In-Service Equipment Monitoring Program

8.3.4.1 Conduct of Operations

After systems have completed the start-up processes, they are available for day-to-day operations. It is important to ensure that systems remain within their nominal performance parameters. If systems fail to operate, repairs are implemented, and operability is re-established.

The Operations Department Conduct of Operations requires that functional testing be done before equipment or systems are considered capable of performing their design function. The requirement for a Conduct of Operations program is documented in Section 5, Administrative Controls, of the TSRs in Attachment 1.

Responsibility for ongoing evaluation falls with many organizations depending on the nature of the evaluation. For example, some equipment is subjected to periodic operability checks to ensure that operating parameters are within the range allowed for reliable operations. Examples are environmental continuous air samplers (covered by WP 02-EM1012, Airborne Particulate Sampling[5]) and systems important to safe operation covered by the TSRs in Attachment 1. The following ensure that waste handling equipment is operating, and operated, in a safe manner and according to design prior to and during waste handling activities:

- A centralized checklist, maintained by Operations, will be completed prior to entering the Waste Handling Mode to meet the requirements of TSR Section 1.2.
- Periodic oversight of the preoperational checks on waste handling equipment and facility activities are conducted by WIPP management.
- The WIPP Operations Department conducts internal assessments on procedural compliance.

- Through normal conduct of operations, operators continuously review procedures for accuracy and improvement as procedures are being used. If an error or improvement is identified, WIPP management is informed to evaluate and take action to change or revise the procedure. This process ensures the effectiveness of procedures, and the safety of personnel and equipment at all times.

Other systems require periodic preventive maintenance. This is performed according to WP 10-WC3004, Preventive Maintenance Administration.[7]

Analytical and measurement equipment are entered into a calibration recall system, to ensure timely calibration and recalibration of this equipment.

8.3.4.2 Resource Conservation and Recovery Act (RCRA)

Equipment instrumental in preventing, detecting, or responding to environmental or human health hazards, such as monitoring equipment, safety and emergency equipment, security devices, and operating or structural equipment are inspected. The WIPP facility maintains a series of written procedures that include detailed inspection steps and checklists. Tables F-1 and F-2 of the RCRA Part B[6] permit application list each item or system requiring inspection.

The operational procedures assign responsibility for conducting the inspection, the frequency of each inspection, the types of problems to be watched for, what to do if items fail inspection, directions on record keeping, and inspector signature, date, and time. Inspections include identifying malfunctions, or deteriorating equipment and structures. Inspection results and data, including deficiencies, discrepancies, and corrective actions taken are recorded.

The frequency of inspections is based on the rate of possible deterioration of the equipment and the probability of an environmental or human health incident if the deterioration or malfunction, or any operator error, goes undetected between inspections.

8.3.5 Maintenance Program

Under normal operations, equipment requiring regular maintenance is expected to remain free of hazardous materials. However, it is assumed that any equipment in waste handling areas may become contaminated. Equipment decontamination provisions include smooth surfaces, minimizing void spaces, and designing for easy removal. Floors, walls, ceilings, and structural steel surfaces in the waste handling areas have special protective coatings to simplify decontamination. Where decontamination is impractical, space is provided for installing temporary shielding, or the equipment may be removed for repair or disposal.

The WIPP is fully committed to achieving compliance with the requirements of DOE Order 4330.4B,[2] Chapter II, for essential equipment. WP 10-2, Maintenance Operations Instruction Manual;[8] WP 10-WC3002, Corrective Maintenance;[9] WP 10-WC3004, Preventive Maintenance Administration;[7] and WP 10-WC.02, Predictive Maintenance Program[10] implement DOE Order 4330.4B. All maintenance procedures will be reviewed every two years (biennially). The maintenance program set forth under DOE Order 4330.4B,[2] Chapter II has been established, developed, and implemented at the WIPP Site.

The MOC is responsible for operating the WIPP facility, including the responsibility for maintenance. The organization, responsibilities, work scope, management and control, and interfaces are prescribed in the above maintenance administrative procedures.

8.3.5.1 Waste Handling Building

The Waste Handling Building (WHB) has certain provisions incorporated above those which are required for routine maintenance activities.

Equipment in the CH TRU and RH waste handling areas is designed for contact maintenance. The hot cell equipment includes manual overrides to ensure that waste handling equipment can place waste canisters in a shielded area before maintenance is performed.

There is a crane maintenance gallery next to the hot cell, where the hot cell crane can be moved and isolated from the hot cell atmosphere without being removed from its rails. This provides shielding from RH TRU waste containers during crane maintenance or repairs. A manipulator repair room is located next to the hot cell operating gallery. The master-slave manipulators can be removed via the operating gallery, and taken to the manipulator repair room for required repair operations without personnel entering the hot cell. Hot cell equipment is modularized to the maximum extent practical, to simplify its removal when replacement or major repair is required. The facility cask and its transfer car can be taken into the RH cask receiving area for maintenance.

The Waste Shaft hoist area includes sufficient space for maintenance. An overhead handling system is included for the hoist equipment, and means are provided for transferring the hoist equipment to the ground level for maintenance or disposal.

8.3.5.2 Shafts

The mine shafts are designed for periodic inspection and maintenance. The top of the Waste Shaft cage, the Air Intake Shaft (AIS) cage, and the Salt Handling (SH) skip/cage are designed to be used as inspection platforms, with associated overhead protection bonnets installed during inspections of those shafts. Inspections in the Exhaust Shaft are conducted with remote controlled TV cameras, since there is no hoist installed in this shaft.

8.3.5.3 Subsurface Areas

Maintenance and repairs are conducted in the underground for excavating equipment, and waste handling and emplacement equipment. Waste disposal equipment that requires maintenance is surveyed and decontaminated, if required, before being taken to subsurface maintenance facilities.

In the event that the facility cask malfunctions during emplacement or retrieval operations, local maintenance equipment can be set up with local shielding, as required. Manual overrides are provided on the waste handling equipment to allow for canister transfer operations to be completed, or recovery of the canister to a safely shielded condition, if the equipment malfunctions. Normal waste-handling equipment maintenance is performed underground at the disposal horizon.

Manufacturers' recommended maintenance procedures are expected to be adequate for the underground mechanical equipment. As in any type of operation, however, regular and periodic inspections are required of all equipment and structures.

To minimize any maintenance excavation or re-excavation, all openings are designed large enough initially to allow for creep.

8.3.5.4 Air Filtering Equipment

The filter systems are periodically inspected, and filters are changed when the pressure drop across them reaches a predetermined level. If leaks are found, repairs are implemented, and the system is retested. HEPA filter testing will be conducted in accordance with ANSI N510.[4]

High Efficiency Particulate Air (HEPA) filters, associated with the underground ventilation system, are located in the Exhaust Filter Building in large filter housings. To prevent contamination from spreading, the used HEPA filters are removed and bagged within the housing for disposal. Access to the filter chamber room, where the housings are located, is through an air lock that provides a boundary to prevent the spread of contamination. Positive airflow into the filter chamber room is maintained during the filter change-out activity. Personnel working within the plenum are provided with protective clothing and respiratory protective equipment.

For the WHB HEPA filters and other smaller filter systems, personnel replacing filters wear suitable protective clothing and carry respiratory equipment. However, they do not enter the housings. Contaminated filters are bagged before they are removed to prevent contamination from spreading during filter change-out. Filter housing maintenance, except for cleaning, is unnecessary.

8.3.5.5 Equipment Decontamination Provisions

Contaminated items are bagged and are then disposed of as radioactive wastes, or decontaminated in a designated area. Decontamination of waste transporters, by wiping with damp rags as frequently as necessary, can be accommodated in either the CH TRU or RH TRU unloading area.

The general decontamination philosophy for the WIPP is to minimize the amounts of waste generated due to decontamination operations, and is accomplished by wiping with damp rags soaked in detergent or a decontamination solution.

8.3.5.6 Other Surface Structures

Surface structures other than the WHB and the Exhaust Filter Building (EFB) are associated with either direct support activities (switchyards, substation, sewage treatment, backup power, shaft headframe, and hoist houses), or indirect support activities (Warehouse Building). These facilities contain systems that require routine maintenance according to common industrial practice and manufacturers' recommendations. No special or unusual maintenance features are incorporated in the design of these facilities.

References for Section 8.3

1 DOE Order 5480.23, Nuclear Safety Analysis Reports, April 10, 1992.

2 DOE Order 4330.4B, Maintenance Management Program, February 10, 1994.

3 WP 09-SU.01, WIPP Start-Up Test Program, Rev. 0, April 1998

4 ANSI N510, American National Standards Institute, Standard for Testing of Nuclear Air Cleaning Systems.

5 WP 02-EM1012, Airborne Particulate Sampling, Rev. 1, July 17, 1998.

6 DOE/WIPP 91-005, Resource Conservation and Recovery Act Part B Application, Rev.6.

7 WP 10-WC3004, Preventive Maintenance Administration, Rev. 2, March 1999.

8 WP 10-2, Maintenance Operations Instruction Manual, Rev.1, November 13, 1997.

9 WP 10-WC3002, Corrective Maintenance, Rev. 3, May 5, 1997.

10 WP 10-WC.02, Predictive Maintenance Program, Rev. 0, June 1997.

Table 8.3-1, WIPP Preoperational Checkout Program

Test Title	Plant Condition	Test Objectives
CH Waste Handling	Before receiving CH Waste	Verify all systems associated with the CH waste disposal function as described in Section 4.3.1.
RH TRU Waste Handling System	Before receiving RH TRU Waste	Verify all systems associated with the RH TRU waste disposal function as described in Section 4.3.2.

This page intentionally left blank

8.4 Operational Safety

8.4.1 Introduction

The MOC ensures that all operations are conducted according to DOE Order 5480.19, Conduct of Operations Requirements for DOE Facilities.[1] The SAR considers the term "operations" as reflecting those daily activities, resources, management, and communication required to support the WIPP in meeting goals and objectives for the intended facility purpose.

Operation of the facility will be according to approved operation procedures, TSRs, and good operating practices. Supervisors are responsible for reporting to the Facility Shift Manager (FSM) any conditions that may affect the operation or operability of the facility. Supervisors must obtain approval for the operation and/or maintenance of the plant equipment and system through the Plan-of-the-Day (POD).

Pre-job briefings will be conducted regularly by supervisors before the evolution for new or complex activities, to ensure that they are completed safely, correctly, and efficiently.

8.4.2 Requirements

The MOC's Conduct of Operations is directed by DOE Order 5480.19,[1] and is implemented by WP 04-CO, Conduct of Operations.[2]

8.4.3 Conduct of Operations

8.4.3.1 Controlled Access Area Activities

Entry to controlled access areas will be limited to persons who need to be in the area on required business. This access will be granted by the control area operator. Additionally, Facility Operations management and designated Operations Assistance Team (OAT) personnel, are granted unrestricted access to the Central Monitoring Room (CMR).

Only persons specifically authorized by administrative procedures may operate controlled area equipment.

8.4.3.2 Communications within the Facility

Timely communication within the facility is enabled by the: public address (PA) system which includes Site Notification System, radios, beepers, mine pagers and phones, and touch-tone telephones. When making site-wide announcements, the Central Monitoring Room Operator (CMRO) will use the PA system (including the Site Notification System [SNS]), and the mine phone.

Personnel notification is accomplished by flashing lights, vibrating personnel pagers, or by persons dedicated to notifying personnel working in areas where the PA system cannot be heard. Emergency communication PA systems will be periodically tested to ensure functionality.

8.4.3.3 Control of On-Shift Training

On-Shift training will be conducted by Level 1 Instructors. A qualified subject matter expert (SME) or On-the Job Training Evaluator (OJTE) will observe trainee performance skills to ensure that no adverse actions occur. Procedure steps, cautions, and notes must be discussed with the instructor before operating any equipment until the student has demonstrated proficiency in performing a skill. Trainees will continue being monitored until demonstrating the proper proficiency.

Training procedures provide documentation guidance for operator qualification and certification programs. Qualification cards will be signed by the SME, documenting that the trainee has successfully and adequately demonstrated proficiency of that skill.

8.4.3.4 Control of Equipment and System Status

The FSM is responsible for maintaining proper configuration, and authorizing changes of general surface and underground equipment, and defense-in-depth equipment and systems. The respective manager or supervisor is responsible for maintaining proper configuration for other activities including: hoisting equipment, waste handling equipment, and systems.

Equipment and systems will be checked for proper alignment before placing the equipment or system into operation. Checklists will be used to ensure that equipment is controlled, checked, and monitored. Following maintenance, equipment will be checked for proper alignment before being returned to operation.

A system is in place to monitor the status of on-site alarms. Procedures initiating appropriate action are in place to monitor equipment parameters for abnormal conditions that could be masked by deficient alarms.

Programs are in place to ensure that operating personnel receive and use the latest revisions or changes to engineering drawings and/or specifications.

8.4.3.5 Lockouts and Tagouts

WP 12-IS.01, Industrial Safety Program,[3] and procedure WP 04-AD3011, Equipment Tagout/Lockout[4] sets forth the policy requiring each employee to properly implement the requirements of DOE Order 5480.19,[1] Chapter IX, to protect personnel, DOE property and plant systems, and prior to entry into a high energy system. This procedure provides for placing, removing, and auditing Operations tags and locks for configuration control, and in addition, provides for caution tags. When conducting maintenance activities, equipment tagout/lockout uses WP 10-AD3005, Control and Use of Maintenance Locks,[6] which complies with DOE Order 5480.19[1] and 29 CFR 1910.147.[7]

8.4.3.6 Independent Verification

Independent Verification is performed on Defense-in-Depth Structures, Systems, and Components when circumstances warrant.

Individuals performing independent verification will be instructed and trained in the appropriate techniques for verifying the correct position of facility components, and will perform the necessary checks in accordance with documented procedures and guidelines.

8.4.3.7 Log Keeping

Logbooks will be kept at all key shift positions, as determined by the importance of the sequential information related to shift events, and the importance of the shift position regarding establishing or maintaining regulatory or DOE requirements.

As a minimum, a logbook will be maintained by the FSM or the CMRO. Information will be recorded accurately and efficiently, following guidance in WP 04-CO, *Conduct of Operations* ,[2] and WP 04-AD3008, *Shift Operating Logs*.[5]

8.4.3.8 Operations Turnover

The Operations Turnover process, as defined in WP 04-CO, *Conduct of Operations*,[2] ensures that during the supervisory turnover process, any conditions related to abnormal lineups, status of major components, surveillance planned or in progress, or evolutions planned or in progress are reported to the oncoming supervisor.

Oncoming personnel and supervisors will conduct a comprehensive review of appropriate written and visual information, as described in WP 04-CO, *Conduct of Operations,*[2] before responsibility for the shift position is transferred. The off-going supervisor will explain all items noted, at a time when facility conditions are stable to the oncoming personnel.

8.4.3.9 Operational Occurrences

WP 12-ES3918 , Reporting Occurrences in Accordance with DOE Order 232.1A,[8] establishes a system for reporting events to the Facility Manager (FM)/Facility Manager Designee (FMD) for categorization of Off-Normal and Unusual occurrences. Operational Emergencies are categorized per WP 12-ER3904,[9] Categorization and Classification of Operational Emergencies which refers to WP 12-ES3918[8] for the less severe events. Events reported to the FM/FMD are categorized within two hours of discovery per the criteria listed in Attachment 1 of WP 12-ES3918.[8] Events are categorized as off-normal, unusual, or emergency occurrences based upon the severity of the incident. All occurrences are investigated and documented per the requirements of 15-MD3102, Event Investigation and Root Cause Analysis ,[10] to determine the root cause, direct cause, and contributing cause. In addition, corrective actions are developed, scheduled, and lessons learned identified. A Notification Report shall be prepared by the FM/FMD, and uploaded into the Occurrence Reporting Processing System (ORPS) database before the close of the next business day from the time of categorization, not to exceed 80 hours. A 10-Day Occurrence Report shall be prepared by the FM/FMD, and uploaded into the ORPS database within 10 working days of categorization, using the information available at the time. A Final Occurrence Report shall be prepared by the FM/FMD, and uploaded into the ORPS database within 45 days of categorization of the occurrence.

8.4.4 Fire Protection

The fire protection program at the WIPP facility ensures the safety of plant personnel, the reliability and continuity of plant operations, and the minimization of property loss. These objectives are met by incorporating automatic fire suppression systems, using fire resistant materials in facility construction, providing fire barriers and fire doors in areas susceptible to fires, and enclosing vertical openings in buildings, thereby preventing the spread of fires.

8.4.4.1 Fire Hazards

The fire hazards at the WIPP due to electrical equipment failure, spontaneous ignition, highly flammable materials, maintenance activities, fuel storage, and office materials are considered to be normal industrial-type fires, and could occur in any site area.

8.4.4.2 Fire Protection Program and Organization

Responsibility for the fire protection program is assigned to the General Manager (GM), while administration, formulation, and implementation of the program is assigned to the manager of Environment, Safety and Health, (ES&H).

8.4.4.3 Combustible Loading Control

The objectives for fire protection at the WIPP facility are to ensure the safety of plant personnel, the reliability and continuity of plant operations, and to minimize property loss. To meet these objectives, the WIPP facility design incorporates the following features:

- With the exceptions of some temporary and other noncritical structures (such as the off-site air monitoring system), all buildings and their support structures are protected by fixed, automatic fire suppression systems designed to the specific, individual hazards of each area. Each building is evaluated annually to determine the fire risk associated with the occupancy.

- Noncombustible construction, fireproof masonry construction, and fire resistant materials are used whenever possible.

- Areas susceptible to fire are separated by fire walls and fire doors, to contain and isolate hazardous materials or operations. Fire separations are installed where required because of different occupancies, per the Uniform Building Code (UBC).

- All vertical openings in buildings are protected by enclosing stairways, elevators, pipeways, electrical penetrations, etc., to prevent fire from spreading to upper floors.

- The exhaust ventilation systems, which remove hot fire gases, toxic contaminants, and explosive gases and smoke, are designed with a high fire integrity.

- The components of the electric service and distribution systems are listed by Underwriters' Laboratory, or approved by Factory Mutual Engineering Corporation. These systems are installed to minimize possible ignition of flammable material and maximize safety.

As part of the improved risk fire protection program, certain passive and active design features including area separation, noncombustible construction, fixed fire suppression systems (water and dry chemical), and manual fire suppression capabilities are used.

To ensure reliability of the active fire protection systems, inspection, testing, and maintenance programs are provided. There are also administrative controls for the fire system impairments, hot work and internal audits of the inspection, testing and maintenance, and other program elements essential to the maintenance of an improved risk fire protection program, as required by DOE orders.

8.4.4.4 Fire Fighting Capabilities

Facilities, equipment, and trained personnel are available to provide the following emergency services for the WIPP facility:

- Fire fighting
- Emergency medical response
- Industrial rescue
- Mine rescue
- Hazardous material response and control

Fire fighting capability includes a fully-equipped pumper engine, associated firefighting equipment, and trained fire fighters. Firefighting activities are led by an emergency services technician (EST) or fire protection technician (FPT), on duty 24 hours a day. Backup fire fighting personnel are provided using cross-trained personnel.

The ESTs/FPTs are state-licensed emergency medical technicians, and provide 24-hour emergency medical response capability at the WIPP facility. During the day shift, a full-time registered nurse is on the site. A fully-equipped first-aid room, ambulance, underground ambulance, and rescue vehicle are available to provide basic life support activities.

The ESTs/FPTs also provide industrial rescue for vehicle accidents, confined space extrication, and other industrial incidents. The technicians provide rope rescue through the use of state-of-the-art hydraulic and manual equipment.

Mine rescue services are provided using two trained mine rescue teams at the WIPP facility. These teams are fully trained in the use of mine rescue procedures and techniques, as well as the use of self-contained breathing apparatus and firefighting equipment. A mine rescue station has been developed and equipped with MSHA-approved, properly maintained, self-contained breathing apparatuses, mine rescue supplies, and required spare parts.

The WIPP facility utilizes numerous materials that meet the NFPA, EPA, or DOT classifications as a hazardous material. The emergency preparedness staff has the equipment and trained personnel necessary to respond to, and control spills and leaks of these materials, and, in some cases, clean up the spills for the protection of life, health, property, and the environment.

An Emergency Management Program has been prepared for the WIPP facility. The WIPP Emergency Management Program[11] provide an organized plan of action for dealing with identified credible emergencies at the WIPP. The plan identifies lines of authority, the responsibilities of emergency response personnel and organizations, and the WIPP manpower and equipment resources available to cope with emergencies.

8.4.4.5 Fire Fighting Readiness Assurance

Exercises and drills are used to demonstrate the effectiveness of the established Emergency Management Program. Evaluations of these exercises ensure an effective and efficient program is in place, and that it is truly capable of mitigating the credible emergency scenarios. Exercises and drills are conducted on a regularly scheduled basis for all WIPP facility response personnel and equipment. WIPP facility Emergency Management promotes involvement in emergency response activities outside the scope of the

WIPP facility. In an effort to maintain a high level of skill level, interest and motivation among response personnel, various response teams participate in local, regional, and national competitions.

The safety program is objectively evaluated by trend analysis, and by determining current status of training, inspections, sampling, monitoring, drills and exercises, and accident frequency. In addition, assessments of the safety program include those conducted by the DOE-CAO.

References for 8.4

1 DOE Order 5480.19, Conduct of Operations Requirements for DOE Facilities, July 9, 1990.

2 WP 04-CO, Conduct of Operations, Rev. 1, December 1997.

3 WP 12-IS.01, Industrial Safety Program, Rev. 1, November 21, 1997.

4 WP 04-AD3011, Equipment Tagout/Lockout, Rev. 2, November 15, 1996.

5 WP 04-AD3008, *Shift Operating Logs*, Rev. 0, August 23, 1996.

6 WP 10-AD3005, Control and Use of Maintenance Locks, Rev. 1, January 12, 1996.

7 29 CFR 1910.147, The Control of Hazardous Energy (Lockout/Tagout), September 20, 1990.

8 WP 12-ES3918, Reporting Occurrences in Accordance with DOE Order 232.1A, Rev. 0, February 15, 1996.

9 WP 12-ER3904, Categorization and Classification of Operational Emergencies, Rev. 1, March 31, 1997.

10 15-MD3102, Event Investigation and Root Cause Analysis, Rev. 0, September 15, 1997.

11 WP 12-9, WIPP Emergency Management Program, Rev. 11, February 14, 1997.

This page intentionally blank

8.5 Emergency Preparedness Program

8.5.1 Introduction

This section briefly describes the significant aspects of the Emergency Preparedness Program. The Emergency Preparedness Program is implemented through WP 12-9, WIPP Emergency Management Program.[1] The WIPP Emergency Management Program will be followed to minimize the impact of emergency events upon the health and safety of plant personnel, the general public, the environment, and the WIPP mission. In events concerning hazardous materials/waste, WP 02-12, WIPP Contingency Plan[2] shall be implemented.

The Emergency Response Program at the WIPP consists of three manuals: the Emergency Management Program;[1] the Contingency Plan;[2] and, WP 12-ER, Emergency Response Procedures.[3]

The WIPP facility Emergency Management Program applies to all personnel employed at, or assigned to the WIPP facility, and defines emergency response roles and responsibilities. The facility Emergency Management Program does not include any required DOE radiological response to transportation accidents that occur away from the facility. Such DOE response, if requested by the state, is directed by the cognizant DOE Operations Office. WIPP facility personnel will be available to support local and state organizations in such cases, as directed by the DOE Albuquerque Operations Office.

8.5.2 Requirements

The Emergency Preparedness Program establishes the requirements and procedures in compliance with the following:

- DOE Order 151.1, Comprehensive Emergency Management System[4]
- DOE Order 232.1 , Occurrence Reporting and Processing of Operations Information[5]
- 40 CFR 264, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities[6]
- 40 CFR 265, Subpart D, Contingency Plan and Emergency Procedures[7]
- 40 CFR 265.37, Arrangements with Local Authorities[8]
- 40 CFR 265.52 (c), Content of Contingency Plan[9]
- 29 CFR 1910.120, Paragraph (p), Certain Operations Conducted Under the Resource Conservation and Recovery Act of 1976 (RCRA)[16]

8.5.3 Scope of Emergency Preparedness

The Emergency Preparedness Program applies to safety response actions relative to the following:

- Radiological emergencies
- Underground emergencies
- Industrial emergencies
- Security emergencies

8.5.4 Emergency Preparedness Planning

Emergency Preparedness is addressed by the WIPP Emergency Management Program. The plan identifies necessary actions for dealing with site-wide and area emergencies, and defines the lines of authority. Responsibilities of emergency response personnel and organizations are detailed in the Program, including a discussion of the WIPP labor and resources required.

Operational Emergencies at the WIPP are classified by Emergency Action Levels (EALs) that provide specific predetermined criteria allowing WIPP emergency personnel to categorize Operational Emergencies. The classification of Operational Emergencies is detailed in procedure WP 12-ER3904, Categorization and Classification of Operational Emergencies.[10]

8.5.4.1 Emergency Response Organization

The Emergency Operations Center (EOC) may be activated depending on the severity or type of emergency. Upon activation of the EOC, the Crisis Manager (CM) directs emergency response actions. These actions may involve DOE facilities in Carlsbad. Management of an emergency depends on the time and location of the event as determined by the FSM or CM. The FSM directs the event until the EOC is activated. Upon activation of the EOC, the WIPP program provides for immediate management response, and for proper notifications made during an emergency.

The WIPP also has in place a Crisis Management Team (CMT), an executive decision-making group tasked specifically to respond to emergencies. The WID GM, or designated alternate, will function as the CM. The CMT consists of several personnel experienced in dealing with emergencies. The WIPP tactics team may be activated with the CMT, to provide technical, logistical, and administrative support. Individuals on these teams are governed by specific directions found within the WIPP Emergency Management Program.[1]

All on-site emergencies shall be reported immediately to the CMRO, where specific information will be gathered relating to that incident.

8.5.4.2 Assessment Actions

Initial radiological release dose to the public calculations are performed in accordance with WP 12-RE3000, *Radiological Engineering Activities*.[12]

The DOE, WID, New Mexico Environment Department (NMED), and the Environmental Evaluation Group (EEG) have signed a protocol[13] that is an agreement for WID to provide NMED and EEG with routine and non-routine (radiation alarm) effluent sample filters for independent analysis. The methods for sample filter transfer to NMED and EEG are described in the protocol,[13] and in WP 12-HP3500, *Airborne Radioactivity*.[14]

8.5.4.3 Notification

The WIPP Emergency Management Program[1] describes the off-site notification procedure, and maintains project credibility by providing timely and accurate information dissemination to the maximum extent permitted by the emergency situation. These emergencies include: sabotage, bombing, kidnaping, hostage incident, natural disaster, or highway accident involving a WIPP shipment.

8.5.4.4 Emergency Facilities and Equipment

Facilities and equipment related to emergency response are closely monitored at the WIPP. Monthly surveillance of items such as radios, telephones, and computers are conducted using a checklist and surveillance log.

8.5.4.5 Memoranda of Understanding and/or Agreements

Memoranda of Understanding (MOUs) between the WIPP and several key community organizations are important aspects of the available protective actions governed by legal cooperation agreements. A tabular summary of these Agreements including their purpose is as follows:

- JOINT POWERS AGREEMENT BETWEEN THE UNITED STATES DEPARTMENT OF ENERGY AND THE CITY OF CARLSBAD AND THE COUNTY OF EDDY AND NEW MEXICO ENERGY, MINERALS AND NATURAL RESOURCES DEPARTMENT FOR A JOINT-USE ALTERNATE EMERGENCY OPERATIONS CENTER. This MOU directs that the parties involved shall share in establishing and maintaining an alternate EOC.

- MUTUAL AID FIRE FIGHTING AGREEMENT BETWEEN THE EDDY COUNTY COMMISSION AND THE U.S. DEPARTMENT OF ENERGY. This Agreement provides for the actual assistance of the parties in the furnishing of fire protection for the Eddy County Fire District and the WIPP Site.

- FEDERAL BUREAU OF INVESTIGATION/DEPARTMENT OF ENERGY MEMORANDUM OF UNDERSTANDING. This MOU deals with threats and criminal acts associated with theft, sabotage, or hostage attempts against the DOE-AL sites within the state of New Mexico.

- MEMORANDUM OF UNDERSTANDING BETWEEN THE DOE AND THE U.S. DEPARTMENT OF INTERIOR, ROSWELL DISTRICT. This agreement provides for a fire-management program that will ensure a timely, well-coordinated, and cost-effective response to suppress wild fire within the land withdrawal area.

- MEMORANDUM OF UNDERSTANDING BETWEEN THE UNITED STATES DEPARTMENT OF ENERGY AND THE NEW MEXICO DEPARTMENT OF PUBLIC SAFETY CONCERNING MUTUAL ASSISTANCE AND EMERGENCY MANAGEMENT. The MOU applies to any actual or potential emergency or incident that: involves a significant threat to employees, or the public; involves DOE property; involves threat to environment reportable to an off-site organization; requires combined resources of the DOE and the State; requires DOE resources unavailable from the State or vice versa; involves any other incident for which a joint determination has been made by the DOE and the State that the provisions of this MOU will apply.

- AGREEMENT BETWEEN CAO MANAGER, U.S. DEPARTMENT OF ENERGY, MISSISSIPPI POTASH INC., and IMC Kalium. This Agreement provides for mine operators having two mine rescue teams available whenever miners are underground, and backup rescue capability is deemed desirable.

- MEMORANDUM OF UNDERSTANDING: EMERGENCY RADIOLOGICAL TREATMENT CENTER FOR THE WASTE ISOLATION PILOT PLANT PROJECT BETWEEN THE U.S. DEPARTMENT OF ENERGY AND GUADALUPE MEDICAL CENTER. (The name of the medical center has been changed to Carlsbad Medical Center.) This MOU provides for an

Emergency Radiological Treatment Center (ERTC) at the GUADALUPE Medical Center.

- MUTUAL AID AGREEMENT BETWEEN THE CITY OF CARLSBAD AND THE U.S. DEPARTMENT OF ENERGY. This Agreement authorizes assistance in times of declared emergency where the enormity of the emergency exceeds the response capability of the responsible jurisdiction.

- MUTUAL AID AGREEMENT BETWEEN THE CITY OF HOBBS AND THE U.S. DEPARTMENT OF ENERGY. This Agreement authorizes assistance in times of declared emergency where the magnitude of the emergency exceeds the response capability of the responsible organization.

- INTERAGENCY AGREEMENT BETWEEN THE U. S. BUREAU OF LAND MANAGEMENT AND THE U. S. DOE, AND THE U. S. NATIONAL PARK SERVICE (NPS), AND THE U. S. FOREST SERVICE. This Agreement provides for assistance in search and rescue missions and training.

- MEMORANDUM OF UNDERSTANDING BETWEEN U.S. DOE AND LEA REGIONAL HOSPITAL (L. H.). This MOU provides for an Emergency Radiological Treatment Center (ERTC) at LEA REGIONAL HOSPITAL.

8.5.4.6 Training and Exercises

Emergency management training consists of formal classroom instruction, self-paced training modules, on-the-job training, drills and exercises. This training allows all emergency management related participants to function safely and skillfully. Individuals participating in these areas must be trained before they are allowed to assist in emergencies.

The Emergency Management Section has developed a procedure for the effective management of drills and exercises. A coordinated program of drills and exercises enhances the ability of specialized teams and individual personnel to respond to potentially adverse situations. The Emergency Management Section conducts a variety of drills and exercises.

A full participation exercise is conducted periodically to demonstrate an integrated emergency response capability. The integrated exercise includes Federal, state, local, regulatory, and/or emergency response organizations which may include DOE/HQ, DOE/AL, and CAO participants.

8.5.4.7 Reentry and Recovery

Guidance for the reentry and recovery following an emergency is based on regard for human life, and conditions existing at the time. The recovery process detailed in WP 12-ER3903, Event Recovery,[15] evaluates the proposed actions by comparing the risks of the hazards to the actual or potential benefits to be gained.

References for Section 8.5

1 WP 12-9, WIPP Emergency Management Program, Rev. 11, February 14, 1997.

2 WP 02-12, WIPP Contingency Plan, Rev. 6, March 11, 1999.

3 WP 12-ER, Emergency Response Procedures.

4 DOE Order 151.1, Comprehensive Emergency Management System, October 26, 1995.

5 DOE Order 232.1 , Occurrence Reporting and Processing of Operations Information, September 25,1995.

6 40 CFR 264, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, June 1993.

7 40 CFR 265, Subpart D, Contingency Plan and Emergency Procedures, May 1980.

8 40 CFR 265.37, Arrangements with Local Authorities, May 1980.

9 40 CFR 265.52 (c), Content of Contingency Plan, May 1980.

10 WP 12-ER3904, Categorization and Classification of Operational Emergencies, Rev. 1, March 31, 1997.

11 International Commission on Radiation Protection-30, 1979 to 1982.

12 WP 12-RE3000, Radiological Engineering Activities, Rev. 3, April 25, 1997.

13 Protocol for providing Effluent Monitoring System Filters to the New Mexico Environment Department and the Environmental Evaluation Group, November 1992.

14 WP 12-HP3500, Airborne Radioactivity, Rev. 3, April 7, 1999.

15 WP 12-ER3903, Event Recovery, Rev. 1, March 21, 1997.

16 29 CFR 1910.120, Paragraph (p), Certain Operations Conducted Under the Resource Conservation and Recovery Act of 1976 (RCRA).

This page intentionally left blank

8.6 Security

8.6.1 Introduction

This section describes the measures taken at the Waste Isolation Pilot Plant (WIPP) during the Disposal Phase to prevent hazards. It describes the security equipment and procedures in place at the WIPP facility that continuously monitor and control entry into the active portion of the facility or Property Protection Area (PPA), as described in Chapter 2, including 24-hour security surveillance, fencing, and signs.

8.6.2 Security Procedures and Equipment

The design and operation of the WIPP facility are specifically planned to fully meet security requirements. The WIPP facility has 24-hour security surveillance, and the means to control entry to the PPA. In addition, warning signs are provided.

8.6.3 24-Hour Surveillance Systems

The WIPP facility's 24-hour surveillance system consists of security officers that provide protection 24 hours per day, 365 days per year. Security officers work to written procedures that require visitors, contractors, and vendors to log in before they are allowed to proceed to the Main Gate for access into the PPA, and require continuous monitoring of the active portion of the facility.

The major duties of the security officers are to control personnel, vehicle, and material access/egress 24 hours per day, 365 days per year. During non-operational hours, the security officers conduct documented security patrols outside of the PPA, at a minimum rate of two per 12-hour shift, as well as inside of the PPA at a rate of one every two hours. In addition to the security officers, WIPP facility employees are called upon to challenge any person in the WIPP facility who is not wearing a badge, or who is not under escort when an escort is required. Further physical protection is provided by fences, protective lighting, and locked buildings.

8.6.4 Barrier and Means to Control Entry

8.6.4.1 Barrier

The surface portion of the WIPP facility PPA is contained within a 35 acre (14 hectares) fenced area. This area is surrounded by a permanent 7 ft (2.13 m) high chain-link fence, topped by three strands of barbed wire, for a total height of 8 ft (2.44 m). The fence encloses major surface structures. The regularly inspected chain-link fencing at the WIPP facility completely surrounds the active portions of the facility. Access is normally through the Main Gate on the west side of the PPA. Two other gates are available for emergency use. One of these gates is opened to allow salt trucks access to the salt pile. Use of all gates is under the supervision of security.

8.6.4.2 Means to Control Entry

Entry into the PPA, whether by personnel or vehicles, is through controlled gates and doors. WIPP-facility access-control procedures are designed to ensure that only properly identified and authorized persons, vehicles, and property are allowed entrance to and exit from the facility. A personnel identification and access control system is maintained within the facility. Employees identify themselves with an identification badge when entering or leaving the premises. Security officers require visitors to show proper authorization before allowing them to enter the facility. In addition, visitors are required to wear a temporary badge, and may require an authorized escort.

8.6.5 Warning Signs

The permanent chain-link fence surrounding the PPA is posted at approximately 50 ft (15.24 m) intervals with DOE "No Trespassing" signs, and with "Danger: Authorized Personnel Only" signs in English and Spanish. The signs are legible from a distance of 25 ft (7.62 m), and can be seen from any approach to the facility. These same signs, plus security and traffic signs, are also located on the controlled gates.

QUALITY ASSURANCE
TABLE OF CONTENTS

This page intentionally left blank

QUALITY ASSURANCE

This chapter describes the essential features of the Westinghouse Waste Isolation Division (WID) Quality Assurance Program (QAP) and the Quality Assurance (QA) requirements which affect the safety of the Waste Isolation Pilot Plant (WIPP). The essential features described include:

- QA requirements imposed on WIPP
- QA Program and Organization
- Personnel Training and Qualification
- Quality Improvement processes
- Document Control
- Quality Assurance Records
- Work Processes
- Design
- Procurement
- Inspection and Acceptance Testing
- Assessment Processes

9.1 Introduction

This chapter is organized to provide a description of general, management, performance, and assessment quality assurance (QA) requirements based on the graded approach that applies to all items and activities at the WIPP. The WID will maintain complete and accurate records as necessary to substantiate its compliance with the requirements.

This page intentionally left blank

9.2 General Requirements

To provide a comprehensive QA program, Title 10 CFR 830.120,[1] *Quality Assurance Requirements,* provides 10 general quality assurance requirements, which are presented in the following three categories; management, performance, and assessment. Additionally, the Environmental Protection Agency (EPA) has further imposed the QA requirements through Title 40 CFR 194.5,[2] Publications Incorporated by Reference. The EPA requires that the QA Program also address sampling, scientific investigations, and software quality requirements. The WID Quality Assurance Program Description (QAPD)[3] meets the requirements of both DOE and the EPA. The specifics of the QA Program are accomplished by using the following sources of QA requirements of the 1989 edition of ASME NQA-1,[4] ASME NQA-2, Part 2.7,[5] ASME NQA-3,[6] 10 CFR 71 Subpart H,[7] and others as reflected in the CAO QAPD, CAO-94-1012.[8] Application of requirements is based on the minimization of risk to the general public, facility personnel, environment, and facility.

This page intentionally left blank

9.3 Management

9.3.1 Program

The requirements and guidance contained in the WID QAPD[3] are based on the principle that work shall be planned, documented, performed under controlled conditions, and periodically assessed to establish work item quality, process effectiveness, and promote improvement. The requirements described in this document reflect the responsibilities assigned to management and personnel of all WID departments and their responsibility for planning, achieving, verifying, and assessing quality and promoting continuous improvement. The Quality Assurance Program delineates the quality contributions of all personnel and encourages their active participation in accomplishing the WID's quality objectives.

Effective implementation of the WID QA program is dependent on the efforts of all levels of the WID organization. The organization is structured such that the individual performing the work is responsible for achieving and maintaining quality; line management is responsible for verifying the quality; and an independent assessor is responsible for independently assessing the quality of the work. Active participation by all personnel is required to accomplish the WID's quality objectives. Quality Assurance Programs, a section of the Quality Assurance (QA) Department, is responsible for defining, integrating, and ensuring effective implementation of QA activities. The WID has applied a graded approach for the application of QA requirements to the WID Quality-affecting activities. All quality-affecting activities performed by the WID will be subjected to all applicable QA requirements.

During the design and construction phase of the WIPP, the QA program was based on ANSI/ASME NQA-1-1979,[9] basic and supplementary requirements. Therefore, the WIPP Design Class system, showing a graded approach to application of the QA requirements for design and construction of WIPP systems, also reflects ANSI/ASME NQA-1-1979.[9]

9.3.2 Organization

The QA Department Manager reports directly to the WID General Manager, and is authorized to establish QA policy and ensure its effective implementation. The QA Department's primary responsibility is the QA oversight of WIPP activities, including verification of adequate QA Program implementation through audit, surveillance, inspection, and assessment; and review of purchase requisitions, design documents, and work packages. The purpose of specifying requirements and associated guidance for a quality assurance program is to ensure that the WID develops and implements an effective QA management system and this management system meets or exceeds the requirements.

Independence of QA personnel in QA oversight of WID activities is assured in two ways:

- The QA Department Manager reports directly to the WID General Manager
- QA is the only function of QA personnel (other than miscellaneous administrative duties)

9.3.3 Personnel Training and Qualification

Personnel performing work will be qualified and capable of performing their assigned tasks. Management shall establish methods for the evaluation, selection, indoctrination, training, and qualification of personnel performing work and qualification requirements will be commensurate with the functions associated with the work performed. An evaluation of experience and educational requirements are assured through the manager's and the hiring authority's position interview and will be documented for position justification.

Training shall emphasize correct performance of work, provide a description of why quality and nuclear safety requirements exist, and describe the fundamentals of the work and its context. Training shall be subject to ongoing review to determine instruction and program effectiveness.

9.4 Quality Improvement

The focus of quality improvement is to reduce the variability of every process influencing the quality of the product. Management at all levels is to be involved in the quality improvement process to ensure that proper focus is given, adequate resources are allocated, and difficult issues are resolved. Quality improvement programs in place include the work authorization program, the process improvement program, and the corrective action program:

- The work authorization program ensures the work is performed under controlled conditions, and that items are maintained to prevent their damage, loss, or deterioration.

- The process improvement program encourages all personnel to identify and suggest improvements.

- The corrective action program provides for correction of adverse conditions and actions to prevent recurrence.

All employees have the responsibility and authority to request that any activity that appears to be unsafe be suspended until the unsafe condition is resolved. Appropriate corrective actions are required to address the following:

- Determine the root cause of the problem
- Resolution of the initial problem
- Describe actions to preclude recurrence of the problem
- Identify the impact of the problem on related items or activities
- Forecast completion dates for the required actions and the individuals responsible for follow-up

The extent of the root cause analysis for nonconforming items and processes is commensurate with the importance or significance of the problem. A condition adverse to quality requires a statement of the probable cause, and a significant condition adverse to quality requires a formal root cause analysis. In addition, all nonconforming items are identified and controlled to prevent inadvertent use. Corrective actions will be implemented in a timely manner and verification/validation will include evaluation of the effectiveness of the actions taken.

This page intentionally left blank

9.5 Documents and Records

The scope of the document control system includes drawings, specifications, system design descriptions, plans, procedures, and instructions. Management shall identify the individuals or organizations responsible for the preparation, review, and approval of controlled documents. The processes for the distribution and use of controlled documents and forms that document or prescribe work shall be reviewed for adequacy, correctness, and completeness prior to approval and issuance and are controlled as follows:

- Documents used to perform work are available to personnel for use at the work location
- Effective dates are established and placed on approved documents
- Major changes shall be reviewed and approved by the same organizations that performed the original review and approval unless other organizations are specifically designated. Minor changes to documents, such as inconsequential editorial corrections, shall not require that the revised documents receive the same review and approval as the original documents.
- Obsolete or superseded documents and forms are controlled to avoid their inadvertent use
- Controls are established and maintained to identify the current status/revision of controlled documents and forms.

9.5.1 Quality Assurance Records

Quality assurance records are completed documents (regardless of medium) that furnish evidence of the quality of items and/or activities affecting safety or waste isolation.

Quality assurance records are identified, prepared, collected, stored, maintained, and dispositioned by all WID departments involved in the performance or control of quality-related activities. Quality assurance records provide documentary evidence that activities are adequately controlled and that associated parts, components, systems, facilities, and services comply with applicable requirements. Requirements and responsibilities for quality assurance record transmittal, distribution, retention, maintenance, disposition, and retrievability are established and documented. All records will follow the guidelines of the Records Inventory and Disposition Schedule for storage and disposition. The records storage arrangements shall provide adequate protection of records to preclude damage from moisture, temperature, rodent infestation, excessive light, electromagnetic fields, or stacking as deemed appropriate for the type of record being stored.

This page intentionally left blank

9.6 Performance

9.6.1 Work Processes

Work shall be performed to established, approved, and documented technical standards and administrative controls, and under controlled conditions using approved instructions, procedures, drawings, or other appropriate means. Equipment/systems shall be identified and controlled to ensure their proper use, and maintained to prevent their damage, loss, or deterioration. Equipment used for process monitoring or data collection shall be calibrated and maintained. Requirements and responsibilities are as follows:

9.6.1.1 Work

Personnel performing work are responsible for the quality of their work. Because the individual worker is the first line in ensuring quality, personnel will be knowledgeable of requirements for work they perform and the capability of the tools and processes they use. Line managers will ensure that personnel working under their supervision are qualified and are provided the necessary training, resources, and administrative controls to accomplish assigned tasks. Criteria describing acceptable work performance shall be defined for the worker. Line managers will periodically assess work and related information to ensure that the desired quality is being achieved, and to identify areas needing improvement. Work shall be planned, authorized, and accomplished under controlled conditions using technical, quality, and implementing procedures commensurate with the complexity and risk of the work.

9.6.1.2 Implementing Procedure

Implementing procedures shall be reviewed, approved, and controlled. Implementing procedures shall be developed, reviewed, and validated by technically competent personnel, and approved by authorized personnel. Administrative process procedures may not require validation. Work process parameters are controlled in accordance with approved instructions or procedures that abide by established technical standards and administrative controls. In addition, conditions necessary for accomplishment of work processes are also listed in procedures or instructions. These conditions include proper equipment, controlled parameters of the process (such as temperature, pressure, flow rate, etc.), and calibration requirements. Specified environmental conditions (e.g., atmospheric conditions, moisture content levels, temperature, etc.) are required to be maintained and specified in the implementing procedure.

9.6.1.3 Item Identification and Control

The identification of items will be maintained to ensure appropriate traceability. Traceability requirements shall be specified in design documents or supporting implementation procedures. Processes will be established and implemented to control consumables and items with limited operating or shelf life, and prevent the use of incorrect or defective items. Marking and labeling of items is done at the time of receipt through installation or end use. Records shall be maintained to ensure that the item can be traced at all times - from its source, through the item's installation or end use. The status of inspections, tests and special controls to preserve its integrity shall be identified either on the item(s) or in documents traceable to the item(s).

9.6.1.4 Handling, Storage, and Shipping

Handling, storage, cleaning, shipping, and other means of packaging, transporting, or preservation of quality-affecting items shall be conducted in accordance with established work and inspection implementing procedures, shipping instructions, or other specified documents. If required for protection or maintenance of particular items, special equipment (such as containers, shock absorbers, and accelerometers), and special protective environments (such as inert gas and specific moisture and temperature levels) shall be specified, planned for, and provided.

Measuring and Test Equipment (M&TE) used in the collection of monitoring data for the establishment of test conditions and the collection of general data is calibrated, adjusted, and maintained at prescribed intervals, or prior to use, against certified equipment having known valid relationships to nationally recognized standards.

9.6.2 Design

Items and processes shall be designed using sound engineering/scientific principles and appropriate standards. Design work, including changes, shall incorporate appropriate requirements such as general design criteria and design bases. Design interfaces shall be identified and controlled. The adequacy of design products shall be verified by individuals or groups other than those who performed the work. Verification work shall be completed before approval and implementation of the design. In establishing design controls, management is responsible to ensure that design inputs are technically correct; that design interfaces are identified; that authorities, responsibilities, and lines of communication are clearly defined; and that the design processes clearly define the acceptance criteria for the product.

Applicable design inputs will be controlled by those responsible for the design. The design process shall be controlled by the Design Classification System, as defined in Section 3.1.3.1 of the SAR. All design analysis shall be planned, controlled, and documented so that the originator and reviewer can be identifiable for each subject. Also, computer software used to perform design analyses shall be developed and qualified. Design interfaces shall be identified and controlled so that efforts are coordinated among affected organizations.

Design verification shall be performed using one or a combination of the following methods: design review, alternate calculations, or qualification testing. Design verification takes place prior to release for procurement or manufacture, construction, or to another organization for use in other design work: and, shall be completed before relying on the item to perform its function, equipment operation, or experimentation. Design verification is performed by qualified individuals other than those who performed the design. Formal design review processes have been established at the WID that independently verify compliance of the design with applicable requirements specified in design input documents. Assumptions, design method, and output will be compared and considered to disclose any discrepancies. Alternative calculations are calculations or analysis that are made with alternate methods to verify correctness of the original calculations or analyses. Qualification testing will demonstrate the adequacy of performance under conditions that simulate the most adverse design conditions on all components of the system or structure. All changes to existing designs must undergo design verification, and be approved by the same groups or organizations that reviewed and approved the original design documents.

9.6.3 Procurement

Procurement planning, development of documentation, selection of suppliers and evaluation of supplier performance are the elements of procurement control implemented for WIPP items and services. Purchased items and services are accepted using specified methods such as: review of manufacturing process control data, source verification, receipt inspection, preinstallation and postinstallation tests, certificates of conformance, or a combination of these methods. Non-conformances consist of one or more of the following: a technical or material requirement is violated; a requirement in a WID-approved supplier document is violated; the deficiency cannot be corrected by continuation of the original manufacturing process or by rework; the item or service does not conform to the original requirement. Methods for disposition of supplier non-conformances must contain provisions for (a) through (e) below:

(a) Submittal of notice of non-conformance by the WID
(b) Evaluation of non-conformances
(c) WID approval of supplier-recommended disposition
(d) Verifying implementation of the approved disposition
(e) Maintenance of records of supplier-submitted non-conformances

Supplier selection shall be based on an evaluation of the supplier's capability to provide items or services in accordance with procurement document requirements that identify the organizational responsibilities for determining the source selection based on the design class and supplier selection, as defined in Section 3.1.3.1 of the SAR, and the risks associated with the end use of the product/service.

9.6.4 Inspection and Acceptance Testing

Inspections, tests, or surveillances required to verify conformance of an item or activity to specified requirements are planned and executed. Characteristics to be inspected, and inspection methods to be employed, are required to be specified, and results documented. Inspection or tests for acceptance are performed by qualified personnel other than those who performed or directly supervised the work. Results are documented, and conformance to acceptance criteria is evaluated. Test procedures are required to include or reference test objectives, and provisions for ensuring that prerequisites for the given test have been met, that adequate instrumentation is available and used, that necessary monitoring is performed, and that suitable environmental conditions are maintained. Test results are evaluated by a responsible authority to ensure that those test requirements have been satisfied. Tools, gauges, instruments, and other M&TE used for quality affecting activities are controlled, and are calibrated and adjusted to maintain accuracy within necessary limits and at specified periods. The status of inspection, test, and operation activities is required to be identified either on the items, or in documents traceable to the items to ensure that required inspections and tests are performed, and to ensure that items that have not passed the required inspections and tests are not inadvertently installed, used, or operated. In addition, a nonconformance program is in place to ensure correction of adverse quality conditions and promote improvement.

9.6.5 Assessment

9.6.5.1 Management Assessment

The overall goal for the performance of planned and periodic management assessment is quality improvement. The WID management assessment process involves all levels of management: first-line (group) managers, intermediate (section) managers, senior management, and the General Manager's Office. Senior management directly participates in management assessment in the evaluation of identified areas for quality improvement from two separate sources, including self-assessments performed by line management, and independent assessments of the activities performed by the QA department. Management assessments focus on the identification and resolution of management issues and problems. Problems that hinder the organization from achieving its objectives shall be identified and corrected. Effective management assessments evaluate such conditions as the state of employee knowledge, motivation, and morale; the amount of mutual trust and communication among workers and organizations; the existence of an atmosphere of creativity and improvement; and the adequacy of human and material resources. Once areas for improvement are positively identified and documented, senior management directs the implementation of preventive or corrective actions.

9.6.5.2 Independent Assessment

The WID independent assessment program includes surveillances and audits. Independent assessment is conducted to evaluate compliance with applicable QAP requirements and implementing procedures, as well as the effectiveness of the overall quality program. Such assessments are performed as an administrative control for activities carried out to comply with the Technical Safety Requirements (TSRs), as described in Chapter 6. Independent assessment is also used to provide independent oversight of self-assessment performed by WID line management. For audits only, an audit plan shall be developed and documented for each audit. The audit plan shall include the scope, purpose, audit personnel, organizations to be notified, and schedule. This plan shall include the scope, purpose, assessment personnel, work to be assessed, organizations to be notified, and schedule. Assessments shall include technical evaluations of the applicable procedures, instructions, activities, and items. The scope will include the work to be assessed and corrective actions taken since the previous assessment. Assessment team members will be selected on the basis of technical qualification, knowledge of the item and/or process being assessed and shall be independent from the items and/or processes being assessed. An assessment team leader is appointed to indoctrinate and supervise the team, organize and direct the assessment and coordinate the preparation and issuance of the assessment report. The technical specialists selected for independent assessment assignments shall be indoctrinated by the team leader commensurate with the scope, complexity, or special nature of the work being assessed. In addition they shall be trained to the requirements of the assessment process associated with their duties. The independent assessment report shall be prepared by the assessment team leader, and issued to the management of the assessed organization and any affected organizations. Results from independent assessments are transmitted to senior management as input for determination of the effectiveness of the integrated QA program. In this regard, personnel performing independent assessments act in a management advisory function.

References for Chapter 9

1. 10 CFR 830.120, Quality Assurance Requirements, 1999.
2. 40 CFR 194.5, Publications Incorporated by Reference, 1998.
3. WP 13-1, WID Quality Assurance Program Description.
4. ASME NQA-1, Quality Assurance Program Requirements for Nuclear Facilities, 1989.
5. ASME NQA-2A-1990 Addenda, Part 2.7, Quality Assurance Program Requirements of Computer Software for Nuclear Facility Applications.
6. ASME NQA-3, Quality Assurance Program Requirements for the Collection of Scientific and Technical Information for Site Characterization of High-Level Nuclear Waste Repositories, 1989.
7. 10 CFR 71, Subpart H, Quality Assurance, 1999.
8. CAO-94-1012, Rev. 2, U.S. Department of Energy Carlsbad Area Office Quality Assurance Program Description, September 1998.
9. ANSI/ASME NQA-1-1979, Quality Assurance Program Requirements for Nuclear Facilities, 1979.

This page intentionally left blank

DECONTAMINATION AND DECOMMISSIONING
TABLE OF CONTENTS

SECTION TITLE PAGE NO.

This page intentionally blank

DECONTAMINATION AND DECOMMISSIONING

10.1 Introduction

The WIPP facility is currently scheduled for a 35 year disposal phase,[1] and will be decommissioned after waste emplacement is completed. Lacking further requirements to operate the WIPP facility, decontamination of the facility to acceptable contamination and radiation levels in conjunction with facility decommissioning will be performed. The ongoing performance assessment documented in (Chapter 3) of SAND 92-0700/1-UC-791[2] is designed to determine the acceptability of the WIPP facility and surrounding site by showing compliance with the requirements of 40 CFR 191, Subpart B.[3] Sections 10.1 through 10.5 are written with the assumption that the WIPP facility is shown to be acceptable as a repository, and, therefore, decommissioning activities begin near the end of its operational life.

Some postoperational requirements exist for the WIPP facility in 40 CFR 191, Subpart B.[3] These "Assurance Requirements," developed by the Environmental Protection Agency (EPA), ensure that cautious steps are taken by the implementing agency (in this case, the DOE) to reduce the uncertainties in projecting the behavior of the natural and engineered components for many thousands of years. The application of these assurance requirements to the WIPP facility is described in detail in DOE/WIPP 91-029.[4]

Decommissioning requirements applicable to the WIPP facility are included in DOE O 430.1A,[5] Life-Cycle Asset Management (previously included in DOE Order 5820.2A[6] and DOE Order 6430.1A.[7]) Additional requirements are included in the Resource Conservation and Recovery Act (RCRA) as implemented in 40 CFR Part 264[8] and Title 20 of the New Mexico Administrative Code, Part 4.1, Subpart V[9] The Closure/Post Closure Plan[10] implements RCRA regulations.

This page intentionally blank

10.2 Decontamination and Decommissioning

The WIPP facility has been designed and will be operated in a manner that will allow ease of decontamination and decommissioning (D&D). Actual D&D activities will be initiated prior to the cessation of WIPP facility operation as required by the WIPP Land Withdrawal Act.[11] At the completion of WIPP facility operations, the facility will consist of surface structures, shafts, and subsurface structures. The overall goal is to restore the surface area now housing the WIPP facility to essentially preconstruction and preoperational conditions. Surface radiological levels shall be returned to levels commensurate with regulatory guidelines. Records of the project shall be listed in the public domain and monuments or markers shall exist at the site to inform future generations of the presence of the WIPP repository (Section 10.4).

10.2.1 Decontamination and Decommissioning Design Features

During the design phase of the facility, general guidance from former DOE Order 6430.1[12] was followed to design and construct the facility. This guidance incorporated structural and internal features that would facilitate the safe and economical decontamination and decommissioning of the facility. To the extent practical, the following features and measures have been incorporated into the WIPP facility design:

- coatings provide easily cleanable surfaces
- cracks, crevices, and joints are sealed to prevent contamination spread to inaccessible areas
- exhaust filters at points of potential contamination minimize contamination of long sections of duct work and downstream exhaust equipment
- architectural or structural features allow the dismantlement and removal of equipment from areas of contamination or potentially high radiation levels to other areas for decontamination, maintenance, or repair.

10.2.2 Decontamination and Decommissioning Activities

Decontamination and decommissioning activities will involve three primary areas: surface structures, subsurface structures, and the shafts. Detailed planning for these activities will begin several years prior to their actual initiation and will incorporate currently available technologies and prescribed decontamination limits.

Surface structures will be decontaminated in accordance with current guidelines, and dismantlement of the buildings will be established in the decommissioning plan.

Decontamination operations and surveillance checks will be conducted during the decommissioning phase, demonstrating that personnel and public exposure limits are maintained as low as reasonably achievable and within the limits of 10 CFR 835, Occupational Radiation Protection.[13]

Since safety is of paramount importance, potentially hazardous operations will not begin until precautions are taken against the release of contamination. These precautions include development of decontamination plans, decontamination procedures, and safety analysis.

Decontamination is defined as the removal or reduction of radioactive or hazardous contamination from facilities, equipment, or soils by washing, chemical or electrochemical action, mechanical cleaning or other techniques to achieve a stated objective or end condition. The policy at the WIPP will be to decontaminate as many areas as possible, consistent with radiation protection policy. Decontamination is part of all closure activities and is a necessary activity in the clean closure of the surface container management units.

Decommissioning includes surveillance and maintenance, decontamination, and dismantlement. These actions are taken to retire the facility from service with adequate regard for the health and safety of workers and the public and protection of the environment. Decommissioning is part of final facility closure only, and will involve the removal of equipment, buildings, closure of the shafts, and establishing active and passive institutional controls for the facility. The ultimate goal of decommissioning is unrestricted release or restricted use of the surface.

The objective of D&D activities at the WIPP facility is to return the surface to as close to the preconstruction condition as reasonably possible, while protecting the health and safety of the public and the environment. D&D activities are discussed in the Conceptual Decontamination and Decommissioning Plan for the Waste Isolation Pilot Plant (DOE/WIPP 95-2072).[14] Major activities planned to accomplish this objective include, but are not limited to the following:

1. Review of operational records for historical information on releases
2. Visual examination of surface structures for evidence of spills or releases
3. Performance of site contamination surveys
4. Decontamination, if necessary, of usable equipment, materials, and structures including surface facilities and areas surrounding the Waste Handling Building (WHB).
5. Disposal of equipment/materials that cannot be decontaminated but that meet waste acceptance criteria in an Hazardous Waste Management Unit (HWMU)
6. Dismantling of surface facilities
7. Dismantling of underground facilities at the time the panels are closed
8. Emplacement of final panel closure system
9. Emplacement of fill material in the underground, if required
10. Emplacement of shaft seals
11. Regrading the surface to approximately original contours
12. Initiation of active controls which includes monitoring and installation of the Permanent Marker System

These activities, in addition to common techniques such as visual inspection and records, will be performed using the best technology available at the time of closure, and will be conducted in a manner that maintains personnel exposure to radiation levels as low as reasonably achievable and exposure to hazardous constituents to levels deemed acceptable by the DOE. This Closure Plan will be amended prior to the initiation of closure activities to specify the D&D methods to be used.

Health and Safety

Before final closure activities begin, health physics personnel will conduct a hazards survey of the unit(s) being closed. A release of radionuclides could also indicate a release of hazardous constituents, in accordance with co-detection principles. If radionuclides are not detected, sampling for hazardous constituents may still be performed if there is evidence that a spill or release has occurred. The purpose of the hazards survey will be to identify potential contamination concerns that may present hazards to workers during the closure activities, and to specify any control measures necessary to reduce worker risk. This survey will provide the information necessary for the health physics personnel to identify the worker qualifications, personal protective equipment, safety awareness, work permits, exposure control programs, and emergency coordination that will be required to perform closure related activities.

This page intentionally blank

10.3 Closure, Monuments, and Records

A record of the WIPP Project shall be listed in the public domain. Active access controls will be employed for at least the first 100 years after the final facility closure. In addition, a passive control system consisting of monuments or markers shall be erected at the site to inform future generations of the WIPP repository location.

Closure of the WIPP facility will result in the following:

- Shafts will be closed and sealed, minimizing the intrusion of fluids into the repository.

- Human intrusion after closure will be unlikely.

- Physical and environmental surveillance can be minimized.

Substantial permanent monuments will identify the WIPP facility. The location of these markers will be established in detail by the decommissioning plan. The markers will contain site description, date of closure, land survey data, and other information required by applicable regulations.

Detailed records shall be filed with local, state, and federal government agencies to ensure that location of the WIPP facility is easily determined. This information together with land survey data will be on record with the United States Geological Survey and other agencies as provided by the decommissioning plan. The DOE will maintain permanent administrative authority over those aspects of land management assigned by law (i.e., by the permanent withdrawal legislation).

This page intentionally blank

10.4 Post Closure Surveillance

Although the Federal Government (initially DOE) could maintain the staffing to conduct periodic surveillance of the site, a contractual arrangement with a local law enforcement or security agency would provide some distinct advantages. Among the advantages are:

- Training in patrol and surveillance activities.
- Authorization to arrest members of the general public who are found to be violating trespassing laws
- The liability associated with apprehension, attempted apprehension, or circumstances arising from attempts would remain with the law enforcement or security agency

Surveillance will consist of drive-by patrolling around the fenced perimeter, 2-3 times per week. In the course of the patrol, particular note shall be taken of the fence integrity. In addition, the locked condition of each gate shall be checked to ensure that gate integrity is maintained and there is no evidence of tampering. Surveillance should also include visual examination of the entire enclosed area for any signs of human activity. A routine summary of each month's surveillance activity shall be prepared documenting the day and time of each patrol and any unusual circumstances that may have been observed. This surveillance routine could continue throughout the active control period and for at least 100 years following the sealing of the shafts.

Upon commencement of construction of the Permanent Marker System, a routine presence at the site will once again be established and periodic surveillance will not be necessary. Once the Permanent Marker System is completed, the active controls program and access control measures will be evaluated and changes necessitated by construction of the Permanent Marker System will be made and implemented for the remainder of the active controls period. With construction of the Permanent Marker System, easy visual inspection of the repository footprint may be curtailed. The berm is an imposing feature which would require it to be scaled in order to achieve an unobstructed view of the footprint. The DOE could defer construction of the Permanent Marker System decades after completion of decommissioning. Due to filling of the repository and extensive decommissioning, maintenance of the physical security of the WIPP facility after closure can be minimized. The physical surveillance requirements will be provided in the final decommissioning plan.

Environmental surveillance after closure will include appropriate radiation monitoring, soil, vegetation, water, and wildlife sample analysis. Frequency and duration of the environmental surveillance program will be defined in the final decommissioning plan as prescribed by standards applicable at the time.

References for Chapter 10

1. DOE/NTP-96-1204, The National Transuranic Waste Management Plan, Rev. 0, September 1996.

2. SAND 92-0700/1-UC-791, Preliminary Performance Assessment for the Waste Isolation Pilot Plant, Volume 1: Third comparison with 40 CFR 191, Subpart B, December 1991.

3. 40 CFR 191, Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-level and Transuranic Radioactive Wastes, U.S. Environmental Protection Agency, September, 1985.

4. DOE/WIPP 91-029, Implementation of the Resource Disincentive 40 CFR Part 191.14(e) at the Waste Isolation Pilot Plant, Rev. 1, June, 1993.

5. DOE O 430.1A, Life-Cycle Asset Management, August 1995

6. DOE Order 5820.2A, Radioactive Waste Management, September 26, 1988.

7. DOE Order 6430.1A, General Design Criteria, April 1989 (For reference only, superceded by DOE O 420.1 and DOE O 430.1A).

8. 40 CFR Part 264, Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities, U.S. Environmental Protection Agency, May 19, 1980 and subsequent amendments.

9. Title 20 of the New Mexico Administrative Code, Part 4.1, Subpart V.

10. Closure and Post Closure Plans, Waste Isolation Pilot Plant, Carlsbad, New Mexico, Westinghouse Electric Corp., August 1988.

11. Public Law 102-579, Waste Isolation Pilot Plant Land Withdrawal Act.

12. Former DOE Order 6430, General Design Criteria Manual for Department of Energy Facilities, June 10, 1981 draft (For reference only, superceded by DOE O 420.1 and DOE O 430.1A).

13. 10 CFR 835, Occupational Radiation Protection, December 14, 1993.

14. DOE/WIPP 2072, Conceptual Decontamination and Decommissioning Plan for the Waste Isolation Pilot Plant, January 1995.

APPENDIX A
Waste Container Inventory Calculations

Table A-1, Summary of Final Waste Forms to be Disposed at the Waste Isolation Pilot Plant

Query of TWBIR, 20 June 1996 — Reported Total Volume of TRU/MTRU Waste Summarized by Final Waste Form					Totals for all Stored TRU Waste Final Waste Forms — See Table A-2 for Individual Waste Stream Data				Distribution of Radionuclide Concentrations of Stored TRU Waste *PE-Ci concentrations are waste stream averaged						
									Overall Average PE-Ci /Drum	Not to be Processed/Repackaged Before WIPP Disposal			To be Processed/Repackaged Before WIPP Disposal		
Final Waste Form Consolidated by Generator Site	Stored Volume, m³	Projected Volume, m³	Anticipated Inventory, m³	Scaled Volume, m³	Equivalent[1] Number 55 Gal Drums	Percent of Total Volume	Total PE-Ci	Percent of Total PE-Ci		PE-Ci* < 8	8 < PE-Ci* < 20	20 < PE-Ci*	PE-Ci* < 8	8 < PE-Ci* < 20	20 < PE-Ci*
Combustible	**5,775**	**4,530**	**10,304**	**35,309**	**27,763**	**9.9%**	**52,857**	**4.3%**	**1.9**	**14.6%**	**0.5%**	**0.1%**	**83.0%**	**1.9%**	**0.0%**
IN	3,305	0	3,305	3,305	15,889	5.6%	13,634	1.1%	0.9	2.7%	0.7%		94.0%	2.6%	
LA	1,821	2,376	4,198	17,315	8,757	3.1%	34,025	2.8%	3.9	16.3%			83.7%		
MD	7	0	7	7	34	0.0%	377	0.0%	11.1	55.9%	23.5%	20.6%	0.0%	0.0%	0.0%
RF	186	906	1,092	6,094	892	0.3%	3,765	0.3%	4.2	47.5%	0.0%	1.1%	39.0%	12.3%	0.0%
RL	456	1,247	1,703	8,588	2,191	0.8%	1,055	0.1%	0.5	79.6%			20.4%		
Filter	**218**	**556**	**774**	**3,845**	**1,048**	**0.4%**	**7,217**	**0.6%**	**6.9**	**60.5%**	**31.4%**	**1.2%**	**6.6%**	**0.0%**	**0.3%**
IN	131	0	131	131	630	0.2%	3,355	0.3%	5.3	97.2%		2.0%	0.3%		0.5%
LL	16	32	48	226	75	0.0%	47	0.0%	0.6	10.4%			89.6%		
MD	1	0	1	1	4	0.0%	1	0.0%	0.1	100.0%			0.0%		
RF	71	524	595	3,487	340	0.1%	3,815	0.3%	11.2	2.9%	97.1%		0.0%	0.0%	
Graphite	**512**	**47**	**559**	**817**	**2,461**	**0.9%**	**3,668**	**0.3%**	**1.5**	**22.3%**	**2.7%**		**75.0%**	**0.0%**	
IN	498	0	498	498	2,395	0.9%	3,016	0.2%	1.3	22.8%	0.2%		77.0%	0.0%	
RF	14	47	61	319	66	0.0%	652	0.1%	9.9	4.5%	95.5%		0.0%	0.0%	
Heterogeneous	**23,016**	**4,009**	**27,025**	**49,157**	**110,655**	**39.3%**	**440,870**	**36.2%**	**4.0**	**5.7%**	**0.0%**	**0.0%**	**82.8%**	**5.7%**	**5.8%**
IN	7,079	0	7,079	7,079	34,034	12.1%	13,678	1.1%	0.4	14.5%		0.0%	85.5%		0.0%
LA	16	29	45	206	77	0.0%	80	0.0%	1.0	6.0%			94.0%		
LL	199	664	863	4,527	956	0.3%	216	0.0%	0.2	29.7%			70.3%		
MD	1	0	1	1	3	0.0%	12	0.0%	3.9	100.0%			0.0%		
NT	613	9	622	672	2,948	1.0%	3,150	0.3%	1.1	0.0%			100.0%		
OR	1,304	256	1,560	2,975	6,270	2.2%	5,078	0.4%	0.8	16.3%		0.0%	83.3%		0.4%
RF	2	0	2	2	9	0.0%	17	0.0%	1.9	100.0%			0.0%		
RL	11,191	0	11,191	11,191	53,802	19.1%	101,855	8.4%	1.9	0.1%		0.0%	99.7%		0.3%
SR	2,584	3,051	5,635	22,477	12,423	4.4%	211,932	17.4%	17.1	0.0%	0.3%	0.0%	0.0%	50.5%	49.2%
SR-OFF SITE	28	0	28	28	133	0.0%	104,853	8.6%	788.4			0.0%			100.0%
Inorganic Non-Metal	**2,928**	**420**	**3,348**	**5,665**	**14,079**	**5.0%**	**49,762**	**4.1%**	**3.5**	**7.9%**	**0.3%**	**0.0%**	**80.6%**	**8.8%**	**2.3%**
IN	2,836	0	2,836	2,836	13,634	4.8%	48,828	4.0%	3.6	5.0%	0.3%	0.0%	83.2%	9.1%	2.3%
RF	58	351	409	2,344	278	0.1%	832	0.1%	3.0	98.9%			1.1%		
RL	35	69	104	485	167	0.1%	103	0.0%	0.6	99.4%	0.6%		0.0%	0.0%	
Lead/Cadmium Metal	**24**	**343**	**367**	**2,259**	**114**	**0.0%**	**85**	**0.0%**	**0.7**	**72.7%**			**27.3%**		
LA	2	0	2	2	9	0.0%	0	0.0%	0.0	0.0%			100.0%		
RF	4	308	312	2,014	19	0.0%	29	0.0%	1.5	94.7%			5.3%		
RL	18	35	52	243	86	0.0%	56	0.0%	0.6	75.6%			24.4%		
Salt Waste	**21**	**3**	**24**	**41**	**102**	**0.0%**	**1,712**	**0.1%**	**16.8**	**16.5%**	**8.4%**	**8.1%**	**23.6%**	**17.7%**	**25.6%**
IN	21	0	21	21	99	0.0%	1,709	0.1%	17.3	14.0%	8.7%	8.4%	24.3%	18.3%	26.4%
LL	1	3	4	20	3	0.0%	3	0.0%	0.8	100.0%			0.0%		

Table A-1, Summary of Final Waste Forms to be Disposed at the Waste Isolation Pilot Plant

Query of TWBIR, 20 June 1996 — Reported Total Volume of TRU/MTRU Waste Summarized by Final Waste Form					Totals for all Stored TRU Waste Final Waste Forms — See Table A-2 for Individual Waste Stream Data				Distribution of Radionuclide Concentrations of Stored TRU Waste *PE-Ci concentrations are waste stream averaged						
									Overall Average PE-Ci /Drum	Not to be Processed/Repackaged Before WIPP Disposal			To be Processed/Repackaged Before WIPP Disposal		
Final Waste Form Consolidated by Generator Site	Stored Volume, m^3	Projected Volume, m^3	Anticipated Inventory, m^3	Scaled Volume, m^3	Equivalent[1] Number 55 Gal Drums	Percent of Total Volume	Total PE-Ci	Percent of Total PE-CI		PE-Ci* < 8	8 < PE-Ci* < 20	20 < PE-Ci*	PE-Ci* < 8	8 < PE-Ci* < 20	20 < PE-Ci*
Soils	**407**	**55**	**462**	**767**	**1,958**	**0.7%**	**5,192**	**0.4%**	**2.7**	**4.9%**	**0.0%**		**70.7%**	**24.5%**	
LA	111	29	140	300	532	0.2%	181	0.0%	0.3	0.0%			100.0%		
MD	177	0	177	177	852	0.3%	25	0.0%	0.0	0.0%			100.0%		
RL	119	26	145	289	574	0.2%	4,986	0.4%	8.7	16.6%	0.0%		0.0%	83.4%	
Solidified Inorganics	**9,635**	**2,906**	**12,541**	**28,584**	**46,321**	**16.5%**	**183,911**	**15.1%**	**4.0**	**33.7%**	**0.1%**	**0.0%**	**64.1%**	**1.7%**	**0.4%**
IN	4,342	0	4,342	4,342	20,875	7.4%	73,621	6.0%	3.5	40.1%	0.1%	0.0%	59.7%	0.0%	0.1%
LA	4,888	2,034	6,922	18,149	23,501	8.4%	16,970	1.4%	0.7	27.1%	0.0%		72.8%	0.1%	
LL	14	6	20	52	69	0.0%	26	0.0%	0.4	100.0%			0.0%		
MD	6	0	6	6	29	0.0%	8	0.0%	0.3	69.0%			31.0%		
NT	6	0	6	6	27	0.0%	40	0.0%	1.5	0.0%			100.0%		
RF	165	132	297	1,024	795	0.3%	4,958	0.4%	6.2	94.6%	5.4%		0.0%	0.0%	
RL	13	7	20	59	62	0.0%	59	0.0%	0.9	27.0%			73.0%		
SR	168	728	896	4,913	807	0.3%	9,783	0.8%	12.1		0.0%	0.0%		97.0%	3.0%
SR-OFF SITE	32	0	32	32	156	0.1%	78,447	6.4%	504.1			0.0%			100.0%
Solidified Organics	**913**	**55**	**968**	**1,272**	**4,388**	**1.6%**	**3,131**	**0.3%**	**0.7**	**24.4%**	**0.1%**		**75.5%**	**0.0%**	
IN	790	0	790	790	3,796	1.3%	1,537	0.1%	0.4	12.6%	0.2%		87.2%	0.0%	
LA	1	29	31	191	7	0.0%	4	0.0%	0.6	100.0%			0.0%		
LL	1	6	7	39	5	0.0%	2	0.0%	0.3	100.0%			0.0%		
RF	110	0	110	110	528	0.2%	1,562	0.1%	3.0	100.0%			0.0%		
RL	11	20	31	142	51	0.0%	26	0.0%	0.5	100.0%			0.0%		
Uncategorized Metal	**10,836**	**3,879**	**14,716**	**36,131**	**52,098**	**18.5%**	**100,776**	**8.3%**	**1.9**	**6.2%**	**0.2%**	**0.1%**	**90.1%**	**2.7%**	**0.7%**
IN	5,865	0	5,865	5,865	28,195	10.0%	38,110	3.1%	1.4	5.1%	0.1%	0.2%	93.0%	1.0%	0.6%
LA	4,214	2,854	7,068	22,822	20,262	7.2%	53,018	4.3%	2.6	3.1%	0.1%		91.8%	5.0%	
MD	82	0	82	82	397	0.1%	201	0.0%	0.5	6.3%			93.7%		
RF	93	250	344	1,726	449	0.2%	2,258	0.2%	5.0	93.5%	4.9%	1.6%	0.0%	0.0%	0.0%
RL	511	658	1,170	4,804	2,458	0.9%	1,008	0.1%	0.4	28.3%			71.7%		
SR	70	117	187	832	338	0.1%	6,180	0.5%	18.3		0.0%	0.0%		35.5%	64.5%
Unknown	**66**	**62**	**128**	**471**	**317**	**0.1%**	**3,567**	**0.3%**	**11.3**	**38.3%**		**2.5%**	**34.9%**		**24.3%**
MD	27	0	27	27	129	0.0%	797	0.1%	6.2	15.1%			84.9%		
OR	18	0	18	18	85	0.0%	2,727	0.2%	32.1			9.4%			90.6%
RL	21	62	84	427	103	0.0%	42	0.0%	0.4	99.1%			0.9%		
Various RF Residues	**4,182**	**0**	**4,182**	**4,182**	**20,105**	**7.1%**	**366,439**	**30.1%**	**18.2**		**0.0%**			**100.0%**	
RF	4,182	0	4,182	4,182	20,105	7.1%	366,439	30.1%	18.2		0.0%			100.0%	
TOTAL	**58,533**	**16,865**	**75,398**	**168,500**	**281,410**	**100.0%**	**1,219,187**	**100.0%**	**4.3**	**11.7%**	**0.3%**	**0.0%**	**74.4%**	**11.0%**	**2.6%**
Percent of Anticipated Inventory	**78%**	**22%**	**100%**												

Table A-1, Summary of Final Waste Forms to be Disposed at the Waste Isolation Pilot Plant

Query of TWBIR, 20 June 1996 Reported Total Volume of TRU/MTRU Waste Summarized by Final Waste Form					Totals for all Stored TRU Waste Final Waste Forms See Table A-2 for Individual Waste Stream Data				Distribution of Radionuclide Concentrations of Stored TRU Waste *PE-Ci concentrations are waste stream averaged						
									Overall Average PE-Ci /Drum	Not to be Processed/Repackaged Before WIPP Disposal			To be Processed/Repackaged Before WIPP Disposal		
Final Waste Form Consolidated by Generator Site	Stored Volume, m³	Projected Volume, m³	Anticipated Inventory, m³	Scaled Volume, m³	Equivalent[1] Number 55 Gal Drums	Percent of Total Volume	Total PE-Ci	Percent of Total PE-CI		PE-Ci* < 8	8 < PE-Ci* < 20	20 < PE-Ci*	PE-Ci* < 8	8 < PE-Ci* < 20	20 < PE-Ci*
Percent of Scaled Volume	35%	10%	45%	100%											

Table A-2, Generator Waste Stream Totals Sorted by Final Waste Form and Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96						Total of All Stored Drums					Stored Not to be Processed					Stored To be Processed				
Final Waste Form	SITE	TWBIR_ ID	% to be Processed	Stored m3	Av. PECi / Drum	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Combustible	MD	MD-W017	0%	1.46	31.7	7	222	7	0.0%	222	7	222	7	0.2%	222	0	0	0	0.0%	0
Combustible	RF	RF-MT2116	0%	2.08	25.9	10	259	17	0.1%	480	10	259	17	0.4%	480	0	0	0	0.0%	0
Combustible	IN	IN-W305.828	0%	10.68	18.2	51	936	68	0.2%	1,416	51	936	68	1.6%	1,416	0	0	0	0.0%	0
Combustible	IN	IN-W305.1068	100%	37.44	18.2	180	3281	248	0.9%	4,697	0	0	68	1.6%	1,416	180	3281	180	0.8%	3,281
Combustible	IN	IN-W256.1062	100%	20.59	17.9	99	1777	347	1.3%	6,474	0	0	68	1.6%	1,416	99	1777	279	1.2%	5,057
Combustible	IN	IN-W256.295	0% *	5.99	17.9	29	517	376	1.4%	6,991	29	517	97	2.3%	1,934	0	0	279	1.2%	5,057
Combustible	IN	IN-W269.535	100%	20.80	14.9	100	1488	476	1.7%	8,479	0	0	97	2.3%	1,934	100	1488	379	1.6%	6,546
Combustible	IN	IN-W269.510	0%	5.99	14.9	29	429	505	1.8%	8,908	29	429	126	3.0%	2,362	0	0	379	1.6%	6,546
Combustible	MD	MD-W003	0%	1.66	11.5	8	92	513	1.8%	9,000	8	92	134	3.2%	2,455	0	0	379	1.6%	6,546
Combustible	IN	IN-W330.678	0%	1.93	11.5	9	107	522	1.9%	9,107	9	107	143	3.4%	2,561	0	0	379	1.6%	6,546
Combustible	IN	IN-W330.677	100%	6.03	11.5	29	334	551	2.0%	9,441	0	0	143	3.4%	2,561	29	334	408	1.7%	6,879
Combustible	RF	RF-MT0339	100%	22.88	10.1	110	1109	661	2.4%	10,549	0	0	143	3.4%	2,561	110	1109	518	2.2%	7,988
Combustible	RF	RF-MT0821	0%	0.42	5.6	2	11	663	2.4%	10,561	2	11	145	3.5%	2,573	0	0	518	2.2%	7,988
Combustible	MD	MD-T009	0%	0.21	5.0	1	5	664	2.4%	10,566	1	5	146	3.5%	2,578	0	0	518	2.2%	7,988
Combustible	LA	LA-T004	98%	1,555.16	4.1	7477	30321	8,141	29.3%	40,887	150	610	297	7.1%	3,188	7326	29711	7,844	33.3%	37,699
Combustible	IN	IN-W327.1085	0%	3.54	4.0	17	68	8,158	29.4%	40,954	17	68	314	7.5%	3,255	0	0	7,844	33.3%	37,699
Combustible	IN	IN-W327.735	0%	1.30	4.0	6	25	8,164	29.4%	40,979	6	25	320	7.6%	3,280	0	0	7,844	33.3%	37,699
Combustible	RF	RF-TT0825	0%	21.63	3.5	104	364	8,268	29.8%	41,343	104	364	424	10.1%	3,644	0	0	7,844	33.3%	37,699
Combustible	RF	RF-TT0821	0%	12.48	3.5	60	209	8,328	30.0%	41,552	60	209	484	11.5%	3,853	0	0	7,844	33.3%	37,699
Combustible	RL	RL-W300	0%	0.42	3.4	2	7	8,330	30.0%	41,559	2	7	486	11.6%	3,860	0	0	7,844	33.3%	37,699
Combustible	MD	MD-T008	0%	3.74	3.2	18	58	8,348	30.1%	41,617	18	58	504	12.0%	3,918	0	0	7,844	33.3%	37,699
Combustible	RF	RF-MT0832	100%	72.38	3.0	348	1042	8,696	31.3%	42,659	0	0	504	12.0%	3,918	348	1042	8,192	34.8%	38,741
Combustible	RF	RF-MT0831	0%	44.93	3.0	216	646	8,912	32.1%	43,305	216	646	720	17.2%	4,564	0	0	8,192	34.8%	38,741
Combustible	RF	RF-MT0833	0%	8.74	3.0	42	125	8,954	32.3%	43,431	42	125	762	18.2%	4,690	0	0	8,192	34.8%	38,741
Combustible	LA	LA-W004	0%	266.29	2.9	1280	3704	10,235	36.9%	47,135	1280	3704	2,042	48.7%	8,394	0	0	8,192	34.8%	38,741
Combustible	RL	RL-W296	0%	3.16	2.8	15	42	10,250	36.9%	47,177	15	42	2,057	49.1%	8,436	0	0	8,192	34.8%	38,741
Combustible	RL	RL-W289	0%	2.08	2.8	10	28	10,260	37.0%	47,204	10	28	2,067	49.3%	8,464	0	0	8,192	34.8%	38,741
Combustible	RL	RL-W293	0%	1.25	2.8	6	17	10,266	37.0%	47,221	6	17	2,073	49.4%	8,480	0	0	8,192	34.8%	38,741
Combustible	RL	RL-W298	32%	16.59	2.5	80	201	10,345	37.3%	47,422	55	137	2,128	50.7%	8,618	25	63	8,217	34.9%	38,804
Combustible	RL	RL-W398	0%	0.21	2.5	1	2	10,346	37.3%	47,424	1	2	2,129	50.8%	8,620	0	0	8,217	34.9%	38,804
Combustible	IN	IN-W252.283	100%	117.73	1.9	566	1082	10,912	39.3%	48,506	0	0	2,129	50.8%	8,620	566	1082	8,783	37.3%	39,886
Combustible	IN	IN-W252.811	0%	32.82	1.9	158	302	11,070	39.9%	48,808	158	302	2,287	54.5%	8,922	0	0	8,783	37.3%	39,886
Combustible	RL	RL-W401	0%	0.62	1.8	3	6	11,073	39.9%	48,813	3	6	2,290	54.6%	8,927	0	0	8,783	37.3%	39,886
Combustible	IN	IN-W250.941	100%	50.96	1.7	245	414	11,318	40.8%	49,228	0	0	2,290	54.6%	8,927	245	414	9,028	38.3%	40,300
Combustible	IN	IN-W250.259	0%	14.07	1.7	68	114	11,386	41.0%	49,342	68	114	2,357	56.2%	9,042	0	0	9,028	38.3%	40,300
Combustible	RL	RL-W397	0%	3.54	1.5	17	25	11,403	41.1%	49,367	17	25	2,374	56.6%	9,067	0	0	9,028	38.3%	40,300
Combustible	IN	IN-W254.290	100%	7.28	1.1	35	39	11,438	41.2%	49,406	0	0	2,374	56.6%	9,067	35	39	9,063	38.5%	40,339
Combustible	IN	IN-W254.289	0%	2.34	1.1	11	12	11,449	41.2%	49,418	11	12	2,386	56.9%	9,080	0	0	9,063	38.5%	40,339
Combustible	RL	RL-W389	0%	0.21	1.0	1	1	11,450	41.2%	49,419	1	1	2,387	56.9%	9,081	0	0	9,063	38.5%	40,339
Combustible	RL	RL-W356	0%	1.25	1.0	6	6	11,456	41.3%	49,425	6	6	2,393	57.1%	9,087	0	0	9,063	38.5%	40,339
Combustible	RL	RL-W372	0%	0.42	1.0	2	2	11,458	41.3%	49,427	2	2	2,395	57.1%	9,089	0	0	9,063	38.5%	40,339
Combustible	IN	IN-W199.1039	0%	0.89	0.9	4	4	11,462	41.3%	49,431	4	4	2,399	57.2%	9,093	0	0	9,063	38.5%	40,339
Combustible	RL	RL-W347	0%	0.21	0.9	1	1	11,463	41.3%	49,432	1	1	2,400	57.2%	9,094	0	0	9,063	38.5%	40,339
Combustible	RL	RL-W388	57%	16.73	0.9	80	74	11,544	41.6%	49,506	35	32	2,435	58.1%	9,125	46	42	9,109	38.6%	40,381
Combustible	RL	RL-W404	0%	2.08	0.9	10	9	11,554	41.6%	49,515	10	9	2,445	58.3%	9,134	0	0	9,109	38.6%	40,381
Combustible	RL	RL-W384	0%	0.62	0.8	3	2	11,557	41.6%	49,517	3	2	2,448	58.4%	9,137	0	0	9,109	38.6%	40,381
Combustible	IN	IN-W198.202	100%	119.60	0.6	575	346	12,132	43.7%	49,863	0	0	2,448	58.4%	9,137	575	346	9,684	41.1%	40,727

Table A-2, Generator Waste Stream Totals Sorted by Final Waste Form and Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96						Total of All Stored Drums					Stored Not to be Processed					Stored To be Processed				
Final Waste Form	SITE	TWBIR_ ID	% to be Processed	Stored m3	Av. PECi / Drum	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Combustible	IN	IN-W198.804	0%	32.82	0.6	158	95	12,290	44.3%	49,958	158	95	2,606	62.1%	9,232	0	0	9,684	41.1%	40,727
Combustible	RL	RL-W365	0%	11.86	0.6	57	34	12,347	44.5%	49,992	57	34	2,663	63.5%	9,265	0	0	9,684	41.1%	40,727
Combustible	RL	RL-W371	58%	6.07	0.6	29	16	12,376	44.6%	50,008	12	7	2,675	63.8%	9,272	17	9	9,701	41.2%	40,736
Combustible	RL	RL-W309	0%	0.21	0.5	1	0	12,377	44.6%	50,009	1	0	2,676	63.8%	9,273	0	0	9,701	41.2%	40,736
Combustible	RL	RL-W321	0%	0.21	0.5	1	0	12,378	44.6%	50,009	1	0	2,677	63.8%	9,273	0	0	9,701	41.2%	40,736
Combustible	RL	RL-W378	89%	16.78	0.3	81	28	12,459	44.9%	50,037	9	3	2,685	64.0%	9,276	72	25	9,773	41.5%	40,761
Combustible	RL	RL-W377	3%	303.79	0.3	1461	492	13,919	50.1%	50,529	1410	475	4,095	97.6%	9,751	51	17	9,824	41.7%	40,778
Combustible	RL	RL-W331	93%	50.79	0.2	244	52	14,163	51.0%	50,581	17	4	4,112	98.1%	9,754	227	49	10,051	42.6%	40,827
Combustible	RL	RL-W322	0%	0.83	0.2	4	1	14,167	51.0%	50,582	4	1	4,116	98.1%	9,755	0	0	10,051	42.6%	40,827
Combustible	RL	RL-W325	0%	0.42	0.2	2	0	14,169	51.0%	50,582	2	0	4,118	98.2%	9,756	0	0	10,051	42.6%	40,827
Combustible	RL	RL-W314	0%	4.58	0.2	22	5	14,191	51.1%	50,587	22	5	4,140	98.7%	9,760	0	0	10,051	42.6%	40,827
Combustible	RL	RL-W305	0%	2.08	0.2	10	2	14,201	51.2%	50,589	10	2	4,150	99.0%	9,762	0	0	10,051	42.6%	40,827
Combustible	IN	IN-W186.187	100%	2,695.26	0.2	12958	2232	27,159	97.8%	52,821	0	0	4,150	99.0%	9,762	12958	2232	23,009	97.6%	43,059
Combustible	RL	RL-W340	0%	0.21	0.1	1	0	27,160	97.8%	52,821	1	0	4,151	99.0%	9,762	0	0	23,009	97.6%	43,059
Combustible	RL	RL-W343	0%	0.62	0.1	3	0	27,163	97.8%	52,821	3	0	4,154	99.1%	9,763	0	0	23,009	97.6%	43,059
Combustible	RL	RL-W368	0%	0.62	0.1	3	0	27,166	97.9%	52,821	3	0	4,157	99.1%	9,763	0	0	23,009	97.6%	43,059
Combustible	IN	IN-W202.224	100%	109.62	0.1	527	33	27,693	99.7%	52,854	0	0	4,157	99.1%	9,763	527	33	23,536	99.9%	43,091
Combustible	IN	IN-W202.1092	0%	0.89	0.1	4	0	27,697	99.8%	52,854	4	0	4,161	99.2%	9,763	0	0	23,536	99.9%	43,091
Combustible	RL	RL-W360	0%	4.78	0.1	23	1	27,720	99.8%	52,856	23	1	4,184	99.8%	9,764	0	0	23,536	99.9%	43,091
Combustible	IN	IN-W336.820	0%	0.68	0.0	3	0	27,724	99.9%	52,856	3	0	4,187	99.9%	9,764	0	0	23,536	99.9%	43,091
Combustible	IN	IN-W336.660	100%	4.16	0.0	20	1	27,744	99.9%	52,856	0	0	4,187	99.9%	9,764	20	1	23,556	99.9%	43,092
Combustible	IN	IN-W205.1086	100%	0.83	0.0	4	0	27,748	99.9%	52,856	0	0	4,187	99.9%	9,764	4	0	23,560	100.0%	43,092
Combustible	IN	IN-W205.220	0%	0.68	0.0	3	0	27,751	100.0%	52,857	3	0	4,191	99.9%	9,765	0	0	23,560	100.0%	43,092
Combustible	RL	RL-W335	92%	2.10	0.0	10	0	27,761	100.0%	52,857	1	0	4,192	100.0%	9,765	9	0	23,570	100.0%	43,092
Combustible	RL	RL-W278	0%	0.42	0.0	2	0	27,763	100.0%	52,857	2	0	4,194	100.0%	9,765	0	0	23,570	100.0%	43,092
Final Waste Form Average PE-Ci/drum								1.9 PE-CI/drum					2.3 PE-CI/drum					1.8 PE-CI/drum		
Filter	IN	IN-W214.1075	100%	0.62	138.0	3	414	3	0.3%	414	0	0	0	0.0%	0	3	414	3	4.2%	414
Filter	IN	IN-W214.755	0%	0.68	138.0	3	452	6	0.6%	866	3	452	3	0.3%	452	0	0	3	4.2%	414
Filter	IN	IN-W213.1069	0%	1.93	99.3	9	921	16	1.5%	1,787	9	921	13	1.3%	1,373	0	0	3	4.2%	414
Filter	RF	RF-TT0491	0%	16.02	18.9	77	1456	93	8.8%	3,243	77	1456	90	9.2%	2,829	0	0	3	4.2%	414
Filter	RF	RF-TT0376	0%	8.94	9.9	43	425	136	12.9%	3,668	43	425	133	13.6%	3,254	0	0	3	4.2%	414
Filter	RF	RF-TT0490	0%	22.17	9.4	107	999	242	23.1%	4,667	107	999	239	24.5%	4,253	0	0	3	4.2%	414
Filter	RF	RF-TT0335	0%	19.34	8.6	93	803	335	32.0%	5,471	93	803	332	34.0%	5,057	0	0	3	4.2%	414
Filter	RF	RF-TT0338	0%	2.08	8.6	10	86	345	32.9%	5,557	10	86	342	35.0%	5,143	0	0	3	4.2%	414
Filter	RF	RF-MT-0491	0%	0.62	4.5	3	13	348	33.2%	5,571	3	13	345	35.4%	5,156	0	0	3	4.2%	414
Filter	RF	RF-MT-0335	0%	1.46	4.5	7	31	355	33.9%	5,602	7	31	352	36.1%	5,188	0	0	3	4.2%	414
Filter	IN	IN-W207.980	0%	0.89	3.6	4	16	359	34.3%	5,617	4	16	356	36.5%	5,203	0	0	3	4.2%	414
Filter	IN	IN-W207.981	100%	0.42	3.6	2	7	361	34.5%	5,625	0	0	356	36.5%	5,203	2	7	5	6.9%	421
Filter	IN	IN-W211.1009	0%	98.47	3.0	473	1429	835	79.6%	7,054	473	1429	830	85.0%	6,632	0	0	5	6.9%	421
Filter	IN	IN-W209.994	0%	10.27	1.6	49	81	884	84.3%	7,134	49	81	879	90.0%	6,713	0	0	5	6.9%	421
Filter	IN	IN-W208.988	0%	2.34	0.9	11	10	895	85.4%	7,145	11	10	890	91.2%	6,723	0	0	5	6.9%	421
Filter	LL	LL-T005	90%	15.54	0.6	75	47	970	92.5%	7,191	8	5	898	92.0%	6,728	67	42	72	100.0%	463
Filter	IN	IN-W210.1001	0%	1.10	0.6	5	3	975	93.0%	7,194	5	3	903	92.5%	6,731	0	0	72	100.0%	463
Filter	IN	IN-W206.935	0%	10.89	0.4	52	20	1,028	98.0%	7,215	52	20	956	97.9%	6,752	0	0	72	100.0%	463
Filter	MD	MD-M001	0%	0.42	0.2	2	0	1,030	98.2%	7,215	2	0	958	98.1%	6,752	0	0	72	100.0%	463

Table A-2, Generator Waste Stream Totals Sorted by Final Waste Form and Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96						Total of All Stored Drums					Stored Not to be Processed					Stored To be Processed				
Final Waste Form	SITE	TWBIR_ ID	% to be Processed	Stored m3	Av. PECi / Drum	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Filter	IN	IN-W212.1058	0%	3.44	**0.1**	17	2	1,046	99.8%	7,217	17	2	974	99.8%	6,754	0	0	72	100.0%	463
Filter	MD	MD-T010	0%	0.42	**0.1**	2	0	1,048	100.0%	7,217	2	0	976	100.0%	6,754	0	0	72	100.0%	463
Final Waste Form Average PE-Ci/drum								**6.9 PE-CI/drum**					**6.9 PE-CI/drum**					**6.4 PE-CI/drum**		
Graphite	RF	RF-TT0303	0%	0.21	**16.7**	1	17	1	0.0%	17	1	17	1	0.2%	17	0	0	0	0.0%	0
Graphite	IN	IN-W271.532	0%	0.89	**10.1**	4	43	5	0.2%	60	4	43	5	0.9%	60	0	0	0	0.0%	0
Graphite	RF	RF-TT0300	0%	12.90	**9.9**	62	614	67	2.7%	674	62	614	67	10.9%	674	0	0	0	0.0%	0
Graphite	RF	RF-TT0312	0%	0.62	**7.1**	3	21	70	2.9%	695	3	21	70	11.4%	695	0	0	0	0.0%	0
Graphite	IN	IN-W272.504	0%	0.89	**6.1**	4	26	75	3.0%	721	4	26	75	12.1%	721	0	0	0	0.0%	0
Graphite	IN	IN-W272.974	100%	1.66	**6.1**	8	49	83	3.4%	770	0	0	75	12.1%	721	8	49	8	0.4%	49
Graphite	IN	IN-W367.973	0%	4.69	**3.8**	23	86	105	4.3%	855	23	86	97	15.8%	807	0	0	8	0.4%	49
Graphite	IN	IN-W370.929	100%	53.46	**2.1**	257	549	362	14.7%	1,405	0	0	97	15.8%	807	257	549	265	14.4%	598
Graphite	IN	IN-W370.836	0%	15.16	**2.1**	73	156	435	17.7%	1,560	73	156	170	27.6%	962	0	0	265	14.4%	598
Graphite	IN	IN-W369.970	100%	9.98	**1.8**	48	85	483	19.6%	1,646	0	0	170	27.6%	962	48	85	313	17.0%	684
Graphite	IN	IN-W369.837	0%	3.23	**1.8**	16	28	499	20.3%	1,674	16	28	186	30.1%	990	0	0	313	17.0%	684
Graphite	IN	IN-W275.502	0%	1.72	**1.2**	8	10	507	20.6%	1,684	8	10	194	31.5%	1,000	0	0	313	17.0%	684
Graphite	IN	IN-W275.967	100%	5.20	**1.2**	25	30	532	21.6%	1,714	0	0	194	31.5%	1,000	25	30	338	18.3%	714
Graphite	IN	IN-W276.966	100%	313.46	**1.0**	1507	1526	2,039	82.8%	3,240	0	0	194	31.5%	1,000	1507	1526	1,845	100.0%	2,240
Graphite	IN	IN-W276.500	0%	86.75	**1.0**	417	422	2,456	99.8%	3,663	417	422	611	99.1%	1,422	0	0	1,845	100.0%	2,240
Graphite	IN	IN-W368.971	0%	1.10	**1.0**	5	5	2,461	100.0%	3,668	5	5	616	100.0%	1,428	0	0	1,845	100.0%	2,240
Final Waste Form Average PE-Ci/drum								**1.5 PE-CI/drum**					**2.3 PE-CI/drum**					**1.2 PE-CI/drum**		
Heterogeneous	OFF S	W027-999-HET	100%	27.66	**788.4**	133	104853	133	0.1%	104,853	0	0	0	0.0%	0	133	104853	133	0.1%	104,853
Heterogeneous	IN	IN-W350.650	0%	0.68	**43.7**	3	143	136	0.1%	104,996	3	143	3	0.1%	143	0	0	133	0.1%	104,853
Heterogeneous	IN	IN-W350.923	100%	0.21	**43.7**	1	44	137	0.1%	105,040	0	0	3	0.1%	143	1	44	134	0.1%	104,897
Heterogeneous	OR	OR-W045	100%	5.41	**26.5**	26	688	163	0.1%	105,729	0	0	3	0.1%	143	26	688	160	0.2%	105,585
Heterogeneous	IN	IN-W329.681	0%	0.89	**21.8**	4	93	168	0.2%	105,822	4	93	8	0.1%	236	0	0	160	0.2%	105,585
Heterogeneous	SR	W027-772F-HET	100%	515.42	**21.5**	2478	53230	2,646	2.4%	159,052	0	0	8	0.1%	236	2478	53230	2,638	2.5%	158,816
Heterogeneous	SR	W027-773A-HET	100%	331.14	**21.5**	1592	34198	4,238	3.8%	193,250	0	0	8	0.1%	236	1592	34198	4,230	4.1%	193,014
Heterogeneous	SR	W027-221H-HET	100%	125.42	**21.5**	603	12953	4,841	4.4%	206,203	0	0	8	0.1%	236	603	12953	4,833	4.6%	205,967
Heterogeneous	SR	W027-235F-HET	100%	34.74	**21.5**	167	3587	5,008	4.5%	209,790	0	0	8	0.1%	236	167	3587	5,000	4.8%	209,554
Heterogeneous	SR	W027-221F-HET	100%	265.62	**21.5**	1277	27431	6,285	5.7%	237,222	0	0	8	0.1%	236	1277	27431	6,277	6.0%	236,985
Heterogeneous	RL	RL-T132	100%	28.70	**21.0**	138	2900	6,423	5.8%	240,121	0	0	8	0.1%	236	138	2900	6,415	6.2%	239,885
Heterogeneous	SR	T001-772F-HET	75%	29.08	**14.7**	140	2048	6,562	5.9%	242,170	35	513	43	0.7%	749	105	1536	6,520	6.3%	241,421
Heterogeneous	SR	T001-235F-HET	100%	162.97	**13.0**	784	10208	7,346	6.6%	252,378	0	0	43	0.7%	749	784	10208	7,303	7.0%	251,629
Heterogeneous	SR	T001-221F-HET	100%	938.70	**12.8**	4513	57689	11,859	10.7%	310,067	0	0	43	0.7%	749	4513	57689	11,816	11.3%	309,318
Heterogeneous	SR	T001-221H-HET	100%	158.14	**12.2**	760	9299	12,619	11.4%	319,366	0	0	43	0.7%	749	760	9299	12,577	12.1%	318,617
Heterogeneous	SR	T001-773A-HET	100%	22.09	**12.1**	106	1287	12,725	11.5%	320,653	0	0	43	0.7%	749	106	1287	12,683	12.2%	319,904
Heterogeneous	RL	RL-W301	0%	0.62	**6.0**	3	18	12,728	11.5%	320,671	3	18	46	0.7%	767	0	0	12,683	12.2%	319,904
Heterogeneous	IN	IN-W325.679	0%	0.68	**5.8**	3	19	12,732	11.5%	320,690	3	19	49	0.8%	786	0	0	12,683	12.2%	319,904
Heterogeneous	IN	IN-W325.1076	100%	0.42	**5.8**	2	12	12,734	11.5%	320,701	0	0	49	0.8%	786	2	12	12,685	12.2%	319,915
Heterogeneous	RL	RL-T123	100%	0.62	**5.5**	3	16	12,737	11.5%	320,718	0	0	49	0.8%	786	3	16	12,688	12.2%	319,932
Heterogeneous	IN	IN-W170.189	0%	0.68	**5.1**	3	17	12,740	11.5%	320,734	3	17	52	0.8%	803	0	0	12,688	12.2%	319,932
Heterogeneous	IN	IN-W170.938	100%	0.42	**5.1**	2	10	12,742	11.5%	320,745	0	0	52	0.8%	803	2	10	12,690	12.2%	319,942
Heterogeneous	MD	MD-T012	0%	0.62	**3.9**	3	12	12,745	11.5%	320,757	3	12	55	0.9%	814	0	0	12,690	12.2%	319,942
Heterogeneous	IN	IN-W204.215	0%	0.89	**3.4**	4	15	12,749	11.5%	320,771	4	15	59	0.9%	829	0	0	12,690	12.2%	319,942
Heterogeneous	IN	IN-W204.216	100%	1.66	**3.4**	8	27	12,757	11.5%	320,798	0	0	59	0.9%	829	8	27	12,698	12.2%	319,969

Table A-2, Generator Waste Stream Totals Sorted by Final Waste Form and Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96						Total of All Stored Drums					Stored Not to be Processed					Stored To be Processed				
Final Waste Form	SITE	TWBIR_ ID	% to be Processed	Stored m3	Av. PECi / Drum	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Heterogeneous	IN	IN-W298.812	0%	15.37	3.4	74	248	12,831	11.6%	321,046	74	248	133	2.1%	1,077	0	0	12,698	12.2%	319,969
Heterogeneous	RL	RL-T107	100%	6,156.09	3.0	29597	89263	42,428	38.3%	410,310	0	0	133	2.1%	1,077	29597	89263	42,294	40.6%	409,233
Heterogeneous	RL	RL-T116	100%	11.02	3.0	53	158	42,481	38.4%	410,468	0	0	133	2.1%	1,077	53	158	42,347	40.6%	409,391
Heterogeneous	RL	RL-W294	0%	1.04	2.8	5	14	42,486	38.4%	410,482	5	14	138	2.2%	1,091	0	0	42,347	40.6%	409,391
Heterogeneous	IN	IN-W281.487	100%	317.82	2.7	1528	4181	44,014	39.8%	414,664	0	0	138	2.2%	1,091	1528	4181	43,875	42.1%	413,573
Heterogeneous	RL	RL-T133	100%	0.21	2.4	1	2	44,015	39.8%	414,666	0	0	138	2.2%	1,091	1	2	43,876	42.1%	413,575
Heterogeneous	RL	RL-T137	100%	151.63	2.4	729	1760	44,744	40.4%	416,426	0	0	138	2.2%	1,091	729	1760	44,605	42.8%	415,336
Heterogeneous	LA	LA-T007	86%	6.66	2.2	32	69	44,776	40.5%	416,495	5	10	143	2.2%	1,101	27	59	44,633	42.8%	415,394
Heterogeneous	IN	IN-W339.655	0%	2.14	2.1	10	22	44,786	40.5%	416,517	10	22	153	2.4%	1,123	0	0	44,633	42.8%	415,394
Heterogeneous	IN	IN-W339.955	100%	7.07	2.1	34	72	44,820	40.5%	416,589	0	0	153	2.4%	1,123	34	72	44,667	42.8%	415,467
Heterogeneous	IN	IN-W345.669	100%	14.35	2.1	69	145	44,889	40.6%	416,734	0	0	153	2.4%	1,123	69	145	44,736	42.9%	415,611
Heterogeneous	IN	IN-W345.819	0%	0.89	2.1	4	9	44,893	40.6%	416,743	4	9	157	2.5%	1,132	0	0	44,736	42.9%	415,611
Heterogeneous	IN	IN-W283.534	0%	0.68	2.1	3	7	44,896	40.6%	416,749	3	7	161	2.5%	1,138	0	0	44,736	42.9%	415,611
Heterogeneous	IN	IN-W283.481	100%	0.21	2.1	1	2	44,897	40.6%	416,752	0	0	161	2.5%	1,138	1	2	44,737	42.9%	415,613
Heterogeneous	RL	RL-T127	100%	283.60	2.0	1363	2687	46,261	41.8%	419,438	0	0	161	2.5%	1,138	1363	2687	46,100	44.2%	418,300
Heterogeneous	RL	RL-W302	0%	0.42	1.9	2	4	46,263	41.8%	419,442	2	4	163	2.6%	1,142	0	0	46,100	44.2%	418,300
Heterogeneous	RF	RF-TT0374	0%	0.62	1.9	3	6	46,266	41.8%	419,448	3	6	166	2.6%	1,148	0	0	46,100	44.2%	418,300
Heterogeneous	RF	RF-MT0374	0%	1.25	1.9	6	11	46,272	41.8%	419,459	6	11	172	2.7%	1,159	0	0	46,100	44.2%	418,300
Heterogeneous	RL	RL-T128	100%	0.42	1.8	2	4	46,274	41.8%	419,463	0	0	172	2.7%	1,159	2	4	46,102	44.2%	418,304
Heterogeneous	IN	IN-W341.954	0%	0.68	1.8	3	6	46,277	41.8%	419,469	3	6	175	2.8%	1,165	0	0	46,102	44.2%	418,304
Heterogeneous	IN	IN-W341.671	100%	0.21	1.8	1	2	46,278	41.8%	419,471	0	0	175	2.8%	1,165	1	2	46,103	44.2%	418,305
Heterogeneous	LL	LL-M001	0%	5.41	1.5	26	38	46,304	41.8%	419,509	26	38	201	3.2%	1,203	0	0	46,103	44.2%	418,305
Heterogeneous	IN	IN-W351.648	0%	0.89	1.5	4	6	46,308	41.8%	419,515	4	6	205	3.2%	1,210	0	0	46,103	44.2%	418,305
Heterogeneous	IN	IN-W351.922	100%	1.25	1.5	6	9	46,314	41.9%	419,524	0	0	205	3.2%	1,210	6	9	46,109	44.2%	418,314
Heterogeneous	RL	RL-W303	0%	0.21	1.4	1	1	46,315	41.9%	419,525	1	1	206	3.2%	1,211	0	0	46,109	44.2%	418,314
Heterogeneous	IN	IN-W289.466	100%	25.38	1.2	122	151	46,437	42.0%	419,676	0	0	206	3.2%	1,211	122	151	46,231	44.3%	418,465
Heterogeneous	IN	IN-W171.184	100%	3.54	1.2	17	20	46,454	42.0%	419,697	0	0	206	3.2%	1,211	17	20	46,248	44.3%	418,486
Heterogeneous	IN	IN-W171.801	0%	0.68	1.2	3	4	46,458	42.0%	419,701	3	4	210	3.3%	1,215	0	0	46,248	44.3%	418,486
Heterogeneous	OR	OR-W053	90%	435.76	1.1	2095	2293	48,553	43.9%	421,993	202	221	411	6.5%	1,436	1893	2072	48,141	46.2%	420,557
Heterogeneous	NT	NT-W001	100%	613.26	1.1	2948	3150	51,501	46.5%	425,143	0	0	411	6.5%	1,436	2948	3150	51,090	49.0%	423,707
Heterogeneous	RL	RL-T140	100%	138.11	1.0	664	695	52,165	47.1%	425,838	0	0	411	6.5%	1,436	664	695	51,754	49.6%	424,402
Heterogeneous	RL	RL-T114	100%	19.58	1.0	94	97	52,259	47.2%	425,935	0	0	411	6.5%	1,436	94	97	51,848	49.7%	424,499
Heterogeneous	RL	RL-W379	0%	0.21	0.8	1	1	52,260	47.2%	425,935	1	1	412	6.5%	1,437	0	0	51,848	49.7%	424,499
Heterogeneous	RL	RL-T129	100%	28.75	0.8	138	110	52,398	47.4%	426,045	0	0	412	6.5%	1,437	138	110	51,986	49.8%	424,609
Heterogeneous	RL	RL-T112	100%	137.74	0.8	662	523	53,061	48.0%	426,568	0	0	412	6.5%	1,437	662	523	52,648	50.5%	425,131
Heterogeneous	OR	OR-W044	100%	522.91	0.6	2514	1605	55,575	50.2%	428,173	0	0	412	6.5%	1,437	2514	1605	55,162	52.9%	426,737
Heterogeneous	RL	RL-T110	100%	494.03	0.6	2375	1494	57,950	52.4%	429,667	0	0	412	6.5%	1,437	2375	1494	57,537	55.2%	428,230
Heterogeneous	LL	LL-T002	0%	47.91	0.6	230	139	58,180	52.6%	429,806	230	139	643	10.1%	1,576	0	0	57,537	55.2%	428,230
Heterogeneous	RL	RL-T131	100%	30.16	0.6	145	81	58,325	52.7%	429,888	0	0	643	10.1%	1,576	145	81	57,682	55.3%	428,312
Heterogeneous	OR	OR-W047	100%	154.13	0.5	741	387	59,066	53.4%	430,274	0	0	643	10.1%	1,576	741	387	58,423	56.0%	428,699
Heterogeneous	IN	IN-W139.627	100%	12.27	0.5	59	28	59,125	53.4%	430,303	0	0	643	10.1%	1,576	59	28	58,482	56.1%	428,727
Heterogeneous	IN	IN-W323.562	0%	0.89	0.5	4	2	59,129	53.4%	430,305	4	2	647	10.2%	1,578	0	0	58,482	56.1%	428,727
Heterogeneous	OR	OR-W048	100%	15.18	0.4	73	31	59,202	53.5%	430,336	0	0	647	10.2%	1,578	73	31	58,555	56.1%	428,758
Heterogeneous	LA	LA-W068	100%	0.42	0.4	2	1	59,204	53.5%	430,336	0	0	647	10.2%	1,578	2	1	58,557	56.1%	428,759
Heterogeneous	IN	IN-W197.802	100%	510.22	0.4	2453	894	61,657	55.7%	431,231	0	0	647	10.2%	1,578	2453	894	61,010	58.5%	429,653
Heterogeneous	IN	IN-W197.803	0%	45.23	0.4	217	79	61,875	55.9%	431,310	217	79	864	13.6%	1,657	0	0	61,010	58.5%	429,653
Heterogeneous	IN	IN-W291.454	0%	0.68	0.3	3	1	61,878	55.9%	431,311	3	1	868	13.7%	1,658	0	0	61,010	58.5%	429,653

Table A-2, Generator Waste Stream Totals Sorted by Final Waste Form and Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96						Total of All Stored Drums					Stored Not to be Processed					Stored To be Processed				
Final Waste Form	SITE	TWBIR_ ID	% to be Processed	Stored m3	Av. PECi / Drum	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Heterogeneous	IN	IN-W291.456	100%	634.40	0.3	3050	1048	64,928	58.7%	432,359	0	0	868	13.7%	1,658	3050	1048	64,060	61.4%	430,701
Heterogeneous	RL	RL-T101	100%	567.94	0.3	2731	904	67,659	61.1%	433,263	0	0	868	13.7%	1,658	2731	904	66,791	64.0%	431,605
Heterogeneous	RL	RL-T118	100%	261.96	0.3	1259	374	68,918	62.3%	433,638	0	0	868	13.7%	1,658	1259	374	68,050	65.2%	431,979
Heterogeneous	RL	RL-T135	100%	0.42	0.3	2	1	68,920	62.3%	433,638	0	0	868	13.7%	1,658	2	1	68,052	65.2%	431,980
Heterogeneous	IN	IN-W308.816	0%	864.91	0.3	4158	1154	73,078	66.0%	434,793	4158	1154	5,026	79.1%	2,813	0	0	68,052	65.2%	431,980
Heterogeneous	IN	IN-W265.516	0%	7.92	0.3	38	10	73,116	66.1%	434,803	38	10	5,064	79.7%	2,823	0	0	68,052	65.2%	431,980
Heterogeneous	IN	IN-W169.191	100%	4,267.12	0.2	20515	4927	93,631	84.6%	439,730	0	0	5,064	79.7%	2,823	20515	4927	88,567	84.9%	436,907
Heterogeneous	IN	IN-W169.985	0%	41.79	0.2	201	48	93,832	84.8%	439,778	201	48	5,265	82.9%	2,871	0	0	88,567	84.9%	436,907
Heterogeneous	LA	LA-W067	100%	8.94	0.2	43	10	93,875	84.8%	439,788	0	0	5,265	82.9%	2,871	43	10	88,610	85.0%	436,917
Heterogeneous	IN	IN-W189.131	0%	1.72	0.2	8	2	93,884	84.8%	439,789	8	2	5,273	83.0%	2,873	0	0	88,610	85.0%	436,917
Heterogeneous	IN	IN-W189.1048	100%	4.99	0.2	24	5	93,908	84.9%	439,794	0	0	5,273	83.0%	2,873	24	5	88,634	85.0%	436,922
Heterogeneous	IN	IN-W302.913	100%	84.86	0.2	408	85	94,316	85.2%	439,880	0	0	5,273	83.0%	2,873	408	85	89,042	85.4%	437,007
Heterogeneous	IN	IN-W302.299	0%	23.45	0.2	113	24	94,428	85.3%	439,903	113	24	5,386	84.8%	2,896	0	0	89,042	85.4%	437,007
Heterogeneous	IN	IN-W203.210	100%	73.22	0.2	352	72	94,780	85.7%	439,976	0	0	5,386	84.8%	2,896	352	72	89,394	85.7%	437,080
Heterogeneous	IN	IN-W203.1081	0%	0.68	0.2	3	1	94,784	85.7%	439,977	3	1	5,389	84.8%	2,897	0	0	89,394	85.7%	437,080
Heterogeneous	IN	IN-W334.675	0%	1.51	0.2	7	1	94,791	85.7%	439,978	7	1	5,396	84.9%	2,898	0	0	89,394	85.7%	437,080
Heterogeneous	IN	IN-W334.961	100%	4.58	0.2	22	4	94,813	85.7%	439,982	0	0	5,396	84.9%	2,898	22	4	89,416	85.7%	437,084
Heterogeneous	RL	RL-W304	75%	2.51	0.2	12	2	94,825	85.7%	439,984	3	1	5,399	85.0%	2,899	9	2	89,425	85.7%	437,085
Heterogeneous	RL	RL-T106	100%	8.11	0.2	39	6	94,864	85.7%	439,990	0	0	5,399	85.0%	2,899	39	6	89,464	85.8%	437,091
Heterogeneous	RL	RL-T109	100%	19.72	0.1	95	13	94,959	85.8%	440,003	0	0	5,399	85.0%	2,899	95	13	89,559	85.9%	437,105
Heterogeneous	RL	RL-T134	100%	0.21	0.1	1	0	94,960	85.8%	440,003	0	0	5,399	85.0%	2,899	1	0	89,560	85.9%	437,105
Heterogeneous	RL	RL-W279	0%	6.93	0.1	33	4	94,993	85.8%	440,007	33	4	5,433	85.5%	2,902	0	0	89,560	85.9%	437,105
Heterogeneous	OR	OR-W041	0%	170.77	0.1	821	74	95,814	86.6%	440,081	821	74	6,254	98.4%	2,976	0	0	89,560	85.9%	437,105
Heterogeneous	IN	IN-W338.657	0%	0.89	0.1	4	0	95,818	86.6%	440,081	4	0	6,258	98.5%	2,977	0	0	89,560	85.9%	437,105
Heterogeneous	IN	IN-W338.956	100%	1.04	0.1	5	0	95,823	86.6%	440,082	0	0	6,258	98.5%	2,977	5	0	89,565	85.9%	437,105
Heterogeneous	RL	RL-T115	100%	1,025.43	0.1	4930	391	100,753	91.1%	440,472	0	0	6,258	98.5%	2,977	4930	391	94,495	90.6%	437,496
Heterogeneous	IN	IN-W225.800	0%	1.10	0.1	5	0	100,759	91.1%	440,473	5	0	6,263	98.6%	2,977	0	0	94,495	90.6%	437,496
Heterogeneous	IN	IN-W225.127	100%	21.63	0.1	104	7	100,863	91.2%	440,479	0	0	6,263	98.6%	2,977	104	7	94,599	90.7%	437,503
Heterogeneous	RL	RL-T145	100%	711.19	0.1	3419	198	104,282	94.2%	440,678	0	0	6,263	98.6%	2,977	3419	198	98,018	94.0%	437,701
Heterogeneous	LL	LL-T003	97%	143.64	0.1	691	39	104,972	94.9%	440,716	18	1	6,282	98.9%	2,978	672	38	98,691	94.6%	437,738
Heterogeneous	IN	IN-W285.815	0%	2.34	0.1	11	1	104,984	94.9%	440,717	11	1	6,293	99.0%	2,979	0	0	98,691	94.6%	437,738
Heterogeneous	IN	IN-W285.471	100%	63.02	0.1	303	17	105,287	95.1%	440,734	0	0	6,293	99.0%	2,979	303	17	98,994	94.9%	437,755
Heterogeneous	IN	IN-W259.552	0%	10.06	0.1	48	3	105,335	95.2%	440,736	48	3	6,341	99.8%	2,981	0	0	98,994	94.9%	437,755
Heterogeneous	IN	IN-W278.1090	0%	0.89	0.0	4	0	105,339	95.2%	440,736	4	0	6,346	99.9%	2,981	0	0	98,994	94.9%	437,755
Heterogeneous	RL	RL-T120	100%	133.81	0.0	643	29	105,983	95.8%	440,766	0	0	6,346	99.9%	2,981	643	29	99,637	95.5%	437,784
Heterogeneous	RL	RL-T122	100%	29.30	0.0	141	6	106,123	95.9%	440,771	0	0	6,346	99.9%	2,981	141	6	99,778	95.7%	437,790
Heterogeneous	RL	RL-T143	100%	403.71	0.0	1941	70	108,064	97.7%	440,841	0	0	6,346	99.9%	2,981	1941	70	101,719	97.5%	437,860
Heterogeneous	RL	RL-T130	100%	0.21	0.0	1	0	108,065	97.7%	440,841	0	0	6,346	99.9%	2,981	1	0	101,720	97.5%	437,860
Heterogeneous	SR	T003-773A-HET	100%	0.62	0.0	3	0	108,068	97.7%	440,841	0	0	6,346	99.9%	2,981	3	0	101,723	97.5%	437,860
Heterogeneous	RL	RL-T108	100%	192.62	0.0	926	22	108,994	98.5%	440,863	0	0	6,346	99.9%	2,981	926	22	102,649	98.4%	437,882
Heterogeneous	RL	RL-T105	100%	80.40	0.0	387	6	109,381	98.8%	440,869	0	0	6,346	99.9%	2,981	387	6	103,035	98.8%	437,888
Heterogeneous	LL	LL-W018	0%	1.89	0.0	9	0	109,390	98.9%	440,869	9	0	6,355	100.0%	2,981	0	0	103,035	98.8%	437,888
Heterogeneous	RL	RL-T113	100%	42.80	0.0	206	1	109,596	99.0%	440,870	0	0	6,355	100.0%	2,981	206	1	103,241	99.0%	437,889
Heterogeneous	RL	RL-T104	100%	4.99	0.0	24	0	109,620	99.1%	440,870	0	0	6,355	100.0%	2,981	24	0	103,265	99.0%	437,889
Heterogeneous	RL	RL-T102	100%	200.12	0.0	962	0	110,582	99.9%	440,870	0	0	6,355	100.0%	2,981	962	0	104,227	99.9%	437,889
Heterogeneous	RL	RL-T125	100%	15.18	0.0	73	0	110,655	100.0%	440,870	0	0	6,355	100.0%	2,981	73	0	104,300	100.0%	437,889

Table A-2, Generator Waste Stream Totals Sorted by Final Waste Form and Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96						Total of All Stored Drums					Stored Not to be Processed					Stored To be Processed				
Final Waste Form	SITE	TWBIR_ ID	% to be Processed	Stored m3	Av. PECi / Drum	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Final Waste Form Average PE-Ci/drum						4.0 PE-CI/drum					0.5 PE-CI/drum					4.2 PE-CI/drum				
Inorganic Non-Metal	IN	IN-W213.252	100%	0.42	1655.1	2	3310	2	0.0%	3,310	0	0	0	0.0%	0	2	3310	2	0.0%	3,310
Inorganic Non-Metal	IN	IN-W321.578	100%	0.21	924.4	1	924	3	0.0%	4,235	0	0	0	0.0%	0	1	924	3	0.0%	4,235
Inorganic Non-Metal	IN	IN-W319.583	100%	0.21	456.9	1	457	4	0.0%	4,692	0	0	0	0.0%	0	1	457	4	0.0%	4,692
Inorganic Non-Metal	IN	IN-W358.948	100%	0.21	400.1	1	400	5	0.0%	5,092	0	0	0	0.0%	0	1	400	5	0.0%	5,092
Inorganic Non-Metal	IN	IN-W367.840	100%	0.21	379.7	1	380	6	0.0%	5,471	0	0	0	0.0%	0	1	380	6	0.0%	5,471
Inorganic Non-Metal	IN	IN-W159.120	100%	0.42	282.9	2	566	8	0.1%	6,037	0	0	0	0.0%	0	2	566	8	0.1%	6,037
Inorganic Non-Metal	IN	IN-W281.488	100%	0.62	273.7	3	821	11	0.1%	6,858	0	0	0	0.0%	0	3	821	11	0.1%	6,858
Inorganic Non-Metal	IN	IN-W252.1000	100%	0.21	191.1	1	191	12	0.1%	7,049	0	0	0	0.0%	0	1	191	12	0.1%	7,049
Inorganic Non-Metal	IN	IN-W329.682	100%	0.21	145.3	1	145	13	0.1%	7,195	0	0	0	0.0%	0	1	145	13	0.1%	7,195
Inorganic Non-Metal	IN	IN-W254.1044	100%	0.21	110.7	1	111	14	0.1%	7,305	0	0	0	0.0%	0	1	111	14	0.1%	7,305
Inorganic Non-Metal	IN	IN-W249.1071	100%	2.29	106.9	11	1176	25	0.2%	8,481	0	0	0	0.0%	0	11	1176	25	0.2%	8,481
Inorganic Non-Metal	IN	IN-W249.527	0%	1.10	106.9	5	563	30	0.2%	9,044	5	563	5	0.5%	563	0	0	25	0.2%	8,481
Inorganic Non-Metal	IN	IN-W368.839	100%	0.21	97.4	1	97	31	0.2%	9,142	0	0	5	0.5%	563	1	97	26	0.2%	8,578
Inorganic Non-Metal	IN	IN-W199.209	100%	0.21	94.7	1	95	32	0.2%	9,236	0	0	5	0.5%	563	1	95	27	0.2%	8,673
Inorganic Non-Metal	IN	IN-W365.842	100%	1.04	62.8	5	314	37	0.3%	9,550	0	0	5	0.5%	563	5	314	32	0.2%	8,987
Inorganic Non-Metal	IN	IN-W207.238	100%	0.21	60.8	1	61	38	0.3%	9,611	0	0	5	0.5%	563	1	61	33	0.3%	9,048
Inorganic Non-Metal	IN	IN-W198.203	100%	0.21	60.2	1	60	39	0.3%	9,671	0	0	5	0.5%	563	1	60	34	0.3%	9,108
Inorganic Non-Metal	IN	IN-W211.249	100%	22.46	50.3	108	5433	147	1.0%	15,105	0	0	5	0.5%	563	108	5433	142	1.1%	14,541
Inorganic Non-Metal	IN	IN-W197.196	100%	2.29	36.5	11	401	158	1.1%	15,506	0	0	5	0.5%	563	11	401	153	1.2%	14,942
Inorganic Non-Metal	IN	IN-W291.455	100%	1.46	34.4	7	240	165	1.2%	15,746	0	0	5	0.5%	563	7	240	160	1.2%	15,183
Inorganic Non-Metal	IN	IN-W373.830	100%	0.21	27.9	1	28	166	1.2%	15,774	0	0	5	0.5%	563	1	28	161	1.2%	15,211
Inorganic Non-Metal	IN	IN-W209.244	100%	3.12	27.2	15	409	181	1.3%	16,183	0	0	5	0.5%	563	15	409	176	1.4%	15,619
Inorganic Non-Metal	IN	IN-W265.517	100%	0.62	26.4	3	79	184	1.3%	16,262	0	0	5	0.5%	563	3	79	179	1.4%	15,698
Inorganic Non-Metal	IN	IN-W364.844	100%	0.62	24.7	3	74	187	1.3%	16,336	0	0	5	0.5%	563	3	74	182	1.4%	15,773
Inorganic Non-Metal	IN	IN-W362.848	100%	8.74	24.7	42	1037	229	1.6%	17,373	0	0	5	0.5%	563	42	1037	224	1.7%	16,809
Inorganic Non-Metal	IN	IN-W169.192	100%	14.56	24.0	70	1681	299	2.1%	19,054	0	0	5	0.5%	563	70	1681	294	2.3%	18,491
Inorganic Non-Metal	IN	IN-W267.514	100%	1.25	22.0	6	132	305	2.2%	19,186	0	0	5	0.5%	563	6	132	300	2.3%	18,622
Inorganic Non-Metal	IN	IN-W348.846	100%	4.16	20.9	20	418	325	2.3%	19,604	0	0	5	0.5%	563	20	418	320	2.5%	19,040
Inorganic Non-Metal	IN	IN-W365.1010	0%	1.30	18.8	6	118	332	2.4%	19,722	6	118	12	1.0%	682	0	0	320	2.5%	19,040
Inorganic Non-Metal	IN	IN-W208.242	100%	1.46	15.3	7	107	339	2.4%	19,829	0	0	12	1.0%	682	7	107	327	2.5%	19,147
Inorganic Non-Metal	IN	IN-W373.1003	0%	0.68	14.0	3	46	342	2.4%	19,874	3	46	15	1.3%	727	0	0	327	2.5%	19,147
Inorganic Non-Metal	IN	IN-W216.99	100%	255.01	12.6	1226	15429	1,568	11.1%	35,303	0	0	15	1.3%	727	1226	15429	1,553	12.0%	34,576
Inorganic Non-Metal	IN	IN-W364.1011	0%	0.89	12.4	4	53	1,572	11.2%	35,356	4	53	19	1.6%	780	0	0	1,553	12.0%	34,576
Inorganic Non-Metal	IN	IN-W362.1020	0%	5.37	12.3	26	319	1,598	11.3%	35,675	26	319	45	3.8%	1,099	0	0	1,553	12.0%	34,576
Inorganic Non-Metal	IN	IN-W163.234	100%	0.42	11.5	2	23	1,600	11.4%	35,698	0	0	45	3.8%	1,099	2	23	1,555	12.0%	34,599
Inorganic Non-Metal	IN	IN-W298.979	100%	0.42	11.2	2	22	1,602	11.4%	35,720	0	0	45	3.8%	1,099	2	22	1,557	12.1%	34,621
Inorganic Non-Metal	IN	IN-W267.1005	0%	1.10	11.0	5	58	1,607	11.4%	35,778	5	58	50	4.3%	1,157	0	0	1,557	12.1%	34,621
Inorganic Non-Metal	IN	IN-W210.247	100%	0.21	10.3	1	10	1,608	11.4%	35,788	0	0	50	4.3%	1,157	1	10	1,558	12.1%	34,632
Inorganic Non-Metal	IN	IN-W363.847	100%	1.04	10.0	5	50	1,613	11.5%	35,838	0	0	50	4.3%	1,157	5	50	1,563	12.1%	34,681
Inorganic Non-Metal	RL	RL-W405	0%	0.21	9.2	1	9	1,614	11.5%	35,847	1	9	51	4.4%	1,166	0	0	1,563	12.1%	34,681
Inorganic Non-Metal	IN	IN-W361.849	100%	2.08	7.8	10	78	1,624	11.5%	35,925	0	0	51	4.4%	1,166	10	78	1,573	12.2%	34,759
Inorganic Non-metal	RF	RF-TT0438	0%	7.70	7.3	37	271	1,661	11.8%	36,196	37	271	88	7.6%	1,437	0	0	1,573	12.2%	34,759
Inorganic Non-metal	RF	RF-MT-0368	100%	0.62	7.2	3	22	1,664	11.8%	36,218	0	0	88	7.6%	1,437	3	22	1,576	12.2%	34,781
Inorganic Non-Metal	IN	IN-W283.963	100%	0.21	6.9	1	7	1,665	11.8%	36,225	0	0	88	7.6%	1,437	1	7	1,577	12.2%	34,788
Inorganic Non-Metal	IN	IN-W317.1028	100%	0.21	6.6	1	7	1,666	11.8%	36,231	0	0	88	7.6%	1,437	1	7	1,578	12.2%	34,794

Table A-2, Generator Waste Stream Totals Sorted by Final Waste Form and Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96						Total of All Stored Drums					Stored Not to be Processed					Stored To be Processed				
Final Waste Form	SITE	TWBIR_ ID	% to be Processed	Stored m3	Av. PECi / Drum	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Inorganic Non-Metal	IN	IN-W206.936	100%	22.46	6.5	108	703	1,774	12.6%	36,935	0	0	88	7.6%	1,437	108	703	1,686	13.1%	35,498
Inorganic Non-Metal	IN	IN-W363.1019	0%	0.89	5.0	4	21	1,778	12.6%	36,956	4	21	92	7.9%	1,458	0	0	1,686	13.1%	35,498
Inorganic Non-Metal	IN	IN-W222.117	100%	39.10	4.5	188	841	1,966	14.0%	37,797	0	0	92	7.9%	1,458	188	841	1,874	14.5%	36,338
Inorganic Non-Metal	IN	IN-W361.1021	0%	1.51	3.9	7	28	1,974	14.0%	37,825	7	28	100	8.5%	1,487	0	0	1,874	14.5%	36,338
Inorganic Non-Metal	IN	IN-W322.851	0%	0.89	3.4	4	14	1,978	14.0%	37,839	4	14	104	8.9%	1,501	0	0	1,874	14.5%	36,338
Inorganic Non-Metal	IN	IN-W322.952	100%	1.66	3.4	8	27	1,986	14.1%	37,866	0	0	104	8.9%	1,501	8	27	1,882	14.6%	36,365
Inorganic Non-Metal	RL	RL-W292	0%	0.21	2.8	1	3	1,987	14.1%	37,869	1	3	105	9.0%	1,504	0	0	1,882	14.6%	36,365
Inorganic Non-Metal	IN	IN-W294.1057	100%	0.42	2.7	2	5	1,989	14.1%	37,875	0	0	105	9.0%	1,504	2	5	1,884	14.6%	36,371
Inorganic Non-Metal	RF	RF-TT0442	0%	28.08	2.7	135	369	2,124	15.1%	38,243	135	369	240	20.6%	1,873	0	0	1,884	14.6%	36,371
Inorganic Non-metal	RF	RF-TT0440	0%	5.63	2.4	27	64	2,151	15.3%	38,308	27	64	267	22.9%	1,937	0	0	1,884	14.6%	36,371
Inorganic Non-Metal	IN	IN-W243.275	100%	7.28	2.3	35	81	2,186	15.5%	38,389	0	0	267	22.9%	1,937	35	81	1,919	14.9%	36,452
Inorganic Non-Metal	IN	IN-W245.1034	100%	0.21	2.2	1	2	2,187	15.5%	38,391	0	0	267	22.9%	1,937	1	2	1,920	14.9%	36,454
Inorganic Non-Metal	IN	IN-W230.940	100%	14.77	2.1	71	153	2,258	16.0%	38,544	0	0	267	22.9%	1,937	71	153	1,991	15.4%	36,607
Inorganic Non-Metal	IN	IN-W230.229	0%	4.27	2.1	21	44	2,279	16.2%	38,588	21	44	288	24.6%	1,981	0	0	1,991	15.4%	36,607
Inorganic Non-Metal	RL	RL-W403	0%	0.62	2.0	3	6	2,282	16.2%	38,594	3	6	291	24.9%	1,987	0	0	1,991	15.4%	36,607
Inorganic Non-Metal	IN	IN-W374.1091	100%	2.08	2.0	10	20	2,292	16.3%	38,614	0	0	291	24.9%	1,987	10	20	2,001	15.5%	36,627
Inorganic Non-Metal	IN	IN-W366.841	0%	1.10	1.9	5	10	2,297	16.3%	38,624	5	10	296	25.3%	1,997	0	0	2,001	15.5%	36,627
Inorganic Non-Metal	IN	IN-W366.1004	100%	2.08	1.9	10	19	2,307	16.4%	38,642	0	0	296	25.3%	1,997	10	19	2,011	15.6%	36,645
Inorganic Non-Metal	RL	RL-W400	0%	0.21	1.9	1	2	2,308	16.4%	38,644	1	2	297	25.4%	1,999	0	0	2,011	15.6%	36,645
Inorganic Non-Metal	IN	IN-W212.251	100%	150.59	1.9	724	1355	3,032	21.5%	39,999	0	0	297	25.4%	1,999	724	1355	2,735	21.2%	38,000
Inorganic Non-Metal	IN	IN-W308.618	100%	503.57	1.9	2421	4481	5,453	38.7%	44,480	0	0	297	25.4%	1,999	2421	4481	5,156	39.9%	42,481
Inorganic Non-metal	RF	RF-MT0440	0%	5.63	1.7	27	45	5,480	38.9%	44,525	27	45	324	27.7%	2,044	0	0	5,156	39.9%	42,481
Inorganic Non-Metal	RF	RF-MT0442	0%	6.66	1.7	32	53	5,512	39.2%	44,579	32	53	356	30.5%	2,098	0	0	5,156	39.9%	42,481
Inorganic Non-Metal	RF	RF-MT0856	0%	0.21	1.7	1	2	5,513	39.2%	44,580	1	2	357	30.6%	2,099	0	0	5,156	39.9%	42,481
Inorganic Non-Metal	IN	IN-W187.121	100%	0.21	1.5	1	2	5,514	39.2%	44,582	0	0	357	30.6%	2,099	1	2	5,157	39.9%	42,483
Inorganic Non-Metal	RL	RL-W393	0%	5.41	1.5	26	39	5,540	39.3%	44,621	26	39	383	32.8%	2,139	0	0	5,157	39.9%	42,483
Inorganic Non-Metal	IN	IN-W205.1087	100%	0.21	1.4	1	1	5,541	39.4%	44,623	0	0	383	32.8%	2,139	1	1	5,158	40.0%	42,484
Inorganic Non-Metal	IN	IN-W245.302	100%	133.74	1.1	643	707	6,184	43.9%	45,330	0	0	383	32.8%	2,139	643	707	5,801	44.9%	43,191
Inorganic Non-Metal	IN	IN-W245.301	0%	37.51	1.1	180	198	6,364	45.2%	45,528	180	198	563	48.2%	2,337	0	0	5,801	44.9%	43,191
Inorganic Non-Metal	IN	IN-W247.1038	100%	0.21	1.1	1	1	6,365	45.2%	45,529	0	0	563	48.2%	2,337	1	1	5,802	44.9%	43,192
Inorganic Non-Metal	IN	IN-W161.231	100%	97.55	1.0	469	489	6,834	48.5%	46,018	0	0	563	48.2%	2,337	469	489	6,271	48.6%	43,681
Inorganic Non-Metal	IN	IN-W161.806	0%	15.79	1.0	76	79	6,910	49.1%	46,098	76	79	639	54.7%	2,416	0	0	6,271	48.6%	43,681
Inorganic Non-Metal	RL	RL-W353	0%	0.83	1.0	4	4	6,914	49.1%	46,102	4	4	643	55.1%	2,420	0	0	6,271	48.6%	43,681
Inorganic Non-Metal	RL	RL-W387	0%	1.46	0.7	7	5	6,921	49.2%	46,107	7	5	650	55.7%	2,425	0	0	6,271	48.6%	43,681
Inorganic Non-Metal	IN	IN-W240.272	100%	167.65	0.7	806	554	7,727	54.9%	46,661	0	0	650	55.7%	2,425	806	554	7,077	54.8%	44,236
Inorganic Non-Metal	IN	IN-W240.931	0%	1.93	0.7	9	6	7,736	55.0%	46,667	9	6	659	56.5%	2,432	0	0	7,077	54.8%	44,236
Inorganic Non-Metal	IN	IN-W296.329	100%	520.21	0.6	2501	1602	10,237	72.7%	48,269	0	0	659	56.5%	2,432	2501	1602	9,578	74.2%	45,837
Inorganic Non-Metal	RL	RL-W364	0%	2.08	0.6	10	6	10,247	72.8%	48,275	10	6	669	57.3%	2,438	0	0	9,578	74.2%	45,837
Inorganic Non-Metal	IN	IN-W243.808	0%	46.06	0.6	221	129	10,469	74.4%	48,403	221	129	891	76.3%	2,566	0	0	9,578	74.2%	45,837
Inorganic Non-Metal	IN	IN-W243.274	100%	174.30	0.6	838	487	11,307	80.3%	48,890	0	0	891	76.3%	2,566	838	487	10,416	80.7%	46,324
Inorganic Non-Metal	IN	IN-W157.907	100%	9.36	0.5	45	24	11,352	80.6%	48,915	0	0	891	76.3%	2,566	45	24	10,461	81.0%	46,348
Inorganic Non-Metal	IN	IN-W247.810	0%	27.51	0.5	132	70	11,484	81.6%	48,985	132	70	1,023	87.6%	2,636	0	0	10,461	81.0%	46,348
Inorganic Non-Metal	IN	IN-W374.829	0%	2.34	0.5	11	6	11,495	81.7%	48,990	11	6	1,034	88.6%	2,642	0	0	10,461	81.0%	46,348
Inorganic Non-Metal	IN	IN-W218.109	100%	183.87	0.4	884	387	12,379	87.9%	49,377	0	0	1,034	88.6%	2,642	884	387	11,345	87.9%	46,736
Inorganic Non-Metal	IN	IN-W257.558	100%	0.21	0.4	1	0	12,380	87.9%	49,378	0	0	1,034	88.6%	2,642	1	0	11,346	87.9%	46,736
Inorganic Non-Metal	IN	IN-W203.211	100%	3.33	0.4	16	7	12,396	88.1%	49,385	0	0	1,034	88.6%	2,642	16	7	11,362	88.0%	46,743
Inorganic Non-Metal	IN	IN-W259.920	100%	2.50	0.3	12	4	12,408	88.1%	49,389	0	0	1,034	88.6%	2,642	12	4	11,374	88.1%	46,747

Table A-2, Generator Waste Stream Totals Sorted by Final Waste Form and Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96						Total of All Stored Drums					Stored Not to be Processed					Stored To be Processed				
Final Waste Form	SITE	TWBIR_ ID	% to be Processed	Stored m3	Av. PECi / Drum	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Inorganic Non-Metal	RF	RF-MT0444	0%	2.72	**0.3**	13	5	12,422	88.2%	49,393	13	5	1,048	89.7%	2,646	0	0	11,374	88.1%	46,747
Inorganic Non-Metal	RL	RL-W376	0%	16.22	**0.3**	78	26	12,500	88.8%	49,419	78	26	1,126	96.4%	2,673	0	0	11,374	88.1%	46,747
Inorganic Non-Metal	RF	RF-MT0855	0%	0.21	**0.3**	1	0	12,501	88.8%	49,420	1	0	1,127	96.5%	2,673	0	0	11,374	88.1%	46,747
Inorganic Non-Metal	IN	IN-W309.609	100%	108.58	**0.2**	522	123	13,023	92.5%	49,543	0	0	1,127	96.5%	2,673	522	123	11,896	92.1%	46,870
Inorganic Non-Metal	RL	RL-W315	0%	0.42	**0.2**	2	0	13,025	92.5%	49,543	2	0	1,129	96.6%	2,674	0	0	11,896	92.1%	46,870
Inorganic Non-Metal	IN	IN-W357.850	100%	0.21	**0.2**	1	0	13,026	92.5%	49,544	0	0	1,129	96.6%	2,674	1	0	11,897	92.1%	46,870
Inorganic Non-metal	RF	RF-MT-0438	0%	0.42	**0.2**	2	0	13,028	92.5%	49,544	2	0	1,131	96.8%	2,674	0	0	11,897	92.1%	46,870
Inorganic Non-Metal	IN	IN-W228.102	100%	198.85	**0.2**	956	208	13,984	99.3%	49,752	0	0	1,131	96.8%	2,674	956	208	12,853	99.6%	47,078
Inorganic Non-Metal	IN	IN-W278.495	100%	4.16	**0.2**	20	3	14,004	99.5%	49,756	0	0	1,131	96.8%	2,674	20	3	12,873	99.7%	47,082
Inorganic Non-Metal	IN	IN-W375.827	100%	7.90	**0.1**	38	4	14,042	99.7%	49,760	0	0	1,131	96.8%	2,674	38	4	12,911	100.0%	47,086
Inorganic Non-Metal	IN	IN-W357.1022	0%	0.68	**0.1**	3	0	14,045	99.8%	49,760	3	0	1,134	97.1%	2,674	0	0	12,911	100.0%	47,086
Inorganic Non-Metal	RL	RL-W342	0%	0.83	**0.1**	4	0	14,049	99.8%	49,761	4	0	1,138	97.4%	2,675	0	0	12,911	100.0%	47,086
Inorganic Non-Metal	RL	RL-W367	0%	2.91	**0.1**	14	1	14,063	99.9%	49,762	14	1	1,152	98.6%	2,676	0	0	12,911	100.0%	47,086
Inorganic Non-Metal	RL	RL-W358	0%	2.50	**0.1**	12	1	14,075	100.0%	49,762	12	1	1,164	99.7%	2,676	0	0	12,911	100.0%	47,086
Inorganic Non-Metal	RL	RL-W392	0%	0.21	**0.0**	1	0	14,076	100.0%	49,762	1	0	1,165	99.7%	2,676	0	0	12,911	100.0%	47,086
Inorganic Non-Metal	RL	RL-W352	0%	0.21	**0.0**	1	0	14,077	100.0%	49,762	1	0	1,166	99.8%	2,676	0	0	12,911	100.0%	47,086
Inorganic Non-Metal	RL	RL-W336	0%	0.42	**0.0**	2	0	14,079	100.0%	49,762	2	0	1,168	100.0%	2,676	0	0	12,911	100.0%	47,086
Final Waste Form Average PE-Ci/drum								**3.5**	**PE-CI/drum**				**2.3**	**PE-CI/drum**				**3.6**	**PE-CI/drum**	
Lead/Cadmium Metal Waste	RF	RF-MT0480	100%	0.21	**6.8**	1	7	1	0.9%	7	0	0	0	0.0%	0	1	7	1	3.2%	7
Lead/Cadmium Metal Waste	RL	RL-W287	0%	0.42	**2.8**	2	6	3	2.6%	12	2	6	2	2.4%	6	0	0	1	3.2%	7
Lead/Cadmium Metal Waste	RL	RL-W290	0%	2.29	**2.8**	11	30	14	12.2%	43	11	30	13	15.6%	36	0	0	1	3.2%	7
Lead/Cadmium Metal Waste	RF	RF-MT0321	0%	3.74	**1.2**	18	22	32	28.0%	65	18	22	31	37.3%	58	0	0	1	3.2%	7
Lead/Cadmium Metal Waste	RL	RL-W349	0%	0.21	**0.9**	1	1	33	28.9%	66	1	1	32	38.5%	59	0	0	1	3.2%	7
Lead/Cadmium Metal Waste	RL	RL-W328	100%	3.78	**0.5**	18	9	51	44.7%	75	0	0	32	38.5%	59	18	9	19	61.5%	16
Lead/Cadmium Metal Waste	RL	RL-W317	0%	1.04	**0.2**	5	1	56	49.1%	76	5	1	37	44.5%	60	0	0	19	61.5%	16
Lead/Cadmium Metal Waste	RL	RL-W306	0%	0.83	**0.2**	4	1	60	52.6%	77	4	1	41	49.3%	61	0	0	19	61.5%	16
Lead/Cadmium Metal Waste	RL	RL-W311	0%	4.41	**0.2**	21	4	81	71.2%	81	21	4	62	74.8%	66	0	0	19	61.5%	16
Lead/Cadmium Metal Waste	RL	RL-W312	0%	2.29	**0.2**	11	2	92	80.8%	83	11	2	73	88.0%	68	0	0	19	61.5%	16
Lead/Cadmium Metal Waste	RL	RL-W318	0%	1.66	**0.2**	8	2	100	87.8%	85	8	2	81	97.6%	70	0	0	19	61.5%	16
Lead/Cadmium Metal Waste	RL	RL-W339	0%	0.42	**0.1**	2	0	102	89.5%	85	2	0	83	100.0%	70	0	0	19	61.5%	16
Lead/Cadmium Metal Waste	LA	LA-W066	100%	1.89	**0.0**	9	0	111	97.5%	85	0	0	83	100.0%	70	9	0	28	90.7%	16
Lead/Cadmium Metal Waste	RL	RL-W277	100%	0.60	**0.0**	3	0	114	100.0%	85	0	0	83	100.0%	70	3	0	31	100.0%	16
Salt Waste	IN	IN-W311.1013	100%	5.41	**35.4**	26	921	26	25.6%	921	0	0	0	0.0%	0	26	921	26	38.2%	921
Salt Waste	IN	IN-W311.604	0%	1.72	**35.4**	8	293	34	33.7%	1,215	8	293	8	24.6%	293	0	0	26	38.2%	921
Salt Waste	IN	IN-W312.602	0%	1.10	**12.4**	5	66	40	38.9%	1,280	5	66	14	40.3%	359	0	0	26	38.2%	921
Salt Waste	IN	IN-W312.942	100%	2.70	**12.4**	13	162	53	51.7%	1,442	0	0	14	40.3%	359	13	162	39	57.4%	1,083
Salt Waste	IN	IN-W314.1017	100%	1.04	**10.8**	5	54	58	56.6%	1,496	0	0	14	40.3%	359	5	54	44	64.7%	1,137
Salt Waste	IN	IN-W314.606	0%	0.68	**10.8**	3	35	61	59.8%	1,531	3	35	17	50.0%	394	0	0	44	64.7%	1,137
Salt Waste	IN	IN-W355.1015	100%	1.04	**7.4**	5	37	66	64.8%	1,568	0	0	17	50.0%	394	5	37	49	72.1%	1,174
Salt Waste	IN	IN-W355.857	0%	0.89	**7.4**	4	32	70	69.0%	1,600	4	32	21	62.7%	426	0	0	49	72.1%	1,174
Salt Waste	IN	IN-W356.1014	100%	3.74	**4.2**	18	76	88	86.7%	1,676	0	0	21	62.7%	426	18	76	67	98.5%	1,251
Salt Waste	IN	IN-W356.856	0%	1.30	**4.2**	6	27	94	92.8%	1,703	6	27	27	81.4%	452	0	0	67	98.5%	1,251
Salt Waste	IN	IN-W354.858	0%	0.68	**1.5**	3	5	98	96.1%	1,708	3	5	31	91.1%	457	0	0	67	98.5%	1,251

Table A-2, Generator Waste Stream Totals Sorted by Final Waste Form and Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96						Total of All Stored Drums					Stored Not to be Processed					Stored To be Processed				
Final Waste Form	SITE	TWBIR_ ID	% to be Processed	Stored m3	Av. PECi / Drum	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Salt Waste	IN	IN-W354.1016	100%	0.21	**1.5**	1	1	99	97.0%	1,709	0	0	31	91.1%	457	1	1	68	100.0%	1,252
Salt Waste	LL	LL-T004	0%	0.62	**0.8**	3	3	102	100.0%	1,712	3	3	34	100.0%	460	0	0	68	100.0%	1,252
Final Waste Form Average PE-Ci/drum									**16.8 PE-CI/drum**					**13.7 PE-CI/drum**					**18.4 PE-CI/drum**	
Soils	RL	RL-T103	100%	99.63	**10.1**	479	4827	479	24.5%	4,827	0	0	0	0.0%	0	479	4827	479	25.7%	4,827
Soils	RL	RL-W283	0%	11.65	**2.6**	56	146	535	27.3%	4,973	56	146	56	58.7%	146	0	0	479	25.7%	4,827
Soils	RL	RL-W354	0%	0.21	**1.0**	1	1	536	27.4%	4,974	1	1	57	59.7%	147	0	0	479	25.7%	4,827
Soils	RL	RL-W316	0%	0.21	**0.5**	1	0	537	27.4%	4,975	1	0	58	60.8%	148	0	0	479	25.7%	4,827
Soils	LA	LA-T008	100%	110.57	**0.3**	532	181	1,069	54.6%	5,156	0	0	58	60.8%	148	532	181	1,011	54.3%	5,008
Soils	RL	RL-W381	0%	6.24	**0.3**	30	10	1,099	56.1%	5,166	30	10	88	92.2%	158	0	0	1,011	54.3%	5,008
Soils	RL	RL-W310	0%	0.29	**0.2**	1	0	1,100	56.2%	5,166	1	0	89	93.7%	158	0	0	1,011	54.3%	5,008
Soils	RL	RL-W323	0%	0.62	**0.2**	3	1	1,103	56.3%	5,167	3	1	92	96.9%	159	0	0	1,011	54.3%	5,008
Soils	RL	RL-W406	0%	0.42	**0.0**	2	0	1,105	56.4%	5,167	2	0	94	99.0%	159	0	0	1,011	54.3%	5,008
Soils	MD	MD-T003	100%	146.94	**0.0**	706	22	1,811	92.5%	5,189	0	0	94	99.0%	159	706	22	1,717	92.2%	5,030
Soils	MD	MD-T005	100%	30.24	**0.0**	145	2	1,957	99.9%	5,192	0	0	94	99.0%	159	145	2	1,862	100.0%	5,033
Soils	RL	RL-W351	0%	0.21	**0.0**	1	0	1,958	100.0%	5,192	1	0	95	100.0%	159	0	0	1,862	100.0%	5,033
Final Waste Form Average PE-Ci/drum									**2.7 PE-CI/drum**					**1.7 PE-CI/drum**					**2.7 PE-CI/drum**	
Solidified Inorganics	OFF S	W027-999-VIT	100%	31.85	**511.8**	153	78373	153	0.3%	78,373	0	0	0	0.0%	0	153	78373	153	0.5%	78,373
Solidified Inorganics	IN	IN-W159.1072	0%	0.68	**141.5**	3	463	156	0.3%	78,836	3	463	3	0.0%	463	0	0	153	0.5%	78,373
Solidified Inorganics	SR	W006-773A-VIT	100%	0.52	**94.9**	2	236	159	0.3%	79,072	0	0	3	0.0%	463	2	236	156	0.5%	78,609
Solidified Inorganics	OFF S	W053-773A-VIT	100%	0.52	**29.6**	2	74	161	0.3%	79,146	0	0	3	0.0%	463	2	74	158	0.5%	78,683
Solidified Inorganics	IN	IN-W146.699	100%	2.29	**23.7**	11	261	172	0.4%	79,407	0	0	3	0.0%	463	11	261	169	0.6%	78,944
Solidified Inorganics	SR	T001-773A-CLAS	100%	4.58	**21.5**	22	473	194	0.4%	79,879	0	0	3	0.0%	463	22	473	191	0.6%	79,416
Solidified Inorganics	RF	RF-MT0377	0%	3.54	**16.2**	17	276	211	0.5%	80,155	17	276	20	0.1%	739	0	0	191	0.6%	79,416
Solidified Inorganics	RF	RF-MT-0823	0%	0.21	**15.7**	1	16	212	0.5%	80,171	1	16	21	0.1%	754	0	0	191	0.6%	79,416
Solidified Inorganics	IN	IN-W315.601	100%	0.42	**15.2**	2	30	214	0.5%	80,201	0	0	21	0.1%	754	2	30	193	0.6%	79,447
Solidified Inorganics	SR	W027-773A-VIT	100%	17.25	**13.5**	83	1123	297	0.6%	81,324	0	0	21	0.1%	754	83	1123	276	0.9%	80,570
Solidified Inorganics	SR	W027-221F-VIT	100%	33.18	**13.5**	160	2160	457	1.0%	83,485	0	0	21	0.1%	754	160	2160	436	1.4%	82,730
Solidified Inorganics	SR	W027-221H-VIT	100%	25.88	**13.5**	124	1685	581	1.3%	85,170	0	0	21	0.1%	754	124	1685	560	1.8%	84,415
Solidified Inorganics	SR	W027-235F-VIT	100%	16.59	**13.5**	80	1080	661	1.4%	86,250	0	0	21	0.1%	754	80	1080	640	2.1%	85,495
Solidified Inorganics	SR	T003-773A-VIT	100%	0.21	**13.5**	1	14	662	1.4%	86,263	0	0	21	0.1%	754	1	14	641	2.1%	85,509
Solidified Inorganics	SR	W027-772F-VIT	100%	10.62	**13.5**	51	691	713	1.5%	86,955	0	0	21	0.1%	754	51	691	692	2.3%	86,200
Solidified Inorganics	LA	LA-T006	88%	4.99	**11.5**	24	276	737	1.6%	87,230	3	33	24	0.2%	788	21	242	713	2.3%	86,442
Solidified Inorganics	IN	IN-W348.1012	0%	2.34	**10.5**	11	118	748	1.6%	87,348	11	118	35	0.2%	905	0	0	713	2.3%	86,442
Solidified Inorganics	RF	RF-MT0001	0%	3.74	**9.1**	18	163	766	1.7%	87,511	18	163	53	0.3%	1,068	0	0	713	2.3%	86,442
Solidified Inorganics	RF	RF-MT0007	0%	0.83	**9.1**	4	36	770	1.7%	87,547	4	36	57	0.4%	1,105	0	0	713	2.3%	86,442
Solidified Inorganics	RF	RF-T010	0%	0.62	**9.1**	3	27	773	1.7%	87,574	3	27	60	0.4%	1,132	0	0	713	2.3%	86,442
Solidified Inorganics	SR	T001-221F-VIT	100%	23.15	**8.2**	111	916	885	1.9%	88,490	0	0	60	0.4%	1,132	111	916	824	2.7%	87,358
Solidified Inorganics	SR	T001-221H-VIT	100%	33.80	**8.2**	163	1324	1,047	2.3%	89,814	0	0	60	0.4%	1,132	163	1324	987	3.2%	88,683
Solidified Inorganics	SR	T001-773A-VIT	100%	0.40	**8.1**	2	15	1,049	2.3%	89,830	0	0	60	0.4%	1,132	2	15	989	3.2%	88,698
Solidified Inorganics	SR	T001-772F-VIT	100%	0.19	**8.1**	1	7	1,050	2.3%	89,837	0	0	60	0.4%	1,132	1	7	989	3.2%	88,705
Solidified Inorganics	SR	T001-235F-VIT	100%	1.48	**8.1**	7	58	1,057	2.3%	89,895	0	0	60	0.4%	1,132	7	58	997	3.2%	88,763
Solidified Inorganics	RF	RF-TT0802	0%	7.49	**7.6**	36	272	1,093	2.4%	90,167	36	272	96	0.6%	1,404	0	0	997	3.2%	88,763
Solidified Inorganics	IN	IN-W216.98	0%	555.65	**6.3**	2671	16805	3,764	8.1%	106,971	2671	16805	2,768	17.7%	18,209	0	0	997	3.2%	88,763
Solidified Inorganics	IN	IN-W216.875	100%	1,478.88	**6.3**	7110	44727	10,874	23.5%	151,698	0	0	2,768	17.7%	18,209	7110	44727	8,107	26.4%	133,490

Table A-2, Generator Waste Stream Totals Sorted by Final Waste Form and Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96						Total of All Stored Drums					Stored Not to be Processed					Stored To be Processed				
Final Waste Form	SITE	TWBIR_ ID	% to be Processed	Stored m3	Av. PECi / Drum	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Solidified Inorganics	RF	RF-MT0807	0%	73.42	6.1	353	2144	11,227	24.2%	153,843	353	2144	3,121	19.9%	20,353	0	0	8,107	26.4%	133,490
Solidified Inorganics	RF	RF-MT0800	0%	65.52	6.0	315	1904	11,542	24.9%	155,747	315	1904	3,436	22.0%	22,257	0	0	8,107	26.4%	133,490
Solidified Inorganics	RF	RF-MT0803	0%	2.91	5.9	14	83	11,556	24.9%	155,830	14	83	3,450	22.0%	22,341	0	0	8,107	26.4%	133,490
Solidified Inorganics	IN	IN-W163.1007	0%	0.68	5.8	3	19	11,560	25.0%	155,849	3	19	3,453	22.1%	22,359	0	0	8,107	26.4%	133,490
Solidified Inorganics	LA	LA-W006	92%	552.19	3.9	2655	10233	14,214	30.7%	166,082	220	846	3,673	23.5%	23,206	2435	9387	10,542	34.4%	142,876
Solidified Inorganics	IN	IN-W177.1083	100%	141.02	3.1	678	2107	14,892	32.2%	168,189	0	0	3,673	23.5%	23,206	678	2107	11,220	36.6%	144,983
Solidified Inorganics	IN	IN-W177.156	0%	39.23	3.1	189	586	15,081	32.6%	168,775	189	586	3,861	24.7%	23,792	0	0	11,220	36.6%	144,983
Solidified Inorganics	IN	IN-W174.154	0%	134.32	2.7	646	1752	15,727	34.0%	170,527	646	1752	4,507	28.8%	25,543	0	0	11,220	36.6%	144,983
Solidified Inorganics	IN	IN-W174.1082	100%	30.37	2.7	146	396	15,873	34.3%	170,923	0	0	4,507	28.8%	25,543	146	396	11,366	37.1%	145,379
Solidified Inorganics	IN	IN-W222.965	100%	10.61	2.2	51	114	15,924	34.4%	171,037	0	0	4,507	28.8%	25,543	51	114	11,417	37.2%	145,493
Solidified Inorganics	IN	IN-W222.116	0%	24.75	2.2	119	266	16,043	34.6%	171,303	119	266	4,626	29.6%	25,809	0	0	11,417	37.2%	145,493
Solidified Inorganics	IN	IN-W332.962	100%	0.83	1.9	4	8	16,047	34.6%	171,310	0	0	4,626	29.6%	25,809	4	8	11,421	37.2%	145,501
Solidified Inorganics	IN	IN-W332.661	0%	0.68	1.9	3	6	16,050	34.6%	171,317	3	6	4,629	29.6%	25,816	0	0	11,421	37.2%	145,501
Solidified Inorganics	IN	IN-W220.114	0%	122.80	1.6	590	937	16,640	35.9%	172,254	590	937	5,220	33.3%	26,753	0	0	11,421	37.2%	145,501
Solidified Inorganics	IN	IN-W220.925	0%	443.04	1.6	2130	3381	18,770	40.5%	175,635	2130	3381	7,350	47.0%	30,134	0	0	11,421	37.2%	145,501
Solidified Inorganics	RL	RL-W394	0%	3.12	1.5	15	22	18,785	40.6%	175,657	15	22	7,365	47.1%	30,156	0	0	11,421	37.2%	145,501
Solidified Inorganics	NT	NT-W021	100%	5.67	1.5	27	40	18,813	40.6%	175,697	0	0	7,365	47.1%	30,156	27	40	11,448	37.3%	145,541
Solidified Inorganics	IN	IN-W179.158	0%	1.51	1.2	7	9	18,820	40.6%	175,706	7	9	7,372	47.1%	30,165	0	0	11,448	37.3%	145,541
Solidified Inorganics	IN	IN-W179.1084	100%	4.58	1.2	22	27	18,842	40.7%	175,733	0	0	7,372	47.1%	30,165	22	27	11,470	37.4%	145,568
Solidified Inorganics	RF	RF-TT0823	0%	7.07	1.1	34	36	18,876	40.8%	175,770	34	36	7,406	47.3%	30,202	0	0	11,470	37.4%	145,568
Solidified Inorganics	IN	IN-W166.928	100%	56.78	1.0	273	275	19,149	41.3%	176,045	0	0	7,406	47.3%	30,202	273	275	11,743	38.3%	145,843
Solidified Inorganics	IN	IN-W166.151	0%	16.00	1.0	77	77	19,226	41.5%	176,122	77	77	7,483	47.8%	30,279	0	0	11,743	38.3%	145,843
Solidified Inorganics	MD	MD-W002	100%	1.87	0.9	9	8	19,235	41.5%	176,130	0	0	7,483	47.8%	30,279	9	8	11,752	38.3%	145,851
Solidified Inorganics	RL	RL-W383	100%	9.45	0.8	45	37	19,280	41.6%	176,166	0	0	7,483	47.8%	30,279	45	37	11,797	38.5%	145,887
Solidified Inorganics	IN	IN-W187.1094	0%	0.68	0.8	3	3	19,284	41.6%	176,169	3	3	7,486	47.8%	30,282	0	0	11,797	38.5%	145,887
Solidified Inorganics	IN	IN-W347.646	100%	51.79	0.7	249	165	19,533	42.2%	176,334	0	0	7,486	47.8%	30,282	249	165	12,046	39.3%	146,052
Solidified Inorganics	IN	IN-W347.818	0%	3.44	0.7	17	11	19,549	42.2%	176,344	17	11	7,503	47.9%	30,293	0	0	12,046	39.3%	146,052
Solidified Inorganics	IN	IN-W247.523	100%	173.68	0.5	835	443	20,384	44.0%	176,787	0	0	7,503	47.9%	30,293	835	443	12,881	42.0%	146,494
Solidified Inorganics	IN	IN-W221.927	0%	3.65	0.4	18	8	20,402	44.0%	176,795	18	8	7,520	48.0%	30,300	0	0	12,881	42.0%	146,494
Solidified Inorganics	IN	IN-W221.113	100%	11.65	0.4	56	25	20,458	44.2%	176,819	0	0	7,520	48.0%	30,300	56	25	12,937	42.2%	146,519
Solidified Inorganics	LL	LL-T001	0%	14.35	0.4	69	26	20,527	44.3%	176,846	69	26	7,589	48.5%	30,327	0	0	12,937	42.2%	146,519
Solidified Inorganics	LA	LA-M002	100%	3,053.53	0.4	14680	5446	35,207	76.0%	182,291	0	0	7,589	48.5%	30,327	14680	5446	27,618	90.0%	151,965
Solidified Inorganics	IN	IN-W188.1093	100%	1.04	0.3	5	2	35,212	76.0%	182,293	0	0	7,589	48.5%	30,327	5	2	27,623	90.1%	151,966
Solidified Inorganics	IN	IN-W188.160	0%	0.68	0.3	3	1	35,215	76.0%	182,294	3	1	7,592	48.5%	30,328	0	0	27,623	90.1%	151,966
Solidified Inorganics	IN	IN-W263.520	100%	14.35	0.3	69	19	35,284	76.2%	182,313	0	0	7,592	48.5%	30,328	69	19	27,692	90.3%	151,985
Solidified Inorganics	IN	IN-W218.909	0%	101.91	0.2	490	107	35,774	77.2%	182,420	490	107	8,082	51.6%	30,435	0	0	27,692	90.3%	151,985
Solidified Inorganics	IN	IN-W257.947	0%	0.68	0.2	3	1	35,778	77.2%	182,421	3	1	8,086	51.7%	30,436	0	0	27,692	90.3%	151,985
Solidified Inorganics	LA	LA-W003	0%	1,277.48	0.2	6142	1016	41,919	90.5%	183,436	6138	1015	14,223	90.9%	31,451	4	1	27,696	90.3%	151,986
Solidified Inorganics	IN	IN-W228.101	0%	287.33	0.1	1381	150	43,301	93.5%	183,587	1381	150	15,605	99.7%	31,601	0	0	27,696	90.3%	151,986
Solidified Inorganics	IN	IN-W228.883	100%	608.82	0.1	2927	319	46,228	99.8%	183,906	0	0	15,605	99.7%	31,601	2927	319	30,623	99.8%	152,305
Solidified Inorganics	IN	IN-W181.162	100%	9.57	0.1	46	4	46,274	99.9%	183,910	0	0	15,605	99.7%	31,601	46	4	30,669	100.0%	152,308
Solidified Inorganics	IN	IN-W375.1096	0%	4.48	0.1	22	1	46,295	99.9%	183,911	22	1	15,626	99.8%	31,602	0	0	30,669	100.0%	152,308
Solidified Inorganics	IN	IN-W353.859	0%	0.68	0.0	3	0	46,299	100.0%	183,911	3	0	15,630	99.9%	31,602	0	0	30,669	100.0%	152,308
Solidified Inorganics	IN	IN-W353.917	100%	0.21	0.0	1	0	46,300	100.0%	183,911	0	0	15,630	99.9%	31,602	1	0	30,670	100.0%	152,309
Solidified Inorganics	MD	MD-T001	0%	4.16	0.0	20	0	46,320	100.0%	183,911	20	0	15,650	100.0%	31,603	0	0	30,670	100.0%	152,309
Solidified Inorganics	RL	RL-W281	0%	0.37	0.0	2	0	46,321	100.0%	183,911	2	0	15,651	100.0%	31,603	0	0	30,670	100.0%	152,309

Table A-2, Generator Waste Stream Totals Sorted by Final Waste Form and Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96						Total of All Stored Drums					Stored Not to be Processed					Stored To be Processed				
Final Waste Form	SITE	TWBIR_ ID	% to be Processed	Stored m3	Av. PECi / Drum	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Final Waste Form Average PE-Ci/drum									4.0 PE-CI/drum					2.0 PE-CI/drum					5.0 PE-CI/drum	
Solidified Organics	IN	IN-W321.1023	0%	1.30	9.2	6	58	6	0.1%	58	6	58	6	0.6%	58	0	0	0	0.0%	0
Solidified Organics	IN	IN-W319.584	0%	0.68	4.6	3	15	10	0.2%	73	3	15	10	0.9%	73	0	0	0	0.0%	0
Solidified Organics	IN	IN-W317.757	100%	39.10	3.3	188	619	198	4.5%	691	0	0	10	0.9%	73	188	619	188	5.7%	619
Solidified Organics	IN	IN-W317.758	0%	11.51	3.3	55	182	253	5.8%	874	55	182	65	6.0%	255	0	0	188	5.7%	619
Solidified Organics	RF	RF-MT0801	0%	108.99	3.0	524	1553	777	17.7%	2,426	524	1553	589	54.7%	1,808	0	0	188	5.7%	619
Solidified Organics	RF	RF-MT0003	0%	0.62	3.0	3	9	780	17.8%	2,435	3	9	592	55.0%	1,816	0	0	188	5.7%	619
Solidified Organics	RL	RL-W285	0%	1.21	2.8	6	16	786	17.9%	2,451	6	16	598	55.5%	1,833	0	0	188	5.7%	619
Solidified Organics	RL	RL-W348	0%	0.21	0.9	1	1	787	17.9%	2,452	1	1	599	55.6%	1,833	0	0	188	5.7%	619
Solidified Organics	RL	RL-W380	0%	0.21	0.8	1	1	788	18.0%	2,453	1	1	600	55.7%	1,834	0	0	188	5.7%	619
Solidified Organics	LA	LA-T002	0%	1.46	0.6	7	4	795	18.1%	2,457	7	4	607	56.3%	1,838	0	0	188	5.7%	619
Solidified Organics	RF	RF-MT0375	0%	0.21	0.4	1	0	796	18.1%	2,457	1	0	608	56.4%	1,839	0	0	188	5.7%	619
Solidified Organics	LL	LL-W019	0%	1.04	0.3	5	2	801	18.2%	2,459	5	2	613	56.9%	1,840	0	0	188	5.7%	619
Solidified Organics	IN	IN-W157.906	100%	163.70	0.3	787	212	1,588	36.2%	2,671	0	0	613	56.9%	1,840	787	212	975	29.4%	831
Solidified Organics	IN	IN-W157.144	0%	49.92	0.3	240	65	1,828	41.7%	2,736	240	65	853	79.2%	1,905	0	0	975	29.4%	831
Solidified Organics	RL	RL-W345	0%	2.08	0.3	10	3	1,838	41.9%	2,739	10	3	863	80.1%	1,908	0	0	975	29.4%	831
Solidified Organics	IN	IN-W167.926	100%	131.46	0.2	632	145	2,470	56.3%	2,883	0	0	863	80.1%	1,908	632	145	1,607	48.5%	976
Solidified Organics	IN	IN-W167.149	0%	36.68	0.2	176	40	2,646	60.3%	2,924	176	40	1,039	96.5%	1,948	0	0	1,607	48.5%	976
Solidified Organics	RL	RL-W333	0%	1.25	0.2	6	1	2,652	60.4%	2,925	6	1	1,045	97.0%	1,949	0	0	1,607	48.5%	976
Solidified Organics	RL	RL-W329	0%	2.08	0.2	10	2	2,662	60.7%	2,927	10	2	1,055	98.0%	1,951	0	0	1,607	48.5%	976
Solidified Organics	RL	RL-W326	0%	1.87	0.2	9	2	2,671	60.9%	2,929	9	2	1,064	98.8%	1,953	0	0	1,607	48.5%	976
Solidified Organics	IN	IN-W309.610	100%	352.77	0.1	1696	200	4,367	99.5%	3,129	0	0	1,064	98.8%	1,953	1696	200	3,303	99.8%	1,176
Solidified Organics	RL	RL-W280	0%	0.21	0.1	1	0	4,368	99.5%	3,129	1	0	1,065	98.9%	1,953	0	0	3,303	99.8%	1,176
Solidified Organics	RL	RL-W286	0%	0.21	0.1	1	0	4,369	99.6%	3,129	1	0	1,066	99.0%	1,953	0	0	3,303	99.8%	1,176
Solidified Organics	IN	IN-W164.1060	100%	1.66	0.1	8	1	4,377	99.8%	3,130	0	0	1,066	99.0%	1,953	8	1	3,311	100.0%	1,177
Solidified Organics	IN	IN-W164.153	0%	0.89	0.1	4	0	4,381	99.8%	3,131	4	0	1,070	99.4%	1,954	0	0	3,311	100.0%	1,177
Solidified Organics	RL	RL-W338	0%	0.21	0.1	1	0	4,382	99.9%	3,131	1	0	1,071	99.5%	1,954	0	0	3,311	100.0%	1,177
Solidified Organics	RL	RL-W344	0%	0.21	0.1	1	0	4,383	99.9%	3,131	1	0	1,072	99.6%	1,954	0	0	3,311	100.0%	1,177
Solidified Organics	RL	RL-W361	0%	0.62	0.1	3	0	4,386	100.0%	3,131	3	0	1,075	99.9%	1,954	0	0	3,311	100.0%	1,177
Solidified Organics	RL	RL-W282	0%	0.33	0.0	2	0	4,388	100.0%	3,131	2	0	1,077	100.0%	1,954	0	0	3,311	100.0%	1,177
Final Waste Form Average PE-Ci/drum									0.7 PE-CI/drum					1.8 PE-CI/drum					0.4 PE-CI/drum	
Uncategorized Metal	IN	IN-W371.1018	100%	0.21	127.9	1	128	1	0.0%	128	0	0	0	0.0%	0	1	128	1	0.0%	128
Uncategorized Metal	IN	IN-W371.831	0%	0.68	127.9	3	419	4	0.0%	546	3	419	3	0.1%	419	0	0	1	0.0%	128
Uncategorized Metal	IN	IN-W280.1066	100%	28.50	121.2	137	16598	141	0.3%	17,145	0	0	3	0.1%	419	137	16598	138	0.3%	16,726
Uncategorized Metal	IN	IN-W280.448	0%	8.34	121.2	40	4857	181	0.3%	22,001	40	4857	43	1.3%	5,275	0	0	138	0.3%	16,726
Uncategorized Metal	IN	IN-W358.855	100%	3.33	120.1	16	1921	197	0.4%	23,922	0	0	43	1.3%	5,275	16	1921	154	0.3%	18,647
Uncategorized Metal	IN	IN-W358.854	0%	0.89	120.1	4	513	202	0.4%	24,435	4	513	48	1.4%	5,788	0	0	154	0.3%	18,647
Uncategorized Metal	IN	IN-W159.119	100%	0.21	47.2	1	47	203	0.4%	24,482	0	0	48	1.4%	5,788	1	47	155	0.3%	18,694
Uncategorized Metal	IN	IN-W214.756	100%	0.21	46.0	1	46	204	0.4%	24,528	0	0	48	1.4%	5,788	1	46	156	0.3%	18,740
Uncategorized Metal	IN	IN-W280.449	100%	0.21	40.4	1	40	205	0.4%	24,569	0	0	48	1.4%	5,788	1	40	157	0.3%	18,781
Uncategorized Metal	IN	IN-W249.528	100%	0.21	35.6	1	36	206	0.4%	24,604	0	0	48	1.4%	5,788	1	36	158	0.3%	18,816
Uncategorized Metal	RF	RF-MT0320	0%	1.46	33.9	7	238	213	0.4%	24,842	7	238	55	1.6%	6,026	0	0	158	0.3%	18,816
Uncategorized Metal	IN	IN-W213.253	100%	0.21	33.1	1	33	214	0.4%	24,875	0	0	55	1.6%	6,026	1	33	159	0.3%	18,849
Uncategorized Metal	IN	IN-W359.853	100%	0.83	25.1	4	100	218	0.4%	24,975	0	0	55	1.6%	6,026	4	100	163	0.3%	18,950
Uncategorized Metal	SR	W027-772F-MET	100%	32.13	21.5	154	3318	372	0.7%	28,293	0	0	55	1.6%	6,026	154	3318	317	0.7%	22,268

Table A-2, Generator Waste Stream Totals Sorted by Final Waste Form and Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96						Total of All Stored Drums					Stored Not to be Processed					Stored To be Processed				
Final Waste Form	SITE	TWBIR_ ID	% to be Processed	Stored m3	Av. PECi / Drum	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Uncategorized Metal	SR	W027-773A-MET	100%	7.56	21.5	36	781	408	0.8%	29,074	0	0	55	1.6%	6,026	36	781	354	0.7%	23,048
Uncategorized Metal	SR	W027-221F-MET	100%	1.89	21.5	9	195	418	0.8%	29,269	0	0	55	1.6%	6,026	9	195	363	0.7%	23,244
Uncategorized Metal	SR	W027-221H-MET	100%	1.89	21.5	9	195	427	0.8%	29,465	0	0	55	1.6%	6,026	9	195	372	0.8%	23,439
Uncategorized Metal	SR	W027-235F-MET	100%	1.89	21.5	9	195	436	0.8%	29,660	0	0	55	1.6%	6,026	9	195	381	0.8%	23,634
Uncategorized Metal	RF	RF-TT0320	0%	4.58	15.5	22	342	458	0.9%	30,001	22	342	77	2.3%	6,367	0	0	381	0.8%	23,634
Uncategorized Metal	SR	T001-221F-MET	100%	23.81	12.5	114	1427	572	1.1%	31,428	0	0	77	2.3%	6,367	114	1427	496	1.0%	25,061
Uncategorized Metal	SR	T001-221H-MET	100%	0.79	12.1	4	46	576	1.1%	31,475	0	0	77	2.3%	6,367	4	46	499	1.0%	25,107
Uncategorized Metal	SR	T001-773A-MET	100%	0.38	12.0	2	22	578	1.1%	31,496	0	0	77	2.3%	6,367	2	22	501	1.0%	25,129
Uncategorized Metal	IN	IN-W304.861	100%	59.07	10.4	284	2949	862	1.7%	34,446	0	0	77	2.3%	6,367	284	2949	785	1.6%	28,079
Uncategorized Metal	IN	IN-W304.860	0%	8.75	10.4	42	437	904	1.7%	34,883	42	437	119	3.5%	6,804	0	0	785	1.6%	28,079
Uncategorized Metal	LA	LA-W005	98%	214.71	8.6	1032	8921	1,936	3.7%	43,804	19	168	138	4.1%	6,973	1013	8753	1,798	3.7%	36,831
Uncategorized Metal	RF	RF-TT0481	0%	0.21	7.3	1	7	1,937	3.7%	43,811	1	7	139	4.2%	6,980	0	0	1,798	3.7%	36,831
Uncategorized Metal	LA	LA-T005	97%	1,503.03	5.4	7226	38837	9,163	17.6%	82,648	216	1163	356	10.6%	8,143	7010	37674	8,808	18.1%	74,506
Uncategorized Metal	RF	RF-TT0824	0%	9.78	4.0	47	190	9,210	17.7%	82,839	47	190	403	12.0%	8,333	0	0	8,808	18.1%	74,506
Uncategorized Metal	RF	RF-TT0480	0%	77.29	4.0	372	1481	9,582	18.4%	84,320	372	1481	774	23.1%	9,815	0	0	8,808	18.1%	74,506
Uncategorized Metal	RL	RL-W299	0%	0.62	3.4	3	10	9,585	18.4%	84,330	3	10	777	23.2%	9,825	0	0	8,808	18.1%	74,506
Uncategorized Metal	IN	IN-W271.533	100%	0.21	3.4	1	3	9,586	18.4%	84,334	0	0	777	23.2%	9,825	1	3	8,809	18.1%	74,509
Uncategorized Metal	IN	IN-W298.317	100%	54.70	3.4	263	883	9,849	18.9%	85,217	0	0	777	23.2%	9,825	263	883	9,072	18.6%	75,392
Uncategorized Metal	RL	RL-W295	0%	1.87	2.8	9	25	9,858	18.9%	85,241	9	25	786	23.5%	9,850	0	0	9,072	18.6%	75,392
Uncategorized Metal	RL	RL-W297	0%	1.66	2.8	8	22	9,866	18.9%	85,264	8	22	794	23.7%	9,872	0	0	9,072	18.6%	75,392
Uncategorized Metal	RL	RL-W288	0%	1.04	2.8	5	14	9,871	18.9%	85,277	5	14	799	23.9%	9,886	0	0	9,072	18.6%	75,392
Uncategorized Metal	RL	RL-W291	94%	7.98	2.8	38	106	9,909	19.0%	85,384	2	6	801	23.9%	9,892	36	100	9,108	18.7%	75,492
Uncategorized Metal	RL	RL-W396	0%	0.21	2.5	1	2	9,910	19.0%	85,386	1	2	802	24.0%	9,894	0	0	9,108	18.7%	75,492
Uncategorized Metal	RL	RL-W399	0%	0.21	1.9	1	2	9,911	19.0%	85,388	1	2	803	24.0%	9,896	0	0	9,108	18.7%	75,492
Uncategorized Metal	IN	IN-W342.652	0%	0.68	1.7	3	6	9,914	19.0%	85,394	3	6	807	24.1%	9,902	0	0	9,108	18.7%	75,492
Uncategorized Metal	IN	IN-W342.953	100%	0.42	1.7	2	3	9,916	19.0%	85,397	0	0	807	24.1%	9,902	2	3	9,110	18.7%	75,495
Uncategorized Metal	MD	MD-T007	78%	23.89	1.6	115	183	10,031	19.3%	85,580	25	40	831	24.8%	9,941	90	143	9,200	18.9%	75,639
Uncategorized Metal	RL	RL-W395	41%	23.39	1.6	112	176	10,144	19.5%	85,756	66	103	897	26.8%	10,045	46	73	9,246	19.0%	75,712
Uncategorized Metal	IN	IN-W204.217	100%	0.21	1.1	1	1	10,145	19.5%	85,757	0	0	897	26.8%	10,045	1	1	9,247	19.0%	75,713
Uncategorized Metal	RL	RL-W390	0%	0.62	1.0	3	3	10,148	19.5%	85,760	3	3	900	26.9%	10,048	0	0	9,247	19.0%	75,713
Uncategorized Metal	RL	RL-W386	0%	0.42	1.0	2	2	10,150	19.5%	85,762	2	2	902	27.0%	10,050	0	0	9,247	19.0%	75,713
Uncategorized Metal	RL	RL-W355	0%	2.08	1.0	10	10	10,160	19.5%	85,773	10	10	912	27.3%	10,060	0	0	9,247	19.0%	75,713
Uncategorized Metal	RL	RL-W370	0%	0.42	1.0	2	2	10,162	19.5%	85,775	2	2	914	27.3%	10,062	0	0	9,247	19.0%	75,713
Uncategorized Metal	RL	RL-W346	0%	0.42	0.9	2	2	10,164	19.5%	85,776	2	2	916	27.4%	10,064	0	0	9,247	19.0%	75,713
Uncategorized Metal	RL	RL-W350	0%	0.21	0.9	1	1	10,165	19.5%	85,777	1	1	917	27.4%	10,065	0	0	9,247	19.0%	75,713
Uncategorized Metal	RL	RL-W385	0%	8.11	0.8	39	33	10,204	19.6%	85,810	39	33	956	28.6%	10,097	0	0	9,247	19.0%	75,713
Uncategorized Metal	RL	RL-W402	0%	1.25	0.8	6	5	10,210	19.6%	85,815	6	5	962	28.7%	10,102	0	0	9,247	19.0%	75,713
Uncategorized Metal	IN	IN-W294.342	100%	406.85	0.8	1956	1608	12,166	23.4%	87,423	0	0	962	28.7%	10,102	1956	1608	11,203	23.0%	77,321
Uncategorized Metal	IN	IN-W294.814	0%	33.50	0.8	161	132	12,327	23.7%	87,555	161	132	1,123	33.6%	10,235	0	0	11,203	23.0%	77,321
Uncategorized Metal	IN	IN-W287.460	0%	211.95	0.6	1019	636	13,346	25.6%	88,191	1019	636	2,142	64.0%	10,870	0	0	11,203	23.0%	77,321
Uncategorized Metal	RL	RL-W362	0%	2.91	0.6	14	8	13,360	25.6%	88,199	14	8	2,156	64.4%	10,878	0	0	11,203	23.0%	77,321
Uncategorized Metal	RL	RL-W363	0%	0.21	0.5	1	1	13,361	25.6%	88,199	1	1	2,157	64.4%	10,879	0	0	11,203	23.0%	77,321
Uncategorized Metal	RL	RL-W369	68%	33.50	0.5	161	81	13,522	26.0%	88,281	52	26	2,210	66.0%	10,905	109	55	11,312	23.2%	77,375
Uncategorized Metal	RL	RL-W307	100%	1.89	0.5	9	4	13,531	26.0%	88,285	0	0	2,210	66.0%	10,905	9	4	11,321	23.2%	77,380
Uncategorized Metal	RL	RL-W319	100%	7.56	0.5	36	17	13,567	26.0%	88,302	0	0	2,210	66.0%	10,905	36	17	11,358	23.3%	77,397
Uncategorized Metal	RL	RL-W324	100%	3.78	0.5	18	9	13,586	26.1%	88,311	0	0	2,210	66.0%	10,905	18	9	11,376	23.3%	77,406
Uncategorized Metal	RL	RL-W334	0%	0.21	0.5	1	0	13,587	26.1%	88,311	1	0	2,211	66.0%	10,906	0	0	11,376	23.3%	77,406

Table A-2, Generator Waste Stream Totals Sorted by Final Waste Form and Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96						Total of All Stored Drums					Stored Not to be Processed					Stored To be Processed				
Final Waste Form	SITE	TWBIR_ ID	% to be Processed	Stored m3	Av. PECi / Drum	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	Total Equiv. Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Uncategorized Metal	IN	IN-W300.930	0%	4.69	0.5	23	11	13,609	26.1%	88,322	23	11	2,233	66.7%	10,916	0	0	11,376	23.3%	77,406
Uncategorized Metal	IN	IN-W300.308	100%	1,509.46	0.5	7257	3466	20,866	40.1%	91,788	0	0	2,233	66.7%	10,916	7257	3466	18,633	38.2%	80,872
Uncategorized Metal	LA	LA-W001	96%	2,203.35	0.5	10593	5017	31,459	60.4%	96,806	406	193	2,640	78.9%	11,109	10187	4825	28,819	59.1%	85,697
Uncategorized Metal	RL	RL-W375	96%	21.62	0.4	104	37	31,563	60.6%	96,842	4	1	2,644	79.0%	11,110	100	35	28,919	59.3%	85,732
Uncategorized Metal	RL	RL-W374	59%	182.40	0.3	877	305	32,440	62.3%	97,147	359	125	3,003	89.7%	11,235	518	180	29,437	60.4%	85,912
Uncategorized Metal	RL	RL-W308	0%	0.42	0.3	2	1	32,442	62.3%	97,148	2	1	3,005	89.8%	11,236	0	0	29,437	60.4%	85,912
Uncategorized Metal	LA	LA-T009	100%	53.54	0.3	257	67	32,699	62.8%	97,215	0	0	3,005	89.8%	11,236	257	67	29,694	60.9%	85,979
Uncategorized Metal	RL	RL-W330	100%	32.13	0.2	154	35	32,854	63.1%	97,250	0	0	3,005	89.8%	11,236	154	35	29,849	61.2%	86,014
Uncategorized Metal	RL	RL-W327	100%	66.15	0.2	318	69	33,172	63.7%	97,319	0	0	3,005	89.8%	11,236	318	69	30,167	61.9%	86,083
Uncategorized Metal	RL	RL-W313	82%	9.22	0.2	44	10	33,216	63.8%	97,329	8	2	3,013	90.0%	11,238	36	8	30,203	62.0%	86,091
Uncategorized Metal	RL	RL-W320	0%	1.66	0.2	8	2	33,224	63.8%	97,331	8	2	3,021	90.2%	11,239	0	0	30,203	62.0%	86,091
Uncategorized Metal	IN	IN-W296.327	100%	3,450.30	0.2	16588	3187	49,812	95.6%	100,518	0	0	3,021	90.2%	11,239	16588	3187	46,791	96.0%	89,279
Uncategorized Metal	IN	IN-W296.813	0%	47.99	0.2	231	44	50,043	96.1%	100,562	231	44	3,252	97.1%	11,283	0	0	46,791	96.0%	89,279
Uncategorized Metal	LA	LA-T001	98%	95.96	0.2	461	79	50,504	96.9%	100,641	10	2	3,262	97.4%	11,285	452	77	47,243	96.9%	89,356
Uncategorized Metal	LA	LA-W009	100%	143.85	0.1	692	97	51,196	98.3%	100,738	1	0	3,263	97.5%	11,285	691	97	47,933	98.3%	89,453
Uncategorized Metal	RL	RL-W341	0%	0.21	0.1	1	0	51,197	98.3%	100,738	1	0	3,264	97.5%	11,285	0	0	47,933	98.3%	89,453
Uncategorized Metal	IN	IN-W203.212	100%	0.21	0.1	1	0	51,198	98.3%	100,738	0	0	3,264	97.5%	11,285	1	0	47,934	98.3%	89,453
Uncategorized Metal	MD	MD-T006	100%	58.59	0.1	282	18	51,480	98.8%	100,756	0	0	3,264	97.5%	11,285	282	18	48,216	98.9%	89,471
Uncategorized Metal	RL	RL-W359	0%	16.64	0.1	80	5	51,560	99.0%	100,761	80	5	3,344	99.9%	11,290	0	0	48,216	98.9%	89,471
Uncategorized Metal	IN	IN-W228.103	100%	31.82	0.0	153	6	51,713	99.3%	100,766	0	0	3,344	99.9%	11,290	153	6	48,369	99.2%	89,476
Uncategorized Metal	RL	RL-W373	99%	80.21	0.0	386	10	52,098	100.0%	100,776	4	0	3,348	100.0%	11,290	382	9	48,751	100.0%	89,486
Final Waste Form Average PE-Ci/drum									**1.9 PE-CI/drum**					**3.4 PE-CI/drum**					**1.8 PE-CI/drum**	
Unknown	OR	OR-W049	91%	17.68	32.1	85	2727	85	26.8%	2,727	8	256	8	6.2%	256	77	2472	77	41.1%	2,472
Unknown	MD	MD-T004	85%	26.84	6.2	129	797	214	67.5%	3,524	19	120	27	21.2%	376	110	676	187	99.5%	3,148
Unknown	RL	RL-W284	0%	0.42	2.6	2	5	216	68.2%	3,529	2	5	29	22.8%	381	0	0	187	99.5%	3,148
Unknown	RL	RL-W391	0%	0.42	1.0	2	2	218	68.8%	3,531	2	2	31	24.3%	383	0	0	187	99.5%	3,148
Unknown	RL	RL-W366	0%	1.46	0.6	7	4	225	71.0%	3,536	7	4	38	29.7%	388	0	0	187	99.5%	3,148
Unknown	RL	RL-W332	100%	0.20	0.5	1	0	226	71.3%	3,536	0	0	38	29.7%	388	1	0	188	100.0%	3,149
Unknown	RL	RL-W382	0%	18.72	0.3	90	30	316	99.7%	3,567	90	30	128	99.2%	418	0	0	188	100.0%	3,149
Unknown	RL	RL-W357	0%	0.21	0.0	1	0	317	100.0%	3,567	1	0	129	100.0%	418	0	0	188	100.0%	3,149
Final Waste Form Average PE-Ci/drum									**11.3 PE-CI/drum**					**3.2 PE-CI/drum**					**16.8 PE-CI/drum**	
Various RF Residues	RF	RF-RESIDUES	100%	4,181.91	18.2	20105	366439	20,105	0.0%	366,439	0	0	0	0.0%	0	20105	366439	20,105	100.0%	366,439

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum														
Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)							CumulativeTotal of All Stored Drums				
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Inorganic Non-Metal	IN	IN-W213.252	**1655.1**	0.0	0.0	1600.7	10.7	0.0	0.0	2	3310	2	0.0%	3,310
Inorganic Non-Metal	IN	IN-W321.578	**924.4**	0.0	0.0	22.2	693.7	153.1	54.9	1	924	3	0.0%	4,235
Heterogeneous	SR-OFF	W027-999-HET	**788.4**	0.5	0.0	765.9	0.6	0.3	0.1	133	104853	136	0.0%	109,088
Solidified Inorganics	SR-OFF	W027-999-VIT	**511.8**	0.3	0.0	497.6	0.0	0.2	0.1	153	78373	289	0.1%	187,461
Inorganic Non-Metal	IN	IN-W319.583	**456.9**	0.0	0.0	10.9	342.9	75.7	27.1	1	457	290	0.1%	187,918
Inorganic Non-Metal	IN	IN-W358.948	**400.1**	0.0	0.0	384.1	1.9	3.6	0.0	1	400	291	0.1%	188,318
Inorganic Non-Metal	IN	IN-W367.840	**379.7**	0.0	0.0	9.1	284.9	62.9	22.5	1	380	292	0.1%	188,698
Inorganic Non-Metal	IN	IN-W159.120	**282.9**	0.0	0.0	273.2	2.2	0.0	0.0	2	566	294	0.1%	189,263
Inorganic Non-Metal	IN	IN-W281.488	**273.7**	0.0	0.0	265.0	1.4	0.0	0.0	3	821	297	0.1%	190,084
Inorganic Non-Metal	IN	IN-W252.1000	**191.1**	6.0	0.0	4.4	139.0	30.7	11.0	1	191	298	0.1%	190,275
Inorganic Non-Metal	IN	IN-W329.682	**145.3**	0.0	0.0	141.4	0.1	0.0	0.0	1	145	299	0.1%	190,421
Solidified Inorganics	IN	IN-W159.1072	**141.5**	0.0	0.0	136.6	1.1	0.0	0.0	3	463	302	0.1%	190,884
Filter	IN	IN-W214.1075	**138.0**	0.0	0.0	133.1	1.3	0.0	0.0	3	414	305	0.1%	191,298
Filter	IN	IN-W214.755	**138.0**	0.0	0.0	133.1	1.3	0.0	0.0	3	452	309	0.1%	191,749
Uncategorized Metal	IN	IN-W371.1018	**127.9**	116.0	0.0	0.3	9.0	2.0	0.7	1	128	310	0.1%	191,877
Uncategorized Metal	IN	IN-W371.831	**127.9**	116.0	0.0	0.3	9.0	2.0	0.7	3	419	313	0.1%	192,296
Uncategorized Metal	IN	IN-W280.1066	**121.2**	0.0	0.0	117.1	0.9	0.0	0.0	137	16598	450	0.2%	208,894
Uncategorized Metal	IN	IN-W280.448	**121.2**	0.0	0.0	117.1	0.9	0.0	0.0	40	4857	490	0.2%	213,751
Uncategorized Metal	IN	IN-W358.855	**120.1**	0.0	0.0	115.2	0.6	1.1	0.0	16	1921	506	0.2%	215,671
Uncategorized Metal	IN	IN-W358.854	**120.1**	0.0	0.0	115.2	0.6	1.1	0.0	4	513	510	0.2%	216,184
Inorganic Non-Metal	IN	IN-W254.1044	**110.7**	0.0	0.0	2.7	83.1	18.3	6.6	1	111	511	0.2%	216,295
Inorganic Non-Metal	IN	IN-W249.1071	**106.9**	0.0	0.0	103.2	0.8	0.0	0.0	11	1176	522	0.2%	217,471
Inorganic Non-Metal	IN	IN-W249.527	**106.9**	0.0	0.0	103.2	0.8	0.0	0.0	5	563	528	0.2%	218,034
Filter	IN	IN-W213.1069	**99.3**	0.0	0.0	96.1	0.6	0.0	0.0	9	921	537	0.2%	218,955
Inorganic Non-Metal	IN	IN-W368.839	**97.4**	0.0	0.0	2.3	73.1	16.1	5.8	1	97	538	0.2%	219,052
Solidified Inorganics	SR	W006-773A-VIT	**94.9**	0.0	0.0	0.0	94.9	0.0	0.0	2	236	540	0.2%	219,289
Inorganic Non-Metal	IN	IN-W199.209	**94.7**	0.0	0.0	2.3	71.1	15.7	5.6	1	95	541	0.2%	219,384
Inorganic Non-Metal	IN	IN-W365.842	**62.8**	51.4	0.0	0.3	8.5	1.9	0.7	5	314	546	0.2%	219,697
Inorganic Non-Metal	IN	IN-W207.238	**60.8**	0.0	0.0	1.5	45.6	10.1	3.6	1	61	547	0.2%	219,758
Inorganic Non-Metal	IN	IN-W198.203	**60.2**	37.5	0.0	0.5	17.0	3.8	1.3	1	60	548	0.2%	219,818
Inorganic Non-Metal	IN	IN-W211.249	**50.3**	3.0	0.0	1.1	35.5	7.8	2.8	108	5433	656	0.2%	225,252
Uncategorized Metal	IN	IN-W159.119	**47.2**	0.0	0.0	45.5	0.4	0.0	0.0	1	47	657	0.2%	225,299
Uncategorized Metal	IN	IN-W214.756	**46.0**	0.0	0.0	44.4	0.4	0.0	0.0	1	46	658	0.2%	225,345
Heterogeneous	IN	IN-W350.650	**43.7**	0.0	0.0	0.0	11.0	32.7	0.0	3	143	662	0.2%	225,488

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum															
Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)							CumulativeTotal of All Stored Drums					
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Heterogeneous	IN	IN-W350.923	43.7	0.0	0.0	0.0	11.0	32.7	0.0	1	44	663	0.2%	225,532
Uncategorized Metal	IN	IN-W280.449	40.4	0.0	0.0	39.0	0.3	0.0	0.0	1	40	664	0.2%	225,572
Inorganic Non-Metal	IN	IN-W197.196	36.5	19.0	0.0	0.4	13.1	2.9	1.0	11	401	675	0.2%	225,973
Uncategorized Metal	IN	IN-W249.528	35.6	0.0	0.0	34.4	0.3	0.0	0.0	1	36	676	0.2%	226,009
Salt Waste	IN	IN-W311.1013	35.4	26.2	0.0	0.2	6.9	1.5	0.5	26	921	702	0.2%	226,930
Salt Waste	IN	IN-W311.604	35.4	26.2	0.0	0.2	6.9	1.5	0.5	8	293	710	0.3%	227,223
Inorganic Non-Metal	IN	IN-W291.455	34.4	12.1	0.0	0.0	4.2	18.1	0.0	7	240	717	0.3%	227,464
Uncategorized Metal	RF	RF-MT0320	33.9	5.9	0.0	0.0	11.2	15.2	1.7	7	238	724	0.3%	227,701
Uncategorized Metal	IN	IN-W213.253	33.1	0.0	0.0	32.0	0.2	0.0	0.0	1	33	725	0.3%	227,735
Unknown	OR	OR-W049	32.1	0.0	0.0	31.2	0.0	0.0	0.0	85	2727	810	0.3%	230,462
Combustible	MD	MD-W017	31.7	0.0	0.0	30.8	0.1	0.0	0.0	7	222	817	0.3%	230,684
Solidified Inorganics	SR-OFF	W053-773A-VIT	29.6	0.0	0.0	0.0	29.6	0.0	0.0	2	74	819	0.3%	230,757
Inorganic Non-Metal	IN	IN-W373.830	27.9	0.0	0.0	0.7	21.0	4.6	1.7	1	28	820	0.3%	230,785
Inorganic Non-Metal	IN	IN-W209.244	27.2	0.0	0.0	0.7	20.4	4.5	1.6	15	409	835	0.3%	231,194
Heterogeneous	OR	OR-W045	26.5	0.0	0.0	1.7	9.2	13.0	2.5	26	688	861	0.3%	231,882
Inorganic Non-Metal	IN	IN-W265.517	26.4	0.2	0.0	0.6	19.7	4.3	1.6	3	79	864	0.3%	231,961
Combustible	RF	RF-MT2116	25.9	12.7	0.0	0.0	7.0	5.6	0.6	10	259	874	0.3%	232,220
Uncategorized Metal	IN	IN-W359.853	25.1	0.0	0.0	24.4	0.0	0.0	0.0	4	100	878	0.3%	232,320
Inorganic Non-Metal	IN	IN-W364.844	24.7	0.0	0.0	0.6	18.5	4.1	1.5	3	74	881	0.3%	232,394
Inorganic Non-Metal	IN	IN-W362.848	24.7	0.0	0.0	0.6	18.5	4.1	1.5	42	1037	923	0.3%	233,431
Inorganic Non-Metal	IN	IN-W169.192	24.0	8.7	0.0	0.4	11.5	2.5	0.9	70	1681	993	0.4%	235,112
Solidified Inorganics	IN	IN-W146.699	23.7	0.1	23.5	0.1	0.1	0.0	0.0	11	261	1,004	0.4%	235,373
Inorganic Non-Metal	IN	IN-W267.514	22.0	0.0	0.0	0.5	16.5	3.6	1.3	6	132	1,010	0.4%	235,505
Heterogeneous	IN	IN-W329.681	21.8	0.0	0.0	21.2	0.0	0.0	0.0	4	93	1,015	0.4%	235,598
Uncategorized Metal	SR	W027-772F-MET	21.5	0.3	0.0	19.0	1.4	0.2	0.1	154	3318	1,169	0.4%	238,916
Heterogeneous	SR	W027-772F-HET	21.5	0.3	0.0	19.0	1.4	0.2	0.1	2478	53230	3,647	1.3%	292,146
Heterogeneous	SR	W027-773A-HET	21.5	0.3	0.0	19.0	1.4	0.2	0.1	1592	34198	5,239	1.9%	326,344
Heterogeneous	SR	W027-221H-HET	21.5	0.3	0.0	19.0	1.4	0.2	0.1	603	12953	5,842	2.1%	339,298
Heterogeneous	SR	W027-235F-HET	21.5	0.3	0.0	19.0	1.4	0.2	0.1	167	3587	6,009	2.1%	342,885
Uncategorized Metal	SR	W027-773A-MET	21.5	0.3	0.0	19.0	1.4	0.2	0.1	36	781	6,045	2.1%	343,666
Uncategorized Metal	SR	W027-221F-MET	21.5	0.3	0.0	19.0	1.4	0.2	0.1	9	195	6,055	2.2%	343,861
Uncategorized Metal	SR	W027-221H-MET	21.5	0.3	0.0	19.0	1.4	0.2	0.1	9	195	6,064	2.2%	344,056
Uncategorized Metal	SR	W027-235F-MET	21.5	0.3	0.0	19.0	1.4	0.2	0.1	9	195	6,073	2.2%	344,251
Solidified Inorganics	SR	T001-773A-CLAS	21.5	0.3	0.0	19.0	1.4	0.2	0.1	22	473	6,095	2.2%	344,724

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)							CumulativeTotal of All Stored Drums				
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Heterogeneous	SR	W027-221F-HET	**21.5**	0.3	0.0	19.0	1.4	0.2	0.1	1277	27431	7,372	2.6%	372,155
Heterogeneous	RL	RL-T132	**21.0**	0.0	0.0	0.4	16.3	3.8	0.4	138	2900	7,510	2.7%	375,055
Inorganic Non-Metal	IN	IN-W348.846	**20.9**	0.0	0.0	0.5	15.7	3.5	1.2	20	418	7,530	2.7%	375,473
Filter	RF	RF-TT0491	**18.9**	0.0	0.0	0.0	10.5	7.6	0.8	77	1456	7,607	2.7%	376,929
Inorganic Non-Metal	IN	IN-W365.1010	**18.8**	15.4	0.0	0.1	2.6	0.6	0.2	6	118	7,613	2.7%	377,047
Various	RF	RF-RESIDUES	**18.2**	5.9	0.0	0.4	9.2	2.1	0.7	20105	366439	27,718	9.8%	743,486
Combustible	IN	IN-W305.828	**18.2**	0.0	0.0	17.7	0.0	0.0	0.0	51	936	27,770	9.9%	744,423
Combustible	IN	IN-W305.1068	**18.2**	0.0	0.0	17.7	0.0	0.0	0.0	180	3281	27,950	9.9%	747,703
Combustible	IN	IN-W256.1062	**17.9**	0.0	0.0	17.1	0.1	0.3	0.0	99	1777	28,049	10.0%	749,480
Combustible	IN	IN-W256.295	**17.9**	0.0	0.0	17.1	0.1	0.3	0.0	29	517	28,077	10.0%	749,997
Graphite	RF	RF-TT0303	**16.7**	0.0	0.0	0.0	9.3	6.7	0.7	1	17	28,078	10.0%	750,014
Solidified Inorganics	RF	RF-MT0377	**16.2**	0.0	0.0	0.0	9.0	6.5	0.7	17	276	28,095	10.0%	750,290
Solidified Inorganics	RF	RF-MT-0823	**15.7**	0.0	0.0	0.0	8.8	6.3	0.6	1	16	28,096	10.0%	750,306
Uncategorized Metal	RF	RF-TT0320	**15.5**	0.0	0.0	0.0	6.9	7.8	0.8	22	342	28,118	10.0%	750,647
Inorganic Non-Metal	IN	IN-W208.242	**15.3**	3.0	0.0	0.3	9.2	2.0	0.7	7	107	28,125	10.0%	750,754
Solidified Inorganics	IN	IN-W315.601	**15.2**	15.0	0.0	0.0	0.2	0.0	0.0	2	30	28,127	10.0%	750,784
Combustible	IN	IN-W269.535	**14.9**	1.3	0.0	1.2	11.2	1.1	0.0	100	1488	28,227	10.0%	752,273
Combustible	IN	IN-W269.510	**14.9**	1.3	0.0	1.2	11.2	1.1	0.0	29	429	28,256	10.0%	752,701
Heterogeneous	SR	T001-772F-HET	**14.7**	0.2	0.0	13.2	0.7	0.1	0.1	140	2048	28,396	10.1%	754,750
Inorganic Non-Metal	IN	IN-W373.1003	**14.0**	0.0	0.0	0.3	10.5	2.3	0.8	3	46	28,399	10.1%	754,795
Solidified Inorganics	SR	W027-773A-VIT	**13.5**	0.2	0.4	12.4	0.1	0.1	0.1	83	1123	28,482	10.1%	755,919
Solidified Inorganics	SR	W027-221F-VIT	**13.5**	0.2	0.4	12.4	0.1	0.1	0.1	160	2160	28,642	10.2%	758,079
Solidified Inorganics	SR	W027-221H-VIT	**13.5**	0.2	0.4	12.4	0.1	0.1	0.1	124	1685	28,766	10.2%	759,764
Solidified Inorganics	SR	W027-235F-VIT	**13.5**	0.2	0.4	12.4	0.1	0.1	0.1	80	1080	28,846	10.3%	760,844
Solidified Inorganics	SR	W027-772F-VIT	**13.5**	0.2	0.4	12.4	0.1	0.1	0.1	51	691	28,897	10.3%	761,535
Solidified Inorganics	SR	T003-773A-VIT	**13.5**	0.2	0.4	12.4	0.1	0.1	0.1	1	14	28,898	10.3%	761,549
Heterogeneous	SR	T001-235F-HET	**13.0**	0.2	0.0	11.8	0.5	0.1	0.1	784	10208	29,682	10.5%	771,757
Heterogeneous	SR	T001-221F-HET	**12.8**	0.2	0.0	11.6	0.5	0.1	0.1	4513	57689	34,195	12.2%	829,446
Inorganic Non-Metal	IN	IN-W216.99	**12.6**	12.0	0.0	0.0	0.4	0.1	0.0	1226	15429	35,421	12.6%	844,875
Uncategorized Metal	SR	T001-221F-MET	**12.5**	0.2	0.0	11.4	0.5	0.1	0.1	114	1427	35,535	12.6%	846,302
Salt Waste	IN	IN-W312.602	**12.4**	0.0	0.0	0.3	9.3	2.1	0.7	5	66	35,540	12.6%	846,367
Salt Waste	IN	IN-W312.942	**12.4**	0.0	0.0	0.3	9.3	2.1	0.7	13	162	35,553	12.6%	846,529
Inorganic Non-Metal	IN	IN-W364.1011	**12.4**	0.0	0.0	0.3	9.3	2.0	0.7	4	53	35,558	12.6%	846,582
Inorganic Non-Metal	IN	IN-W362.1020	**12.3**	0.0	0.0	0.3	9.3	2.0	0.7	26	319	35,583	12.6%	846,901

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)							CumulativeTotal of All Stored Drums				
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Heterogeneous	SR	T001-221H-HET	12.2	0.2	0.0	11.2	0.5	0.1	0.1	760	9299	36,344	12.9%	856,199
Heterogeneous	SR	T001-773A-HET	12.1	0.2	0.0	11.1	0.4	0.1	0.1	106	1287	36,450	13.0%	857,487
Uncategorized Metal	SR	T001-221H-MET	12.1	0.2	0.0	11.0	0.4	0.1	0.1	4	46	36,454	13.0%	857,533
Uncategorized Metal	SR	T001-773A-MET	12.0	0.2	0.0	11.0	0.4	0.1	0.1	2	22	36,455	13.0%	857,555
Inorganic Non-Metal	IN	IN-W163.234	11.5	0.0	0.0	0.3	8.7	1.9	0.7	2	23	36,457	13.0%	857,578
Combustible	MD	MD-W003	11.5	0.0	0.0	10.3	1.0	0.0	0.0	8	92	36,465	13.0%	857,670
Combustible	IN	IN-W330.678	11.5	0.0	0.0	11.2	0.0	0.0	0.0	9	107	36,475	13.0%	857,777
Combustible	IN	IN-W330.677	11.5	0.0	0.0	11.2	0.0	0.0	0.0	29	334	36,504	13.0%	858,110
Solidified Inorganics	LA	LA-T006	11.5	0.0	0.0	10.8	0.3	0.0	0.0	24	276	36,528	13.0%	858,386
Inorganic Non-Metal	IN	IN-W298.979	11.2	0.9	0.0	0.2	7.7	1.7	0.6	2	22	36,530	13.0%	858,408
Inorganic Non-Metal	IN	IN-W267.1005	11.0	0.0	0.0	0.3	8.2	1.8	0.7	5	58	36,535	13.0%	858,466
Salt Waste	IN	IN-W314.1017	10.8	0.0	0.0	0.3	8.1	1.8	0.6	5	54	36,540	13.0%	858,520
Salt Waste	IN	IN-W314.606	10.8	0.0	0.0	0.3	8.1	1.8	0.6	3	35	36,543	13.0%	858,555
Solidified Inorganics	IN	IN-W348.1012	10.5	0.0	0.0	0.3	7.8	1.7	0.6	11	118	36,555	13.0%	858,673
Uncategorized Metal	IN	IN-W304.861	10.4	0.0	0.0	10.0	0.1	0.0	0.0	284	2949	36,839	13.1%	861,623
Uncategorized Metal	IN	IN-W304.860	10.4	0.0	0.0	10.0	0.1	0.0	0.0	42	437	36,881	13.1%	862,060
Inorganic Non-Metal	IN	IN-W210.247	10.3	0.0	0.0	0.2	7.7	1.7	0.6	1	10	36,882	13.1%	862,070
Graphite	IN	IN-W271.532	10.1	0.0	0.0	0.0	3.1	7.0	0.0	4	43	36,886	13.1%	862,113
Combustible	RF	RF-MT0339	10.1	4.6	0.0	0.0	2.2	2.9	0.3	110	1109	36,996	13.1%	863,222
Soils	RL	RL-T103	10.1	0.0	0.0	0.2	7.8	1.8	0.2	479	4827	37,475	13.3%	868,049
Inorganic Non-Metal	IN	IN-W363.847	10.0	0.0	0.0	0.2	7.5	1.6	0.6	5	50	37,480	13.3%	868,098
Graphite	RF	RF-TT0300	9.9	0.0	0.0	0.0	4.7	4.7	0.5	62	614	37,542	13.3%	868,712
Filter	RF	RF-TT0376	9.9	0.0	0.0	0.0	4.2	5.1	0.6	43	425	37,585	13.4%	869,137
Filter	RF	RF-TT0490	9.4	0.0	0.0	0.0	4.1	4.8	0.5	107	999	37,692	13.4%	870,136
Solidified Organics	IN	IN-W321.1023	9.2	0.0	0.0	0.2	6.9	1.5	0.5	6	58	37,698	13.4%	870,194
Inorganic Non-Metal	RL	RL-W405	9.2	9.1	0.0	0.0	0.1	0.0	0.0	1	9	37,699	13.4%	870,204
Solidified Inorganics	RF	RF-MT0001	9.1	7.5	0.0	0.0	0.9	0.6	0.1	18	163	37,717	13.4%	870,367
Solidified Inorganics	RF	RF-MT0007	9.1	7.5	0.0	0.0	0.9	0.6	0.1	4	36	37,721	13.4%	870,403
Solidified Inorganics	RF	RF-T010	9.1	7.5	0.0	0.0	0.9	0.6	0.1	3	27	37,724	13.4%	870,430
Uncategorized Metal	LA	LA-W005	8.6	0.0	0.0	0.3	8.3	0.0	0.0	1032	8921	38,756	13.8%	879,351
Filter	RF	RF-TT0335	8.6	0.0	0.0	0.0	3.6	4.6	0.5	93	803	38,849	13.8%	880,154
Filter	RF	RF-TT0338	8.6	0.0	0.0	0.0	3.6	4.6	0.5	10	86	38,859	13.8%	880,241
Solidified Inorganics	SR	T001-221F-VIT	8.2	0.1	0.5	7.2	0.0	0.1	0.0	111	916	38,970	13.8%	881,156
Solidified Inorganics	SR	T001-221H-VIT	8.2	0.1	0.5	7.2	0.0	0.1	0.0	163	1324	39,133	13.9%	882,481

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum															
Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)							CumulativeTotal of All Stored Drums					
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Solidified Inorganics	SR	T001-773A-VIT	8.1	0.1	0.5	7.1	0.0	0.1	0.0	2	15	39,135	13.9%	882,496
Solidified Inorganics	SR	T001-772F-VIT	8.1	0.1	0.5	7.1	0.0	0.1	0.0	1	7	39,136	13.9%	882,504
Solidified Inorganics	SR	T001-235F-VIT	8.1	0.1	0.5	7.1	0.0	0.1	0.0	7	58	39,143	13.9%	882,561
Inorganic Non-Metal	IN	IN-W361.849	7.8	0.0	0.0	0.2	5.8	1.3	0.5	10	78	39,153	13.9%	882,639
Solidified Inorganics	RF	RF-TT0802	7.6	7.3	0.0	0.0	0.1	0.1	0.0	36	272	39,189	13.9%	882,911
Salt Waste	IN	IN-W355.1015	7.4	0.0	0.0	0.2	5.6	1.2	0.4	5	37	39,194	13.9%	882,948
Salt Waste	IN	IN-W355.857	7.4	0.0	0.0	0.2	5.6	1.2	0.4	4	32	39,198	13.9%	882,980
Uncategorized Metal	RF	RF-TT0481	7.3	3.5	0.0	0.0	2.1	1.5	0.2	1	7	39,199	13.9%	882,987
Inorganic Non-metal	RF	RF-TT0438	7.3	0.0	0.0	0.0	3.2	3.7	0.4	37	271	39,236	13.9%	883,258
Inorganic Non-metal	RF	RF-MT-0368	7.2	0.0	0.0	0.0	3.1	4.1	0.0	3	22	39,239	13.9%	883,280
Graphite	RF	RF-TT0312	7.1	0.0	0.0	0.0	2.8	3.9	0.4	3	21	39,242	13.9%	883,301
Inorganic Non-Metal	IN	IN-W283.963	6.9	0.0	0.0	0.2	5.2	1.1	0.4	1	7	39,243	13.9%	883,308
Lead/Cadmium Metal W	RF	RF-MT0480	6.8	4.2	0.0	0.0	1.1	1.5	0.2	1	7	39,244	13.9%	883,315
Inorganic Non-Metal	IN	IN-W317.1028	6.6	1.3	0.0	0.1	4.0	0.9	0.3	1	7	39,245	13.9%	883,322
Inorganic Non-Metal	IN	IN-W206.936	6.5	0.2	0.0	0.2	4.8	1.1	0.4	108	703	39,353	14.0%	884,025
Solidified Inorganics	IN	IN-W216.98	6.3	6.0	0.0	0.0	0.2	0.0	0.0	2671	16805	42,024	14.9%	900,830
Solidified Inorganics	IN	IN-W216.875	6.3	6.0	0.0	0.0	0.2	0.0	0.0	7110	44727	49,134	17.5%	945,557
Unknown	MD	MD-T004	6.2	0.0	0.0	6.0	0.1	0.0	0.0	129	797	49,263	17.5%	946,354
Graphite	IN	IN-W272.504	6.1	0.0	0.0	0.1	4.6	1.0	0.4	4	26	49,268	17.5%	946,380
Graphite	IN	IN-W272.974	6.1	0.0	0.0	0.1	4.6	1.0	0.4	8	49	49,276	17.5%	946,428
Solidified Inorganics	RF	RF-MT0807	6.1	5.2	0.0	0.0	0.4	0.4	0.0	353	2144	49,629	17.6%	948,573
Solidified Inorganics	RF	RF-MT0800	6.0	5.2	0.0	0.0	0.4	0.4	0.0	315	1904	49,944	17.7%	950,477
Heterogeneous	RL	RL-W301	6.0	0.0	0.0	0.0	4.7	1.1	0.1	3	18	49,947	17.7%	950,495
Solidified Inorganics	RF	RF-MT0803	5.9	5.1	0.0	0.0	0.4	0.4	0.0	14	83	49,961	17.8%	950,578
Solidified Inorganics	IN	IN-W163.1007	5.8	0.0	0.0	0.1	4.3	1.0	0.3	3	19	49,964	17.8%	950,597
Heterogeneous	IN	IN-W325.679	5.8	0.0	0.0	5.6	0.0	0.0	0.0	3	19	49,967	17.8%	950,616
Heterogeneous	IN	IN-W325.1076	5.8	0.0	0.0	5.6	0.0	0.0	0.0	2	12	49,969	17.8%	950,627
Combustible	RF	RF-MT0821	5.6	2.7	0.0	0.0	1.6	1.2	0.1	2	11	49,971	17.8%	950,639
Heterogeneous	RL	RL-T123	5.5	0.0	0.0	0.1	4.3	1.0	0.1	3	16	49,974	17.8%	950,655
Uncategorized Metal	LA	LA-T005	5.4	0.0	0.0	4.1	1.1	0.0	0.0	7226	38837	57,200	20.3%	989,492
Heterogeneous	IN	IN-W170.189	5.1	1.2	0.0	0.0	4.0	0.0	0.0	3	17	57,204	20.3%	989,509
Heterogeneous	IN	IN-W170.938	5.1	1.2	0.0	0.0	4.0	0.0	0.0	2	10	57,206	20.3%	989,520
Combustible	MD	MD-T009	5.0	0.0	0.0	3.6	1.4	0.0	0.0	1	5	57,207	20.3%	989,525
Inorganic Non-Metal	IN	IN-W363.1019	5.0	0.0	0.0	0.1	3.7	0.8	0.3	4	21	57,211	20.3%	989,546

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum															
Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)							CumulativeTotal of All Stored Drums					
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Solidified Organics	IN	IN-W319.584	4.6	0.0	0.0	0.1	3.4	0.8	0.3	3	15	57,214	20.3%	989,561
Filter	RF	RF-MT-0491	4.5	0.1	0.0	0.0	1.7	2.4	0.3	3	13	57,217	20.3%	989,574
Inorganic Non-Metal	IN	IN-W222.117	4.5	0.0	0.0	0.1	3.4	0.7	0.3	188	841	57,405	20.4%	990,415
Filter	RF	RF-MT-0335	4.5	0.1	0.0	0.0	1.7	2.4	0.3	7	31	57,412	20.4%	990,446
Salt Waste	IN	IN-W356.1014	4.2	3.5	0.0	0.0	0.6	0.1	0.0	18	76	57,430	20.4%	990,522
Salt Waste	IN	IN-W356.856	4.2	3.5	0.0	0.0	0.6	0.1	0.0	6	27	57,436	20.4%	990,549
Combustible	LA	LA-T004	4.1	0.0	0.0	3.8	0.2	0.0	0.0	7477	30321	64,913	23.1%	1,020,870
Uncategorized Metal	RF	RF-TT0824	4.0	2.3	0.0	0.0	0.8	0.9	0.1	47	190	64,960	23.1%	1,021,060
Uncategorized Metal	RF	RF-TT0480	4.0	2.2	0.0	0.0	0.7	0.9	0.1	372	1481	65,332	23.2%	1,022,541
Combustible	IN	IN-W327.1085	4.0	0.0	0.0	3.9	0.0	0.0	0.0	17	68	65,349	23.2%	1,022,609
Combustible	IN	IN-W327.735	4.0	0.0	0.0	3.9	0.0	0.0	0.0	6	25	65,355	23.2%	1,022,634
Heterogeneous	MD	MD-T012	3.9	0.0	0.0	2.3	1.6	0.0	0.0	3	12	65,358	23.2%	1,022,646
Inorganic Non-Metal	IN	IN-W361.1021	3.9	0.0	0.0	0.1	2.9	0.6	0.2	7	28	65,365	23.2%	1,022,674
Solidified Inorganics	LA	LA-W006	3.9	1.2	0.0	0.5	2.2	0.0	0.0	2655	10233	68,020	24.2%	1,032,907
Graphite	IN	IN-W367.973	3.8	0.0	0.0	0.1	2.8	0.6	0.2	23	86	68,043	24.2%	1,032,993
Filter	IN	IN-W207.980	3.6	0.0	0.0	0.1	2.7	0.6	0.2	4	16	68,047	24.2%	1,033,008
Filter	IN	IN-W207.981	3.6	0.0	0.0	0.1	2.7	0.6	0.2	2	7	68,049	24.2%	1,033,015
Combustible	RF	RF-TT0825	3.5	2.3	0.0	0.0	0.5	0.7	0.1	104	364	68,153	24.2%	1,033,380
Combustible	RF	RF-TT0821	3.5	2.3	0.0	0.0	0.5	0.7	0.1	60	209	68,213	24.2%	1,033,588
Combustible	RL	RL-W300	3.4	0.0	0.0	0.0	2.7	0.6	0.1	2	7	68,215	24.2%	1,033,595
Uncategorized Metal	RL	RL-W299	3.4	0.0	0.0	0.0	2.7	0.6	0.1	3	10	68,218	24.2%	1,033,605
Heterogeneous	IN	IN-W204.215	3.4	1.8	0.0	1.6	0.0	0.0	0.0	4	15	68,222	24.2%	1,033,620
Heterogeneous	IN	IN-W204.216	3.4	1.8	0.0	1.6	0.0	0.0	0.0	8	27	68,230	24.2%	1,033,647
Inorganic Non-Metal	IN	IN-W322.851	3.4	0.0	0.0	0.0	2.8	0.6	0.0	4	14	68,234	24.2%	1,033,662
Inorganic Non-Metal	IN	IN-W322.952	3.4	0.0	0.0	0.0	2.8	0.6	0.0	8	27	68,242	24.3%	1,033,689
Uncategorized Metal	IN	IN-W271.533	3.4	0.0	0.0	0.0	1.0	2.3	0.0	1	3	68,243	24.3%	1,033,692
Heterogeneous	IN	IN-W298.812	3.4	0.3	0.0	0.1	2.3	0.5	0.2	74	248	68,317	24.3%	1,033,940
Uncategorized Metal	IN	IN-W298.317	3.4	0.3	0.0	0.1	2.3	0.5	0.2	263	883	68,580	24.4%	1,034,823
Solidified Organics	IN	IN-W317.757	3.3	0.6	0.0	0.1	2.0	0.4	0.2	188	619	68,768	24.4%	1,035,441
Solidified Organics	IN	IN-W317.758	3.3	0.6	0.0	0.1	2.0	0.4	0.2	55	182	68,824	24.5%	1,035,623
Combustible	MD	MD-T008	3.2	0.0	0.0	3.1	0.0	0.0	0.0	18	58	68,842	24.5%	1,035,682
Solidified Inorganics	IN	IN-W177.1083	3.1	0.0	0.0	3.0	0.0	0.0	0.0	678	2107	69,520	24.7%	1,037,788
Solidified Inorganics	IN	IN-W177.156	3.1	0.0	0.0	3.0	0.0	0.0	0.0	189	586	69,708	24.8%	1,038,375
Filter	IN	IN-W211.1009	3.0	0.2	0.0	0.1	2.1	0.5	0.2	473	1429	70,182	24.9%	1,039,803

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum															
Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)							CumulativeTotal of All Stored Drums					
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Heterogeneous	RL	RL-T107	3.0	0.0	0.0	2.4	0.4	0.1	0.0	29597	89263	99,778	35.5%	1,129,067
Combustible	RF	RF-MT0832	3.0	1.7	0.0	0.0	0.5	0.7	0.1	348	1042	100,126	35.6%	1,130,109
Combustible	RF	RF-MT0831	3.0	1.7	0.0	0.0	0.5	0.7	0.1	216	646	100,342	35.7%	1,130,755
Heterogeneous	RL	RL-T116	3.0	0.0	0.0	0.1	2.3	0.5	0.1	53	158	100,395	35.7%	1,130,913
Combustible	RF	RF-MT0833	3.0	1.7	0.0	0.0	0.5	0.7	0.1	42	125	100,437	35.7%	1,131,039
Solidified Organics	RF	RF-MT0801	3.0	1.0	0.0	0.0	0.8	0.6	0.6	524	1553	100,961	35.9%	1,132,591
Solidified Organics	RF	RF-MT0003	3.0	1.0	0.0	0.0	0.8	0.6	0.6	3	9	100,964	35.9%	1,132,600
Combustible	LA	LA-W004	2.9	0.0	0.0	1.5	1.3	0.0	0.0	1280	3704	102,245	36.3%	1,136,304
Combustible	RL	RL-W296	2.8	0.0	0.0	0.0	2.2	0.5	0.1	15	42	102,260	36.3%	1,136,346
Inorganic Non-Metal	RL	RL-W292	2.8	0.0	0.0	0.0	2.2	0.5	0.1	1	3	102,261	36.3%	1,136,349
Lead/Cadmium Metal W	RL	RL-W287	2.8	0.0	0.0	0.0	2.2	0.5	0.1	2	6	102,263	36.3%	1,136,355
Lead/Cadmium Metal W	RL	RL-W290	2.8	0.0	0.0	0.0	2.2	0.5	0.1	11	30	102,274	36.3%	1,136,385
Uncategorized Metal	RL	RL-W295	2.8	0.0	0.0	0.0	2.2	0.5	0.1	9	25	102,283	36.3%	1,136,410
Uncategorized Metal	RL	RL-W297	2.8	0.0	0.0	0.0	2.2	0.5	0.1	8	22	102,291	36.3%	1,136,432
Combustible	RL	RL-W289	2.8	0.0	0.0	0.0	2.2	0.5	0.1	10	28	102,301	36.4%	1,136,460
Combustible	RL	RL-W293	2.8	0.0	0.0	0.0	2.2	0.5	0.1	6	17	102,307	36.4%	1,136,477
Heterogeneous	RL	RL-W294	2.8	0.0	0.0	0.0	2.2	0.5	0.1	5	14	102,312	36.4%	1,136,490
Solidified Organics	RL	RL-W285	2.8	0.0	0.0	0.0	2.2	0.5	0.1	6	16	102,318	36.4%	1,136,506
Uncategorized Metal	RL	RL-W288	2.8	0.0	0.0	0.0	2.2	0.5	0.1	5	14	102,323	36.4%	1,136,520
Uncategorized Metal	RL	RL-W291	2.8	0.0	0.0	0.0	2.2	0.5	0.1	38	106	102,361	36.4%	1,136,626
Inorganic Non-Metal	IN	IN-W294.1057	2.7	0.1	0.0	0.1	2.0	0.4	0.2	2	5	102,363	36.4%	1,136,632
Heterogeneous	IN	IN-W281.487	2.7	0.0	0.0	2.7	0.0	0.0	0.0	1528	4181	103,891	36.9%	1,140,813
Inorganic Non-Metal	RF	RF-TT0442	2.7	0.0	0.0	0.0	1.2	1.4	0.1	135	369	104,026	37.0%	1,141,182
Solidified Inorganics	IN	IN-W174.154	2.7	0.0	0.0	2.6	0.0	0.0	0.0	646	1752	104,672	37.2%	1,142,934
Solidified Inorganics	IN	IN-W174.1082	2.7	0.0	0.0	2.6	0.0	0.0	0.0	146	396	104,818	37.2%	1,143,330
Soils	RL	RL-W283	2.6	2.6	0.0	0.0	0.0	0.0	0.0	56	146	104,874	37.3%	1,143,476
Unknown	RL	RL-W284	2.6	2.6	0.0	0.0	0.0	0.0	0.0	2	5	104,876	37.3%	1,143,482
Combustible	RL	RL-W298	2.5	0.0	0.0	0.0	2.0	0.5	0.1	80	201	104,955	37.3%	1,143,683
Combustible	RL	RL-W398	2.5	2.0	0.0	0.0	0.3	0.1	0.0	1	2	104,956	37.3%	1,143,685
Uncategorized Metal	RL	RL-W396	2.5	2.0	0.0	0.0	0.3	0.1	0.0	1	2	104,957	37.3%	1,143,687
Heterogeneous	RL	RL-T133	2.4	0.0	0.0	0.0	1.9	0.4	0.1	1	2	104,958	37.3%	1,143,690
Heterogeneous	RL	RL-T137	2.4	1.4	0.0	0.0	0.8	0.2	0.0	729	1760	105,687	37.6%	1,145,450
Inorganic Non-metal	RF	RF-TT0440	2.4	0.0	0.0	0.0	1.0	1.3	0.1	27	64	105,715	37.6%	1,145,515
Inorganic Non-Metal	IN	IN-W243.275	2.3	0.1	0.0	0.1	1.6	0.4	0.1	35	81	105,750	37.6%	1,145,596

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum															
Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)							CumulativeTotal of All Stored Drums					
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci	
Solidified Inorganics	IN	IN-W222.965	2.2	0.0	0.0	0.1	1.7	0.4	0.1	51	114	105,801	37.6%	1,145,710	
Solidified Inorganics	IN	IN-W222.116	2.2	0.0	0.0	0.1	1.7	0.4	0.1	119	266	105,920	37.6%	1,145,976	
Inorganic Non-Metal	IN	IN-W245.1034	2.2	0.0	0.0	0.1	1.6	0.4	0.1	1	2	105,921	37.6%	1,145,978	
Heterogeneous	LA	LA-T007	2.2	0.0	0.0	0.3	1.8	0.0	0.0	32	69	105,953	37.7%	1,146,047	
Inorganic Non-Metal	IN	IN-W230.940	2.1	0.0	0.0	0.1	1.6	0.4	0.1	71	153	106,024	37.7%	1,146,200	
Inorganic Non-Metal	IN	IN-W230.229	2.1	0.0	0.0	0.1	1.6	0.4	0.1	21	44	106,044	37.7%	1,146,244	
Graphite	IN	IN-W370.929	2.1	0.0	0.0	0.1	1.6	0.4	0.1	257	549	106,301	37.8%	1,146,793	
Graphite	IN	IN-W370.836	2.1	0.0	0.0	0.1	1.6	0.4	0.1	73	156	106,374	37.8%	1,146,949	
Heterogeneous	IN	IN-W339.655	2.1	0.0	0.0	0.0	2.1	0.0	0.0	10	22	106,384	37.8%	1,146,971	
Heterogeneous	IN	IN-W339.955	2.1	0.0	0.0	0.0	2.1	0.0	0.0	34	72	106,418	37.8%	1,147,043	
Heterogeneous	IN	IN-W345.669	2.1	1.4	0.0	0.3	0.3	0.2	0.0	69	145	106,487	37.8%	1,147,187	
Heterogeneous	IN	IN-W345.819	2.1	1.4	0.0	0.3	0.3	0.2	0.0	4	9	106,492	37.8%	1,147,196	
Heterogeneous	IN	IN-W283.534	2.1	0.0	0.0	0.0	1.6	0.3	0.1	3	7	106,495	37.8%	1,147,203	
Heterogeneous	IN	IN-W283.481	2.1	0.0	0.0	0.0	1.6	0.3	0.1	1	2	106,496	37.8%	1,147,205	
Inorganic Non-Metal	RL	RL-W403	2.0	0.0	0.0	0.0	1.6	0.4	0.0	3	6	106,499	37.8%	1,147,211	
Heterogeneous	RL	RL-T127	2.0	1.2	0.0	0.0	0.6	0.1	0.0	1363	2687	107,862	38.3%	1,149,898	
Inorganic Non-Metal	IN	IN-W374.1091	2.0	0.0	0.0	0.0	1.5	0.3	0.1	10	20	107,872	38.3%	1,149,918	
Heterogeneous	RL	RL-W302	1.9	1.9	0.0	0.0	0.0	0.0	0.0	2	4	107,874	38.3%	1,149,921	
Solidified Inorganics	IN	IN-W332.962	1.9	0.0	0.0	1.9	0.0	0.0	0.0	4	8	107,878	38.3%	1,149,929	
Solidified Inorganics	IN	IN-W332.661	1.9	0.0	0.0	1.9	0.0	0.0	0.0	3	6	107,882	38.3%	1,149,936	
Combustible	IN	IN-W252.283	1.9	0.1	0.0	0.0	1.4	0.3	0.1	566	1082	108,448	38.5%	1,151,017	
Combustible	IN	IN-W252.811	1.9	0.1	0.0	0.0	1.4	0.3	0.1	158	302	108,605	38.6%	1,151,319	
Inorganic Non-Metal	IN	IN-W366.841	1.9	0.0	0.0	0.0	1.4	0.3	0.1	5	10	108,611	38.6%	1,151,329	
Inorganic Non-Metal	IN	IN-W366.1004	1.9	0.0	0.0	0.0	1.4	0.3	0.1	10	19	108,621	38.6%	1,151,348	
Heterogeneous	RF	RF-MT0374	1.9	0.0	0.0	0.0	1.0	0.8	0.1	6	11	108,627	38.6%	1,151,359	
Heterogeneous	RF	RF-TT0374	1.9	0.0	0.0	0.0	1.0	0.8	0.1	3	6	108,630	38.6%	1,151,365	
Inorganic Non-Metal	RL	RL-W400	1.9	0.0	0.0	0.0	0.8	0.8	0.2	1	2	108,631	38.6%	1,151,366	
Inorganic Non-Metal	IN	IN-W212.251	1.9	0.1	0.0	0.0	1.3	0.3	0.1	724	1355	109,355	38.9%	1,152,721	
Uncategorized Metal	RL	RL-W399	1.9	0.0	0.0	0.0	0.8	0.8	0.2	1	2	109,356	38.9%	1,152,723	
Inorganic Non-Metal	IN	IN-W308.618	1.9	1.3	0.0	0.1	0.5	0.0	0.0	2421	4481	111,777	39.7%	1,157,204	
Combustible	RL	RL-W401	1.8	0.0	0.0	0.0	0.8	0.8	0.2	3	6	111,780	39.7%	1,157,210	
Heterogeneous	RL	RL-T128	1.8	1.8	0.0	0.0	0.0	0.0	0.0	2	4	111,782	39.7%	1,157,213	
Heterogeneous	IN	IN-W341.954	1.8	0.0	0.0	0.0	1.8	0.0	0.0	3	6	111,785	39.7%	1,157,219	
Heterogeneous	IN	IN-W341.671	1.8	0.0	0.0	0.0	1.8	0.0	0.0	1	2	111,786	39.7%	1,157,221	

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)							CumulativeTotal of All Stored Drums				
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Graphite	IN	IN-W369.970	1.8	0.0	0.0	0.0	1.3	0.3	0.1	48	85	111,834	39.7%	1,157,306
Graphite	IN	IN-W369.837	1.8	0.0	0.0	0.0	1.3	0.3	0.1	16	28	111,849	39.7%	1,157,334
Uncategorized Metal	IN	IN-W342.652	1.7	1.7	0.0	0.0	0.0	0.0	0.0	3	6	111,853	39.7%	1,157,340
Uncategorized Metal	IN	IN-W342.953	1.7	1.7	0.0	0.0	0.0	0.0	0.0	2	3	111,855	39.7%	1,157,343
Combustible	IN	IN-W250.941	1.7	0.0	0.0	0.0	1.3	0.3	0.1	245	414	112,100	39.8%	1,157,757
Combustible	IN	IN-W250.259	1.7	0.0	0.0	0.0	1.3	0.3	0.1	68	114	112,167	39.9%	1,157,872
Inorganic Non-metal	RF	RF-MT0440	1.7	0.0	0.0	0.0	0.7	0.9	0.1	27	45	112,194	39.9%	1,157,917
Inorganic Non-Metal	RF	RF-MT0442	1.7	0.0	0.0	0.0	0.7	0.9	0.1	32	53	112,226	39.9%	1,157,970
Inorganic Non-Metal	RF	RF-MT0856	1.7	0.0	0.0	0.0	0.7	0.9	0.1	1	2	112,227	39.9%	1,157,972
Filter	IN	IN-W209.994	1.6	0.0	0.0	0.0	1.2	0.3	0.1	49	81	112,277	39.9%	1,158,053
Uncategorized Metal	MD	MD-T007	1.6	0.0	0.0	1.5	0.1	0.0	0.0	115	183	112,392	39.9%	1,158,236
Solidified Inorganics	IN	IN-W220.114	1.6	1.4	0.0	0.0	0.1	0.0	0.0	590	937	112,982	40.1%	1,159,173
Solidified Inorganics	IN	IN-W220.925	1.6	1.4	0.0	0.0	0.1	0.0	0.0	2130	3381	115,112	40.9%	1,162,554
Uncategorized Metal	RL	RL-W395	1.6	1.3	0.0	0.0	0.1	0.1	0.0	112	176	115,224	40.9%	1,162,730
Inorganic Non-Metal	IN	IN-W187.121	1.5	0.0	0.0	0.0	1.2	0.3	0.1	1	2	115,225	40.9%	1,162,732
Inorganic Non-Metal	RL	RL-W393	1.5	1.3	0.0	0.0	0.1	0.1	0.0	26	39	115,251	41.0%	1,162,771
Combustible	RL	RL-W397	1.5	1.3	0.0	0.0	0.1	0.1	0.0	17	25	115,268	41.0%	1,162,796
Solidified Inorganics	RL	RL-W394	1.5	1.3	0.0	0.0	0.1	0.1	0.0	15	22	115,283	41.0%	1,162,819
Heterogeneous	LL	LL-M001	1.5	0.3	0.4	0.5	0.1	0.1	0.0	26	38	115,309	41.0%	1,162,857
Salt Waste	IN	IN-W354.858	1.5	0.0	0.0	0.0	1.1	0.2	0.1	3	5	115,313	41.0%	1,162,862
Salt Waste	IN	IN-W354.1016	1.5	0.0	0.0	0.0	1.1	0.2	0.1	1	1	115,314	41.0%	1,162,863
Solidified Inorganics	NT	NT-W021	1.5	0.0	0.0	0.0	1.2	0.2	0.1	27	40	115,341	41.0%	1,162,903
Heterogeneous	IN	IN-W351.648	1.5	0.0	0.0	0.0	0.3	1.1	0.0	4	6	115,345	41.0%	1,162,909
Heterogeneous	IN	IN-W351.922	1.5	0.0	0.0	0.0	0.3	1.1	0.0	6	9	115,351	41.0%	1,162,918
Heterogeneous	RL	RL-W303	1.4	0.0	0.0	0.0	1.2	0.2	0.0	1	1	115,352	41.0%	1,162,919
Inorganic Non-Metal	IN	IN-W205.1087	1.4	0.0	0.0	0.0	1.0	0.2	0.1	1	1	115,353	41.0%	1,162,921
Lead/Cadmium Metal W	RF	RF-MT0321	1.2	0.4	0.0	0.0	0.3	0.4	0.0	18	22	115,371	41.0%	1,162,943
Heterogeneous	IN	IN-W289.466	1.2	0.1	0.0	0.0	1.1	0.0	0.0	122	151	115,493	41.0%	1,163,094
Solidified Inorganics	IN	IN-W179.158	1.2	0.0	0.0	1.2	0.0	0.0	0.0	7	9	115,501	41.0%	1,163,103
Solidified Inorganics	IN	IN-W179.1084	1.2	0.0	0.0	1.2	0.0	0.0	0.0	22	27	115,523	41.1%	1,163,130
Graphite	IN	IN-W275.502	1.2	0.0	0.0	0.0	0.9	0.2	0.1	8	10	115,531	41.1%	1,163,140
Graphite	IN	IN-W275.967	1.2	0.0	0.0	0.0	0.9	0.2	0.1	25	30	115,556	41.1%	1,163,171
Heterogeneous	IN	IN-W171.184	1.2	0.1	0.0	0.0	1.0	0.0	0.1	17	20	115,573	41.1%	1,163,191
Heterogeneous	IN	IN-W171.801	1.2	0.1	0.0	0.0	1.0	0.0	0.1	3	4	115,576	41.1%	1,163,195

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum															
Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)							CumulativeTotal of All Stored Drums					
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Uncategorized Metal	IN	IN-W204.217	1.1	0.6	0.0	0.5	0.0	0.0	0.0	1	1	115,577	41.1%	1,163,196
Combustible	IN	IN-W254.290	1.1	0.0	0.0	0.0	0.8	0.2	0.1	35	39	115,612	41.1%	1,163,235
Combustible	IN	IN-W254.289	1.1	0.0	0.0	0.0	0.8	0.2	0.1	11	12	115,623	41.1%	1,163,247
Inorganic Non-Metal	IN	IN-W245.302	1.1	0.0	0.0	0.0	0.8	0.2	0.1	643	707	116,266	41.3%	1,163,955
Inorganic Non-Metal	IN	IN-W245.301	1.1	0.0	0.0	0.0	0.8	0.2	0.1	180	198	116,447	41.4%	1,164,153
Heterogeneous	OR	OR-W053	1.1	0.8	0.0	0.0	0.3	0.0	0.0	2095	2293	118,542	42.1%	1,166,446
Heterogeneous	NT	NT-W001	1.1	0.1	0.0	0.1	0.9	0.0	0.0	2948	3150	121,490	43.2%	1,169,596
Solidified Inorganics	RF	RF-TT0823	1.1	0.9	0.0	0.0	0.1	0.1	0.0	34	36	121,524	43.2%	1,169,632
Inorganic Non-Metal	IN	IN-W247.1038	1.1	0.0	0.0	0.0	0.8	0.2	0.1	1	1	121,525	43.2%	1,169,633
Heterogeneous	RL	RL-T140	1.0	0.8	0.0	0.0	0.2	0.0	0.0	664	695	122,189	43.4%	1,170,328
Inorganic Non-Metal	IN	IN-W161.231	1.0	0.0	0.0	0.0	0.8	0.2	0.1	469	489	122,658	43.6%	1,170,817
Inorganic Non-Metal	IN	IN-W161.806	1.0	0.0	0.0	0.0	0.8	0.2	0.1	76	79	122,734	43.6%	1,170,896
Uncategorized Metal	RL	RL-W390	1.0	0.3	0.0	0.0	0.6	0.2	0.0	3	3	122,737	43.6%	1,170,899
Combustible	RL	RL-W389	1.0	0.3	0.0	0.0	0.6	0.2	0.0	1	1	122,738	43.6%	1,170,900
Uncategorized Metal	RL	RL-W386	1.0	0.3	0.0	0.0	0.6	0.2	0.0	2	2	122,740	43.6%	1,170,902
Unknown	RL	RL-W391	1.0	0.3	0.0	0.0	0.6	0.2	0.0	2	2	122,742	43.6%	1,170,904
Heterogeneous	RL	RL-T114	1.0	0.0	0.0	0.0	0.8	0.2	0.0	94	97	122,836	43.7%	1,171,001
Inorganic Non-Metal	RL	RL-W353	1.0	0.0	0.0	0.0	0.8	0.2	0.0	4	4	122,840	43.7%	1,171,005
Soils	RL	RL-W354	1.0	0.0	0.0	0.0	0.8	0.2	0.0	1	1	122,841	43.7%	1,171,006
Uncategorized Metal	RL	RL-W355	1.0	0.0	0.0	0.0	0.8	0.2	0.0	10	10	122,851	43.7%	1,171,016
Combustible	RL	RL-W356	1.0	0.0	0.0	0.0	0.8	0.2	0.0	6	6	122,857	43.7%	1,171,022
Graphite	IN	IN-W276.966	1.0	0.0	0.0	0.0	0.7	0.2	0.1	1507	1526	124,364	44.2%	1,172,549
Graphite	IN	IN-W276.500	1.0	0.0	0.0	0.0	0.7	0.2	0.1	417	422	124,781	44.3%	1,172,971
Solidified Inorganics	IN	IN-W166.928	1.0	0.0	0.0	0.0	0.8	0.2	0.1	273	275	125,054	44.4%	1,173,246
Solidified Inorganics	IN	IN-W166.151	1.0	0.0	0.0	0.0	0.8	0.2	0.1	77	77	125,131	44.5%	1,173,324
Graphite	IN	IN-W368.971	1.0	0.0	0.0	0.0	0.7	0.2	0.1	5	5	125,136	44.5%	1,173,329
Combustible	RL	RL-W372	1.0	0.1	0.0	0.0	0.7	0.2	0.0	2	2	125,138	44.5%	1,173,331
Uncategorized Metal	RL	RL-W370	1.0	0.1	0.0	0.0	0.7	0.2	0.0	2	2	125,140	44.5%	1,173,333
Combustible	IN	IN-W199.1039	0.9	0.0	0.0	0.0	0.7	0.2	0.1	4	4	125,145	44.5%	1,173,337
Combustible	RL	RL-W347	0.9	0.8	0.0	0.0	0.1	0.0	0.0	1	1	125,146	44.5%	1,173,338
Lead/Cadmium Metal W	RL	RL-W349	0.9	0.8	0.0	0.0	0.1	0.0	0.0	1	1	125,147	44.5%	1,173,339
Solidified Organics	RL	RL-W348	0.9	0.8	0.0	0.0	0.1	0.0	0.0	1	1	125,148	44.5%	1,173,339
Uncategorized Metal	RL	RL-W346	0.9	0.8	0.0	0.0	0.1	0.0	0.0	2	2	125,150	44.5%	1,173,341
Uncategorized Metal	RL	RL-W350	0.9	0.8	0.0	0.0	0.1	0.0	0.0	1	1	125,151	44.5%	1,173,342

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)							CumulativeTotal of All Stored Drums				
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Combustible	RL	RL-W388	**0.9**	0.2	0.0	0.0	0.5	0.1	0.0	80	74	125,231	44.5%	1,173,416
Filter	IN	IN-W208.988	**0.9**	0.2	0.0	0.0	0.5	0.1	0.0	11	10	125,242	44.5%	1,173,426
Combustible	RL	RL-W404	**0.9**	0.0	0.0	0.0	0.6	0.2	0.0	10	9	125,252	44.5%	1,173,435
Solidified Inorganics	MD	MD-W002	**0.9**	0.0	0.0	0.8	0.0	0.0	0.0	9	8	125,261	44.5%	1,173,443
Salt Waste	LL	LL-T004	**0.8**	0.4	0.0	0.1	0.1	0.2	0.1	3	3	125,264	44.5%	1,173,446
Uncategorized Metal	RL	RL-W385	**0.8**	0.2	0.0	0.0	0.5	0.1	0.0	39	33	125,303	44.5%	1,173,478
Uncategorized Metal	RL	RL-W402	**0.8**	0.0	0.0	0.0	0.6	0.2	0.0	6	5	125,309	44.5%	1,173,483
Uncategorized Metal	IN	IN-W294.342	**0.8**	0.0	0.0	0.0	0.6	0.1	0.0	1956	1608	127,265	45.2%	1,175,091
Uncategorized Metal	IN	IN-W294.814	**0.8**	0.0	0.0	0.0	0.6	0.1	0.0	161	132	127,426	45.3%	1,175,223
Solidified Inorganics	RL	RL-W383	**0.8**	0.1	0.0	0.0	0.6	0.1	0.0	45	37	127,472	45.3%	1,175,260
Heterogeneous	RL	RL-W379	**0.8**	0.1	0.0	0.0	0.6	0.1	0.0	1	1	127,473	45.3%	1,175,261
Solidified Organics	RL	RL-W380	**0.8**	0.1	0.0	0.0	0.6	0.1	0.0	1	1	127,474	45.3%	1,175,261
Combustible	RL	RL-W384	**0.8**	0.6	0.0	0.0	0.2	0.0	0.0	3	2	127,477	45.3%	1,175,264
Heterogeneous	RL	RL-T129	**0.8**	0.0	0.0	0.7	0.1	0.0	0.0	138	110	127,615	45.3%	1,175,374
Heterogeneous	RL	RL-T112	**0.8**	0.5	0.0	0.0	0.2	0.1	0.0	662	523	128,277	45.6%	1,175,897
Solidified Inorganics	IN	IN-W187.1094	**0.8**	0.0	0.0	0.0	0.6	0.1	0.0	3	3	128,281	45.6%	1,175,899
Inorganic Non-Metal	RL	RL-W387	**0.7**	0.2	0.0	0.0	0.4	0.1	0.0	7	5	128,288	45.6%	1,175,904
Inorganic Non-Metal	IN	IN-W240.272	**0.7**	0.1	0.0	0.0	0.5	0.1	0.0	806	554	129,094	45.9%	1,176,458
Inorganic Non-Metal	IN	IN-W240.931	**0.7**	0.1	0.0	0.0	0.5	0.1	0.0	9	6	129,103	45.9%	1,176,465
Solidified Inorganics	IN	IN-W347.646	**0.7**	0.0	0.0	0.0	0.2	0.4	0.0	249	165	129,352	46.0%	1,176,629
Solidified Inorganics	IN	IN-W347.818	**0.7**	0.0	0.0	0.0	0.2	0.4	0.0	17	11	129,368	46.0%	1,176,640
Inorganic Non-Metal	IN	IN-W296.329	**0.6**	0.0	0.0	0.0	0.5	0.1	0.0	2501	1602	131,869	46.9%	1,178,242
Heterogeneous	OR	OR-W044	**0.6**	0.0	0.2	0.1	0.0	0.2	0.2	2514	1605	134,383	47.8%	1,179,847
Heterogeneous	RL	RL-T110	**0.6**	0.0	0.0	0.0	0.5	0.1	0.0	2375	1494	136,758	48.6%	1,181,341
Filter	LL	LL-T005	**0.6**	0.1	0.5	0.0	0.0	0.0	0.0	75	47	136,833	48.6%	1,181,388
Uncategorized Metal	IN	IN-W287.460	**0.6**	0.0	0.0	0.0	0.0	0.6	0.0	1019	636	137,852	49.0%	1,182,023
Filter	IN	IN-W210.1001	**0.6**	0.0	0.0	0.0	0.5	0.1	0.0	5	3	137,857	49.0%	1,182,026
Unknown	RL	RL-W366	**0.6**	0.0	0.0	0.0	0.4	0.2	0.0	7	4	137,864	49.0%	1,182,031
Heterogeneous	LL	LL-T002	**0.6**	0.2	0.0	0.1	0.2	0.1	0.1	230	139	138,095	49.1%	1,182,170
Combustible	IN	IN-W198.202	**0.6**	0.4	0.0	0.0	0.2	0.0	0.0	575	346	138,670	49.3%	1,182,516
Combustible	IN	IN-W198.804	**0.6**	0.4	0.0	0.0	0.2	0.0	0.0	158	95	138,828	49.3%	1,182,611
Combustible	RL	RL-W365	**0.6**	0.0	0.0	0.0	0.4	0.2	0.0	57	34	138,885	49.4%	1,182,644
Inorganic Non-Metal	RL	RL-W364	**0.6**	0.0	0.0	0.0	0.4	0.1	0.0	10	6	138,895	49.4%	1,182,650
Uncategorized Metal	RL	RL-W362	**0.6**	0.0	0.0	0.0	0.4	0.1	0.0	14	8	138,909	49.4%	1,182,658

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)							CumulativeTotal of All Stored Drums				
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Inorganic Non-Metal	IN	IN-W243.808	0.6	0.0	0.0	0.0	0.4	0.1	0.0	221	129	139,130	49.4%	1,182,787
Inorganic Non-Metal	IN	IN-W243.274	0.6	0.0	0.0	0.0	0.4	0.1	0.0	838	487	139,968	49.7%	1,183,274
Solidified Organics	LA	LA-T002	0.6	0.1	0.0	0.0	0.5	0.0	0.0	7	4	139,975	49.7%	1,183,278
Heterogeneous	RL	RL-T131	0.6	0.4	0.0	0.0	0.2	0.0	0.0	145	81	140,120	49.8%	1,183,359
Combustible	RL	RL-W371	0.6	0.1	0.0	0.0	0.3	0.1	0.0	29	16	140,149	49.8%	1,183,375
Uncategorized Metal	RL	RL-W363	0.5	0.0	0.0	0.0	0.4	0.1	0.0	1	1	140,150	49.8%	1,183,376
Inorganic Non-Metal	IN	IN-W157.907	0.5	0.1	0.0	0.0	0.4	0.1	0.0	45	24	140,195	49.8%	1,183,400
Solidified Inorganics	IN	IN-W247.523	0.5	0.0	0.0	0.0	0.4	0.1	0.0	835	443	141,030	50.1%	1,183,843
Inorganic Non-Metal	IN	IN-W247.810	0.5	0.0	0.0	0.0	0.4	0.1	0.0	132	70	141,162	50.2%	1,183,913
Heterogeneous	OR	OR-W047	0.5	0.0	0.2	0.2	0.0	0.0	0.0	741	387	141,903	50.4%	1,184,300
Uncategorized Metal	RL	RL-W369	0.5	0.1	0.0	0.0	0.3	0.1	0.0	161	81	142,064	50.5%	1,184,381
Inorganic Non-Metal	IN	IN-W374.829	0.5	0.0	0.0	0.0	0.4	0.1	0.0	11	6	142,076	50.5%	1,184,386
Heterogeneous	IN	IN-W139.627	0.5	0.5	0.0	0.0	0.0	0.0	0.0	59	28	142,135	50.5%	1,184,415
Lead/Cadmium Metal W	RL	RL-W328	0.5	0.1	0.0	0.0	0.3	0.1	0.0	18	9	142,153	50.5%	1,184,423
Uncategorized Metal	RL	RL-W307	0.5	0.1	0.0	0.0	0.3	0.1	0.0	9	4	142,162	50.5%	1,184,428
Uncategorized Metal	RL	RL-W319	0.5	0.1	0.0	0.0	0.3	0.1	0.0	36	17	142,198	50.5%	1,184,445
Uncategorized Metal	RL	RL-W324	0.5	0.1	0.0	0.0	0.3	0.1	0.0	18	9	142,217	50.5%	1,184,454
Unknown	RL	RL-W332	0.5	0.1	0.0	0.0	0.3	0.1	0.0	1	0	142,218	50.5%	1,184,454
Combustible	RL	RL-W309	0.5	0.1	0.0	0.0	0.3	0.1	0.0	1	0	142,219	50.5%	1,184,455
Combustible	RL	RL-W321	0.5	0.1	0.0	0.0	0.3	0.1	0.0	1	0	142,220	50.5%	1,184,455
Soils	RL	RL-W316	0.5	0.1	0.0	0.0	0.3	0.1	0.0	1	0	142,221	50.5%	1,184,456
Uncategorized Metal	RL	RL-W334	0.5	0.1	0.0	0.0	0.3	0.1	0.0	1	0	142,222	50.5%	1,184,456
Uncategorized Metal	IN	IN-W300.930	0.5	0.0	0.0	0.0	0.3	0.1	0.0	23	11	142,244	50.5%	1,184,467
Uncategorized Metal	IN	IN-W300.308	0.5	0.0	0.0	0.0	0.3	0.1	0.0	7257	3466	149,501	53.1%	1,187,933
Heterogeneous	IN	IN-W323.562	0.5	0.0	0.0	0.4	0.1	0.0	0.0	4	2	149,505	53.1%	1,187,935
Uncategorized Metal	LA	LA-W001	0.5	0.0	0.0	0.3	0.2	0.0	0.0	10593	5017	160,098	56.9%	1,192,952
Solidified Inorganics	IN	IN-W221.927	0.4	0.0	0.0	0.0	0.3	0.1	0.0	18	8	160,116	56.9%	1,192,960
Solidified Inorganics	IN	IN-W221.113	0.4	0.0	0.0	0.0	0.3	0.1	0.0	56	25	160,172	56.9%	1,192,985
Solidified Organics	RF	RF-MT0375	0.4	0.0	0.0	0.0	0.2	0.2	0.0	1	0	160,173	56.9%	1,192,985
Inorganic Non-Metal	IN	IN-W218.109	0.4	0.4	0.0	0.0	0.1	0.0	0.0	884	387	161,057	57.2%	1,193,373
Heterogeneous	OR	OR-W048	0.4	0.0	0.4	0.0	0.0	0.0	0.0	73	31	161,130	57.3%	1,193,403
Inorganic Non-Metal	IN	IN-W257.558	0.4	0.0	0.0	0.0	0.3	0.1	0.0	1	0	161,131	57.3%	1,193,404
Inorganic Non-Metal	IN	IN-W203.211	0.4	0.1	0.0	0.3	0.0	0.0	0.0	16	7	161,147	57.3%	1,193,410
Filter	IN	IN-W206.935	0.4	0.0	0.0	0.0	0.3	0.1	0.0	52	20	161,199	57.3%	1,193,431

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum

Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)							CumulativeTotal of All Stored Drums				
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Heterogeneous	LA	LA-W068	0.4	0.0	0.0	0.1	0.3	0.0	0.0	2	1	161,201	57.3%	1,193,432
Solidified Inorganics	LL	LL-T001	0.4	0.1	0.0	0.0	0.1	0.1	0.0	69	26	161,270	57.3%	1,193,458
Solidified Inorganics	LA	LA-M002	0.4	0.2	0.0	0.0	0.1	0.0	0.0	14680	5446	175,951	62.5%	1,198,904
Heterogeneous	IN	IN-W197.802	0.4	0.2	0.0	0.0	0.1	0.0	0.0	2453	894	178,404	63.4%	1,199,798
Heterogeneous	IN	IN-W197.803	0.4	0.2	0.0	0.0	0.1	0.0	0.0	217	79	178,621	63.5%	1,199,877
Uncategorized Metal	RL	RL-W375	0.4	0.1	0.0	0.0	0.2	0.1	0.0	104	37	178,725	63.5%	1,199,914
Uncategorized Metal	RL	RL-W374	0.3	0.1	0.0	0.0	0.2	0.1	0.0	877	305	179,602	63.8%	1,200,219
Inorganic Non-Metal	IN	IN-W259.920	0.3	0.0	0.0	0.0	0.3	0.0	0.0	12	4	179,614	63.8%	1,200,223
Inorganic Non-Metal	RF	RF-MT0444	0.3	0.0	0.0	0.0	0.1	0.2	0.0	13	5	179,627	63.8%	1,200,228
Heterogeneous	IN	IN-W291.454	0.3	0.1	0.0	0.0	0.0	0.2	0.0	3	1	179,630	63.8%	1,200,229
Heterogeneous	IN	IN-W291.456	0.3	0.1	0.0	0.0	0.0	0.2	0.0	3050	1048	182,680	64.9%	1,201,276
Combustible	RL	RL-W378	0.3	0.1	0.0	0.0	0.2	0.1	0.0	81	28	182,761	64.9%	1,201,304
Soils	LA	LA-T008	0.3	0.0	0.0	0.2	0.1	0.0	0.0	532	181	183,293	65.1%	1,201,486
Unknown	RL	RL-W382	0.3	0.1	0.0	0.0	0.2	0.1	0.0	90	30	183,383	65.2%	1,201,516
Inorganic Non-Metal	RL	RL-W376	0.3	0.1	0.0	0.0	0.2	0.1	0.0	78	26	183,461	65.2%	1,201,542
Combustible	RL	RL-W377	0.3	0.1	0.0	0.0	0.2	0.1	0.0	1461	492	184,921	65.7%	1,202,034
Soils	RL	RL-W381	0.3	0.1	0.0	0.0	0.2	0.1	0.0	30	10	184,951	65.7%	1,202,044
Inorganic Non-Metal	RF	RF-MT0855	0.3	0.0	0.0	0.0	0.1	0.2	0.0	1	0	184,952	65.7%	1,202,044
Heterogeneous	RL	RL-T101	0.3	0.0	0.0	0.0	0.3	0.1	0.0	2731	904	187,683	66.7%	1,202,948
Solidified Inorganics	IN	IN-W188.1093	0.3	0.0	0.0	0.0	0.2	0.1	0.0	5	2	187,688	66.7%	1,202,950
Solidified Inorganics	IN	IN-W188.160	0.3	0.0	0.0	0.0	0.2	0.1	0.0	3	1	187,691	66.7%	1,202,951
Solidified Organics	LL	LL-W019	0.3	0.2	0.0	0.0	0.0	0.1	0.0	5	2	187,696	66.7%	1,202,953
Heterogeneous	RL	RL-T118	0.3	0.2	0.0	0.0	0.1	0.0	0.0	1259	374	188,955	67.1%	1,203,327
Heterogeneous	RL	RL-T135	0.3	0.0	0.0	0.0	0.2	0.1	0.0	2	1	188,957	67.1%	1,203,328
Heterogeneous	IN	IN-W308.816	0.3	0.2	0.0	0.0	0.1	0.0	0.0	4158	1154	193,116	68.6%	1,204,482
Solidified Inorganics	IN	IN-W263.520	0.3	0.0	0.0	0.3	0.0	0.0	0.0	69	19	193,185	68.6%	1,204,501
Solidified Organics	IN	IN-W157.906	0.3	0.0	0.0	0.0	0.2	0.0	0.0	787	212	193,972	68.9%	1,204,713
Solidified Organics	IN	IN-W157.144	0.3	0.0	0.0	0.0	0.2	0.0	0.0	240	65	194,212	69.0%	1,204,778
Heterogeneous	IN	IN-W265.516	0.3	0.0	0.0	0.0	0.2	0.0	0.0	38	10	194,250	69.0%	1,204,788
Solidified Organics	RL	RL-W345	0.3	0.1	0.0	0.0	0.1	0.0	0.0	10	3	194,260	69.0%	1,204,791
Uncategorized Metal	RL	RL-W308	0.3	0.1	0.0	0.0	0.1	0.0	0.0	2	1	194,262	69.0%	1,204,791
Uncategorized Metal	LA	LA-T009	0.3	0.0	0.0	0.0	0.3	0.0	0.0	257	67	194,519	69.1%	1,204,858
Soils	RL	RL-W310	0.2	0.1	0.0	0.0	0.1	0.0	0.0	1	0	194,520	69.1%	1,204,859
Heterogeneous	IN	IN-W169.191	0.2	0.1	0.0	0.0	0.1	0.0	0.0	20515	4927	215,035	76.4%	1,209,786

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum															
Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)							CumulativeTotal of All Stored Drums					
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Heterogeneous	IN	IN-W169.985	0.2	0.1	0.0	0.0	0.1	0.0	0.0	201	48	215,236	76.5%	1,209,834
Inorganic Non-Metal	IN	IN-W309.609	0.2	0.0	0.0	0.0	0.2	0.0	0.0	522	123	215,758	76.7%	1,209,957
Inorganic Non-Metal	RL	RL-W315	0.2	0.1	0.0	0.0	0.1	0.0	0.0	2	0	215,760	76.7%	1,209,958
Heterogeneous	LA	LA-W067	0.2	0.0	0.1	0.1	0.1	0.0	0.0	43	10	215,803	76.7%	1,209,967
Solidified Organics	IN	IN-W167.926	0.2	0.0	0.0	0.0	0.2	0.0	0.0	632	145	216,435	76.9%	1,210,112
Solidified Organics	IN	IN-W167.149	0.2	0.0	0.0	0.0	0.2	0.0	0.0	176	40	216,612	77.0%	1,210,153
Uncategorized Metal	RL	RL-W330	0.2	0.1	0.0	0.0	0.1	0.0	0.0	154	35	216,766	77.0%	1,210,188
Inorganic Non-Metal	IN	IN-W357.850	0.2	0.0	0.0	0.0	0.2	0.0	0.0	1	0	216,767	77.0%	1,210,188
Solidified Inorganics	IN	IN-W218.909	0.2	0.2	0.0	0.0	0.0	0.0	0.0	490	107	217,257	77.2%	1,210,295
Inorganic Non-metal	RF	RF-MT-0438	0.2	0.0	0.0	0.0	0.0	0.0	0.2	2	0	217,259	77.2%	1,210,296
Uncategorized Metal	RL	RL-W327	0.2	0.1	0.0	0.0	0.1	0.0	0.0	318	69	217,577	77.3%	1,210,365
Inorganic Non-Metal	IN	IN-W228.102	0.2	0.2	0.0	0.0	0.0	0.0	0.0	956	208	218,533	77.7%	1,210,573
Uncategorized Metal	RL	RL-W313	0.2	0.1	0.0	0.0	0.1	0.0	0.0	44	10	218,578	77.7%	1,210,583
Combustible	RL	RL-W331	0.2	0.1	0.0	0.0	0.1	0.0	0.0	244	52	218,822	77.8%	1,210,635
Solidified Organics	RL	RL-W333	0.2	0.1	0.0	0.0	0.1	0.0	0.0	6	1	218,828	77.8%	1,210,636
Lead/Cadmium Metal W	RL	RL-W317	0.2	0.1	0.0	0.0	0.1	0.0	0.0	5	1	218,833	77.8%	1,210,637
Solidified Inorganics	IN	IN-W257.947	0.2	0.0	0.0	0.0	0.2	0.0	0.0	3	1	218,836	77.8%	1,210,638
Heterogeneous	IN	IN-W189.131	0.2	0.0	0.0	0.0	0.2	0.0	0.0	8	2	218,844	77.8%	1,210,640
Heterogeneous	IN	IN-W189.1048	0.2	0.0	0.0	0.0	0.2	0.0	0.0	24	5	218,868	77.8%	1,210,645
Heterogeneous	IN	IN-W302.913	0.2	0.2	0.0	0.0	0.0	0.0	0.0	408	85	219,276	77.9%	1,210,730
Heterogeneous	IN	IN-W302.299	0.2	0.2	0.0	0.0	0.0	0.0	0.0	113	24	219,389	78.0%	1,210,754
Combustible	RL	RL-W322	0.2	0.1	0.0	0.0	0.1	0.0	0.0	4	1	219,393	78.0%	1,210,755
Lead/Cadmium Metal W	RL	RL-W306	0.2	0.1	0.0	0.0	0.1	0.0	0.0	4	1	219,397	78.0%	1,210,756
Lead/Cadmium Metal W	RL	RL-W311	0.2	0.1	0.0	0.0	0.1	0.0	0.0	21	4	219,418	78.0%	1,210,760
Combustible	RL	RL-W325	0.2	0.1	0.0	0.0	0.1	0.0	0.0	2	0	219,420	78.0%	1,210,760
Soils	RL	RL-W323	0.2	0.1	0.0	0.0	0.1	0.0	0.0	3	1	219,423	78.0%	1,210,761
Heterogeneous	IN	IN-W203.210	0.2	0.0	0.0	0.2	0.0	0.0	0.0	352	72	219,775	78.1%	1,210,833
Heterogeneous	IN	IN-W203.1081	0.2	0.0	0.0	0.2	0.0	0.0	0.0	3	1	219,778	78.1%	1,210,834
Combustible	RL	RL-W314	0.2	0.1	0.0	0.0	0.1	0.0	0.0	22	5	219,800	78.1%	1,210,839
Lead/Cadmium Metal W	RL	RL-W312	0.2	0.1	0.0	0.0	0.1	0.0	0.0	11	2	219,811	78.1%	1,210,841
Combustible	RL	RL-W305	0.2	0.1	0.0	0.0	0.1	0.0	0.0	10	2	219,821	78.1%	1,210,843
Solidified Organics	RL	RL-W329	0.2	0.1	0.0	0.0	0.1	0.0	0.0	10	2	219,831	78.1%	1,210,845
Solidified Organics	RL	RL-W326	0.2	0.1	0.0	0.0	0.1	0.0	0.0	9	2	219,840	78.1%	1,210,847
Lead/Cadmium Metal W	RL	RL-W318	0.2	0.1	0.0	0.0	0.1	0.0	0.0	8	2	219,848	78.1%	1,210,848

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum															
Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)							CumulativeTotal of All Stored Drums					
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Uncategorized Metal	RL	RL-W320	0.2	0.1	0.0	0.0	0.1	0.0	0.0	8	2	219,856	78.1%	1,210,850
Filter	MD	MD-M001	0.2	0.0	0.0	0.2	0.0	0.0	0.0	2	0	219,858	78.1%	1,210,851
Uncategorized Metal	IN	IN-W296.327	0.2	0.0	0.0	0.0	0.1	0.0	0.0	16588	3187	236,446	84.0%	1,214,038
Uncategorized Metal	IN	IN-W296.813	0.2	0.0	0.0	0.0	0.1	0.0	0.0	231	44	236,677	84.1%	1,214,082
Heterogeneous	IN	IN-W334.675	0.2	0.0	0.0	0.0	0.2	0.0	0.0	7	1	236,684	84.1%	1,214,083
Heterogeneous	IN	IN-W334.961	0.2	0.0	0.0	0.0	0.2	0.0	0.0	22	4	236,706	84.1%	1,214,087
Heterogeneous	RL	RL-W304	0.2	0.1	0.0	0.0	0.0	0.0	0.0	12	2	236,718	84.1%	1,214,089
Combustible	IN	IN-W186.187	0.2	0.0	0.0	0.0	0.1	0.0	0.0	12958	2232	249,676	88.7%	1,216,322
Uncategorized Metal	LA	LA-T001	0.2	0.0	0.0	0.1	0.1	0.0	0.0	461	79	250,138	88.9%	1,216,400
Solidified Inorganics	LA	LA-W003	0.2	0.0	0.0	0.0	0.1	0.0	0.0	6142	1016	256,280	91.1%	1,217,416
Inorganic Non-Metal	IN	IN-W278.495	0.2	0.0	0.0	0.0	0.1	0.0	0.0	20	3	256,300	91.1%	1,217,419
Heterogeneous	RL	RL-T106	0.2	0.0	0.0	0.0	0.1	0.0	0.0	39	6	256,339	91.1%	1,217,425
Uncategorized Metal	LA	LA-W009	0.1	0.1	0.0	0.0	0.0	0.0	0.0	692	97	257,030	91.3%	1,217,522
Heterogeneous	RL	RL-T109	0.1	0.0	0.0	0.0	0.1	0.0	0.0	95	13	257,125	91.4%	1,217,535
Heterogeneous	RL	RL-T134	0.1	0.0	0.0	0.0	0.1	0.0	0.0	1	0	257,126	91.4%	1,217,536
Solidified Organics	IN	IN-W309.610	0.1	0.0	0.0	0.0	0.1	0.0	0.0	1696	200	258,822	92.0%	1,217,736
Inorganic Non-Metal	IN	IN-W375.827	0.1	0.0	0.0	0.0	0.1	0.0	0.0	38	4	258,860	92.0%	1,217,740
Heterogeneous	RL	RL-W279	0.1	0.0	0.0	0.0	0.1	0.0	0.0	33	4	258,893	92.0%	1,217,744
Solidified Organics	RL	RL-W280	0.1	0.0	0.0	0.0	0.1	0.0	0.0	1	0	258,894	92.0%	1,217,744
Solidified Organics	RL	RL-W286	0.1	0.0	0.0	0.0	0.1	0.0	0.0	1	0	258,895	92.0%	1,217,744
Filter	IN	IN-W212.1058	0.1	0.0	0.0	0.0	0.1	0.0	0.0	17	2	258,912	92.0%	1,217,746
Inorganic Non-Metal	IN	IN-W357.1022	0.1	0.0	0.0	0.0	0.1	0.0	0.0	3	0	258,915	92.0%	1,217,746
Solidified Organics	IN	IN-W164.1060	0.1	0.0	0.0	0.0	0.1	0.0	0.0	8	1	258,923	92.0%	1,217,747
Solidified Organics	IN	IN-W164.153	0.1	0.0	0.0	0.0	0.1	0.0	0.0	4	0	258,927	92.0%	1,217,748
Solidified Inorganics	IN	IN-W228.101	0.1	0.1	0.0	0.0	0.0	0.0	0.0	1381	150	260,309	92.5%	1,217,898
Solidified Inorganics	IN	IN-W228.883	0.1	0.1	0.0	0.0	0.0	0.0	0.0	2927	319	263,236	93.5%	1,218,217
Combustible	RL	RL-W340	0.1	0.1	0.0	0.0	0.0	0.0	0.0	1	0	263,237	93.5%	1,218,217
Lead/Cadmium Metal W	RL	RL-W339	0.1	0.1	0.0	0.0	0.0	0.0	0.0	2	0	263,239	93.5%	1,218,217
Solidified Organics	RL	RL-W338	0.1	0.1	0.0	0.0	0.0	0.0	0.0	1	0	263,240	93.5%	1,218,217
Filter	MD	MD-T010	0.1	0.0	0.0	0.1	0.0	0.0	0.0	2	0	263,242	93.5%	1,218,217
Heterogeneous	OR	OR-W041	0.1	0.0	0.0	0.0	0.1	0.0	0.0	821	74	264,063	93.8%	1,218,291
Heterogeneous	IN	IN-W338.657	0.1	0.0	0.0	0.0	0.1	0.0	0.0	4	0	264,067	93.8%	1,218,292
Heterogeneous	IN	IN-W338.956	0.1	0.0	0.0	0.0	0.1	0.0	0.0	5	0	264,072	93.8%	1,218,292
Solidified Inorganics	IN	IN-W181.162	0.1	0.0	0.0	0.0	0.1	0.0	0.0	46	4	264,118	93.9%	1,218,296

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum															
Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)							CumulativeTotal of All Stored Drums					
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci
Inorganic Non-Metal	RL	RL-W342	0.1	0.1	0.0	0.0	0.0	0.0	0.0	4	0	264,122	93.9%	1,218,296
Uncategorized Metal	RL	RL-W341	0.1	0.1	0.0	0.0	0.0	0.0	0.0	1	0	264,123	93.9%	1,218,296
Combustible	RL	RL-W343	0.1	0.1	0.0	0.0	0.0	0.0	0.0	3	0	264,126	93.9%	1,218,297
Heterogeneous	RL	RL-T115	0.1	0.0	0.0	0.0	0.1	0.0	0.0	4930	391	269,056	95.6%	1,218,687
Inorganic Non-Metal	RL	RL-W367	0.1	0.0	0.0	0.0	0.1	0.0	0.0	14	1	269,070	95.6%	1,218,689
Combustible	RL	RL-W368	0.1	0.0	0.0	0.0	0.1	0.0	0.0	3	0	269,073	95.6%	1,218,689
Uncategorized Metal	IN	IN-W203.212	0.1	0.0	0.0	0.1	0.0	0.0	0.0	1	0	269,074	95.6%	1,218,689
Heterogeneous	IN	IN-W225.800	0.1	0.0	0.0	0.0	0.0	0.0	0.0	5	0	269,079	95.6%	1,218,689
Heterogeneous	IN	IN-W225.127	0.1	0.0	0.0	0.0	0.0	0.0	0.0	104	7	269,183	95.7%	1,218,696
Uncategorized Metal	MD	MD-T006	0.1	0.0	0.0	0.1	0.0	0.0	0.0	282	18	269,465	95.8%	1,218,714
Solidified Organics	RL	RL-W344	0.1	0.1	0.0	0.0	0.0	0.0	0.0	1	0	269,466	95.8%	1,218,714
Combustible	IN	IN-W202.224	0.1	0.0	0.0	0.0	0.0	0.0	0.0	527	33	269,993	95.9%	1,218,747
Combustible	IN	IN-W202.1092	0.1	0.0	0.0	0.0	0.0	0.0	0.0	4	0	269,997	95.9%	1,218,747
Combustible	RL	RL-W360	0.1	0.0	0.0	0.0	0.0	0.0	0.0	23	1	270,020	96.0%	1,218,748
Inorganic Non-Metal	RL	RL-W358	0.1	0.0	0.0	0.0	0.0	0.0	0.0	12	1	270,032	96.0%	1,218,749
Solidified Organics	RL	RL-W361	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3	0	270,035	96.0%	1,218,749
Uncategorized Metal	RL	RL-W359	0.1	0.0	0.0	0.0	0.0	0.0	0.0	80	5	270,115	96.0%	1,218,754
Solidified Inorganics	IN	IN-W375.1096	0.1	0.0	0.0	0.0	0.0	0.0	0.0	22	1	270,137	96.0%	1,218,755
Heterogeneous	RL	RL-T145	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3419	198	273,556	97.2%	1,218,953
Heterogeneous	LL	LL-T003	0.1	0.0	0.0	0.0	0.0	0.0	0.0	691	39	274,246	97.5%	1,218,992
Heterogeneous	IN	IN-W285.815	0.1	0.0	0.0	0.0	0.1	0.0	0.0	11	1	274,258	97.5%	1,218,993
Heterogeneous	IN	IN-W285.471	0.1	0.0	0.0	0.0	0.1	0.0	0.0	303	17	274,561	97.6%	1,219,009
Heterogeneous	IN	IN-W259.552	0.1	0.0	0.0	0.0	0.0	0.0	0.0	48	3	274,609	97.6%	1,219,012
Heterogeneous	IN	IN-W278.1090	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4	0	274,613	97.6%	1,219,012
Heterogeneous	RL	RL-T120	0.0	0.0	0.0	0.0	0.0	0.0	0.0	643	29	275,257	97.8%	1,219,041
Soils	RL	RL-W406	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2	0	275,259	97.8%	1,219,041
Heterogeneous	RL	RL-T122	0.0	0.0	0.0	0.0	0.0	0.0	0.0	141	6	275,400	97.9%	1,219,047
Uncategorized Metal	IN	IN-W228.103	0.0	0.0	0.0	0.0	0.0	0.0	0.0	153	6	275,553	97.9%	1,219,053
Heterogeneous	RL	RL-T143	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1941	70	277,493	98.6%	1,219,122
Soils	MD	MD-T003	0.0	0.0	0.0	0.0	0.0	0.0	0.0	706	22	278,200	98.9%	1,219,144
Heterogeneous	RL	RL-T130	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1	0	278,201	98.9%	1,219,144
Combustible	IN	IN-W336.820	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3	0	278,204	98.9%	1,219,144
Combustible	IN	IN-W336.660	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20	1	278,224	98.9%	1,219,145
Heterogeneous	SR	T003-773A-HET	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3	0	278,227	98.9%	1,219,145

Table A-3, Generator Waste Stream Totals Sorted by Average PE-Ci/Drum																
Source: TWBIR Database Query, 20 June 96			Concentration of Selected Isotopes (per equivalent drum based on scaled volumes)								CumulativeTotal of All Stored Drums					
Final Waste Form	SITE	TWBIR_ ID	Av. PECi / Drum	Am-241 PE-Ci WF=1.0	Cm-244 PE-Ci WF=1.9	Pu-238 PE-Ci WF=1.13	Pu-239 PE-Ci WF=1.0	Pu-240 PE-Ci WF=1.0	Pu-241 PE-Ci WF=52.0	Equiv. Stored Drums	Total Pe-Ci	Cum. Equiv. Drums	Drum Percentile	Cum. PE-Ci		
Uncategorized Metal	RL	RL-W373	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	386	10	278,613	99.0%	1,219,155		
Heterogeneous	RL	RL-T108	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	926	22	279,539	99.3%	1,219,177		
Solidified Inorganics	IN	IN-W353.859	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	3	0	279,542	99.3%	1,219,177		
Solidified Inorganics	IN	IN-W353.917	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	1	0	279,543	99.3%	1,219,177		
Soils	MD	MD-T005	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	145	2	279,689	99.4%	1,219,179		
Heterogeneous	RL	RL-T105	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	387	6	280,075	99.5%	1,219,185		
Solidified Inorganics	MD	MD-T001	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	20	0	280,095	99.5%	1,219,186		
Combustible	IN	IN-W205.1086	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	4	0	280,099	99.5%	1,219,186		
Combustible	IN	IN-W205.220	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	3	0	280,102	99.5%	1,219,186		
Combustible	RL	RL-W335	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	10	0	280,112	99.5%	1,219,186		
Inorganic Non-Metal	RL	RL-W392	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	1	0	280,113	99.5%	1,219,186		
Heterogeneous	LL	LL-W018	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	9	0	280,123	99.5%	1,219,186		
Heterogeneous	RL	RL-T113	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	206	1	280,328	99.6%	1,219,187		
Heterogeneous	RL	RL-T104	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	24	0	280,352	99.6%	1,219,187		
Heterogeneous	RL	RL-T102	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	962	0	281,314	100.0%	1,219,187		
Heterogeneous	RL	RL-T125	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	73	0	281,387	100.0%	1,219,187		
Combustible	RL	RL-W278	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	2	0	281,389	100.0%	1,219,187		
Inorganic Non-Metal	RL	RL-W336	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	2	0	281,391	100.0%	1,219,187		
Lead/Cadmium Metal W	RL	RL-W277	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	3	0	281,394	100.0%	1,219,187		
Solidified Inorganics	RL	RL-W281	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	2	0	281,396	100.0%	1,219,187		
Solidified Organics	RL	RL-W282	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	2	0	281,398	100.0%	1,219,187		
Inorganic Non-Metal	RL	RL-W352	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	1	0	281,399	100.0%	1,219,187		
Soils	RL	RL-W351	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	1	0	281,400	100.0%	1,219,187		
Unknown	RL	RL-W357	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	1	0	281,401	100.0%	1,219,187		
Lead/Cadmium Metal W	LA	LA-W066	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	9	0	281,410	100.0%	1,219,187		

Table A-4, Scaled Pu Mixes For 55 Gallon Drums and SWBs (Ref. DOE/WIPP 91-058)						Page 1 of 6
91-058 Pu Mixes Scaled to 200 FGE 55 Gallon Drums						
Pu-83 Mix[a]						
Isotope	Weight %	Mass (g)[b]	Specific Activity (Ci/g)	Activity (Ci)	PE-Ci Wt. Factor	PE-Ci[c]
Pu-238	80	597.944	1.71E+01	1.02E+04	1.13E+00	9.05E+03
Pu-239	16.3	121.831	6.22E-02	7.58E+00	1.00E+00	7.58E+00
Pu-240	3	22.423	2.28E-01	5.11E+00	1.00E+00	5.11E+00
Pu-241	0.6	4.485	1.03E+02	4.62E+02	5.20E+01	8.88E+00
Pu-242	0.1	0.747	3.93E-03	2.94E-03	1.06E+00	2.77E-03
Totals	100	747.430		10699.45		9070.11
Pu-57 Mix						
Isotope	Weight %	Mass (g)[b]	Specific Activity (Ci/g)	Activity (Ci)	PE-Ci. Wt. Factor	PE-Ci[c]
Pu-238	0.23	0.553	1.71E+01	9.45E+00	1.13E+00	8.36E+00
Pu-239	75.1	180.420	6.22E-02	1.12E+01	1.00E+00	1.12E+01
Pu-240	20.9	50.210	2.28E-01	1.14E+01	1.00E+00	1.14E+01
Pu-241	3.4	8.168	1.03E+02	8.41E+02	5.20E+01	1.62E+01
Pu-242	0.45	1.081	3.93E-03	4.25E-03	1.06E+00	4.01E-03
Totals	100.08	240.432		873.44		47.22
Pu-51 Mix						
Isotope	Weight %	Mass (g)[b]	Specific Activity (Ci/g)	Activity (Ci)	PE-Ci Wt. Factor	PE-Ci[c]
Pu-238	0.014	0.030	1.71E+01	5.05E-01	1.13E+00	4.47E-01
Pu-239	93.55	197.175	6.22E-02	1.23E+01	1.00E+00	1.23E+01
Pu-240	5.888	12.410	2.28E-01	2.83E+00	1.00E+00	2.83E+00
Pu-241	0.536	1.130	1.03E+02	1.16E+02	5.20E+01	2.24E+00
Pu-242	0.023	0.048	3.93E-03	1.91E-04	1.06E+00	1.80E-04
Totals	100.011	210.793		131.96		17.79

Table A-4, Scaled Pu Mixes For 55 Gallon Drums and SWBs (Ref. DOE/WIPP 91-058)						Page 2 of 6
91-058 Pu Mixes Scaled to 200 FGE 55 Gallon Drums						
Pu-52 Mix						
Isotope	Weight %	Mass (g)[(b)]	Specific Activity (Ci/g)	Activity (Ci)	PE-Ci. Wt. Factor	PE-Ci[(c)]
Pu-238	0.01	0.021	1.71E+01	3.61E-01	1.13E+00	3.19E-01
Pu-239	93.89	198.108	6.22E-02	1.23E+01	1.00E+00	1.23E+01
Pu-240	5.75	12.133	2.28E-01	2.77E+00	1.00E+00	2.77E+00
Pu-241	0.34	0.717	1.03E+02	7.39E+01	5.20E+01	1.42E+00
Pu-242	0.02	0.042	3.93E-03	1.66E-04	1.06E+00	1.56E-04
Totals	100.01	211.0211		89.33		16.83
Pu-53 Mix						
Isotope	Weight %	Mass (g)[(b)]	Specific Activity (Ci/g)	Activity (Ci)	PE-Ci Wt. Factor	PE-Ci[(c)]
Pu-238	0.03	0.065	1.71E+01	1.11E+00	1.13E+00	9.79E-01
Pu-239	90.82	195.853	6.22E-02	1.22E+01	1.00E+00	1.22E+01
Pu-240	8.3	17.899	2.28E-01	4.08E+00	1.00E+00	4.08E+00
Pu-241	0.77	1.661	1.03E+02	1.71E+02	5.20E+01	3.29E+00
Pu-242	0.09	0.194	3.93E-03	7.63E-04	1.06E+00	7.20E-04
Totals	100.01	215.671565		188.39		20.53
Pu-54 Mix						
Isotope	Weight %	Mass (g)[(b)]	Specific Activity (Ci/g)	Activity (Ci)	PE-Ci Wt. Factor	PE-Ci[(c)]
Pu-238	0.05	0.111	1.71E+01	1.89E+00	1.13E+00	1.68E+00
Pu-239	86.36	191.279	6.22E-02	1.19E+01	1.00E+00	1.19E+01
Pu-240	11.75	26.025	2.28E-01	5.93E+00	1.00E+00	5.93E+00
Pu-241	1.63	3.610	1.03E+02	3.72E+02	5.20E+01	7.15E+00
Pu-242	0.21	0.465	3.93E-03	1.83E-03	1.06E+00	1.72E-03
Totals	100	221.49		391.72		26.66

Table A-4, Scaled Pu Mixes For 55 Gallon Drums and SWBs (Ref. DOE/WIPP 91-058)						**Page 3 of 6**
91-058 Pu Mixes Scaled to 200 FGE 55 Gallon Drums						
Pu-55 Mix						
Isotope	Weight %	Mass (g)(b)	Specific Activity (Ci/g)	Activity (Ci)	PE-Ci Wt. Factor	PE-Ci(c)
Pu-238	0.02	0.046	1.71E+01	7.91E-01	1.13E+00	7.00E-01
Pu-239	83.7	193.498	6.22E-02	1.20E+01	1.00E+00	1.20E+01
Pu-240	14.9	34.446	2.28E-01	7.85E+00	1.00E+00	7.85E+00
Pu-241	1.1	2.543	1.03E+02	2.62E+02	5.20E+01	5.04E+00
Pu-242	0.24	0.555	3.93E-03	2.18E-03	1.06E+00	2.06E-03
Totals	99.96	231.087528		282.64		25.63
Pu-56 Mix						
Isotope	Weight %	Mass (g)(b)	Specific Activity (Ci/g)	Activity (Ci)	PE-Ci Wt. Factor	PE-Ci(c)
Pu-238	0.014	0.032	1.71E+01	5.54E-01	1.13E+00	4.90E-01
Pu-239	80.5	186.148	6.22E-02	1.16E+01	1.00E+00	1.16E+01
Pu-240	16	36.998	2.28E-01	8.44E+00	1.00E+00	8.44E+00
Pu-241	2.5	5.781	1.03E+02	5.95E+02	5.20E+01	1.15E+01
Pu-242	0.74	1.711	3.93E-03	6.72E-03	1.06E+00	6.34E-03
Totals	99.754	230.6711496		615.60		32.01
91-058 Pu Mixes Scaled to 325g for SWB						
Pu-83 Mixa						
Isotope	Weight %	Mass (g)(b)	Specific Activity (Ci/g)	Activity (Ci)	PE-Ci Wt. Factor	PE-Ci(c)
Pu-238	80	971.656	1.71E+01	1.66E+04	1.13E+00	1.47E+04
Pu-239	16.3	197.975	6.22E-02	1.23E+01	1.00E+00	1.23E+01
Pu-240	3	36.437	2.28E-01	8.31E+00	1.00E+00	8.31E+00
Pu-241	0.6	7.287	1.03E+02	7.51E+02	5.20E+01	1.44E+01
Pu-242	0.1	1.215	3.93E-03	4.77E-03	1.06E+00	4.50E-03
Totals	100	1214.57		17371.61		14739.00

Table A-4, Scaled Pu Mixes For 55 Gallon Drums and SWBs (Ref. DOE/WIPP 91-058)						Page 4 of 6
91-058 Pu Mixes Scaled to 200 FGE 55 Gallon Drums						
Pu-57 Mix						
Isotope	Weight %	Mass (g)[b]	Specific Activity (Ci/g)	Activity (Ci)	PE-Ci Wt. Factor	PE-Ci[c]
Pu-238	0.23	0.898	1.71E+01	1.54E+01	1.13E+00	1.36E+01
Pu-239	75.1	293.183	6.22E-02	1.82E+01	1.00E+00	1.82E+01
Pu-240	20.9	81.592	2.28E-01	1.86E+01	1.00E+00	1.86E+01
Pu-241	3.4	13.273	1.03E+02	1.37E+03	5.20E+01	2.63E+01
Pu-242	0.45	1.757	3.93E-03	6.90E-03	1.06E+00	6.51E-03
Totals	100.08	390.702312		1422.21		76.72
Pu-51 Mix						
Isotope	Weight %	Mass (g)[b]	Specific Activity (Ci/g)	Activity (Ci)	PE-Ci Wt. Factor	PE-Ci[c]
Pu-238	0.014	0.048	1.71E+01	8.20E-01	1.13E+00	7.26E-01
Pu-239	93.55	320.381	6.22E-02	1.99E+01	1.00E+00	1.99E+01
Pu-240	5.888	20.165	2.28E-01	4.60E+00	1.00E+00	4.60E+00
Pu-241	0.536	1.836	1.03E+02	1.89E+02	5.20E+01	3.64E+00
Pu-242	0.023	0.079	3.93E-03	3.10E-04	1.06E+00	2.92E-04
Totals	100.011	342.5076717		214.32		28.90
Pu-52 Mix						
Isotope	Weight %	Mass (g)[b]	Specific Activity (Ci/g)	Activity (Ci)	PE-Ci Wt. Factor	PE-Ci[c]
Pu-238	0.01	0.034	1.71E+01	5.86E-01	1.13E+00	5.19E-01
Pu-239	93.89	321.930	6.22E-02	2.00E+01	1.00E+00	2.00E+01
Pu-240	5.75	19.716	2.28E-01	4.50E+00	1.00E+00	4.50E+00
Pu-241	0.34	1.166	1.03E+02	1.20E+02	5.20E+01	2.31E+00
Pu-242	0.02	0.069	3.93E-03	2.70E-04	1.06E+00	2.54E-04
Totals	100.01	342.914288		145.09		27.35

Table A-4, Scaled Pu Mixes For 55 Gallon Drums and SWBs (Ref. DOE/WIPP 91-058)						Page 5 of 6
91-058 Pu Mixes Scaled to 200 FGE 55 Gallon Drums						
Pu-53 Mix						
Isotope	Weight %	Mass (g)[(b)]	Specific Activity (Ci/g)	Activity (Ci)	PE-Ci Wt. Factor	PE-Ci[(c)]
Pu-238	0.03	0.105	1.71E+01	1.80E+00	1.13E+00	1.59E+00
Pu-239	90.82	318.261	6.22E-02	1.98E+01	1.00E+00	1.98E+01
Pu-240	8.3	29.086	2.28E-01	6.63E+00	1.00E+00	6.63E+00
Pu-241	0.77	2.698	1.03E+02	2.78E+02	5.20E+01	5.34E+00
Pu-242	0.09	0.315	3.93E-03	1.24E-03	1.06E+00	1.17E-03
Totals	100.01	350.465043		306.23		33.36
Pu-54 Mix						
Isotope	Weight %	Mass (g)[(b)]	Specific Activity (Ci/g)	Activity (Ci)	PE-Ci Wt. Factor	PE-Ci[(c)]
Pu-238	0.05	0.180	1.71E+01	3.08E+00	1.13E+00	2.72E+00
Pu-239	86.36	310.827	6.22E-02	1.93E+01	1.00E+00	1.93E+01
Pu-240	11.75	42.291	2.28E-01	9.64E+00	1.00E+00	9.64E+00
Pu-241	1.63	5.867	1.03E+02	6.04E+02	5.20E+01	1.16E+01
Pu-242	0.21	0.756	3.93E-03	2.97E-03	1.06E+00	2.80E-03
Totals	100	359.92		636.02		43.32
Pu-55 Mix						
Isotope	Weight %	Mass (g)[(b)]	Specific Activity (Ci/g)	Activity (Ci)	PE-Ci Wt. Factor	PE-Ci[(c)]
Pu-238	0.02	0.075	1.71E+01	1.28E+00	1.13E+00	1.14E+00
Pu-239	83.7	314.436	6.22E-02	1.96E+01	1.00E+00	1.96E+01
Pu-240	14.9	55.975	2.28E-01	1.28E+01	1.00E+00	1.28E+01
Pu-241	1.1	4.132	1.03E+02	4.26E+02	5.20E+01	8.19E+00
Pu-242	0.24	0.902	3.93E-03	3.54E-03	1.06E+00	3.34E-03
Totals	99.96	375.519732		459.68		41.65

Table A-4, Scaled Pu Mixes For 55 Gallon Drums and SWBs (Ref. DOE/WIPP 91-058)						Page 6 of 6
91-058 Pu Mixes Scaled to 200 FGE 55 Gallon Drums						
Pu-56 Mix						
Isotope	Weight %	Mass (g)(b)	Specific Activity (Ci/g)	Activity (Ci)	PE-Ci Wt. Factor	PE-Ci(c)
Pu-238	0.014	0.053	1.71E+01	9.00E-01	1.13E+00	7.96E-01
Pu-239	80.5	302.495	6.22E-02	1.88E+01	1.00E+00	1.88E+01
Pu-240	16	60.123	2.28E-01	1.37E+01	1.00E+00	1.37E+01
Pu-241	2.5	9.394	1.03E+02	9.68E+02	5.20E+01	1.86E+01
Pu-242	0.74	2.781	3.93E-03	1.09E-02	1.06E+00	1.03E-02
Totals	99.754	374.8456058		1001.41		51.94

Notes:

a. It is noted that thermal power limitations will limit the transuranic content for this mix to a value that is less than the content allowable based on the WAC Nuclear Criticality Limits. However, the calculations are performed here for comparision purposes.

b. Isotopic mass scaled to 200 Pu-239 Fissile Gram Equivalents (FGEs) for 55-gal drums and 325 FGEs for Standard Waste Boxes. The following equation is used to calculate the scaled isotopic masses:

$$Pu-239\ FGE = \sum_{i=1}^{n} * M_i\ (FGE\ Factor)_i$$

where: Pu-239 FGE = 200g for drums or 325g for SWBs
Mi = mass of isotope I = (wt%) i (Total FGE scaled mass, MPu, of Pu in grams)
FGE Factori = FGE Factor from Table 10.1 of Nu Pac TRUPACT-II SAR

for example, for 55-gal drums:
200g = (wt% Pu-238)(MPu)(1.13E-01)+(wt% Pu-239)(MPu)(1)+(wt% Pu-240)(MPu)(2.25E-02)+
(wt% Pu-241)(MPu)(2.25)+(wt% Pu-242)(MPu)(7.5E-03)

c. Pu-239 Equivalent Curies (PE-Ci) are calculated using the following equation:

$$PE-Ci_{mix} = \sum_{i=1}^{n} * \frac{M_i\ *(Specific\ Activity\ Ci/g)}{PE-Ci\ Weighting\ Factor}$$

See Appendix B for PE-Ci Weighting Factors

Table A-5 Random Binomial Sampling from the Distribution of All Equivalent 55 Gallon Waste Containers
Sheet 1 of 8 - See Sheets 7 & 8 for a discussion of the calculation.

From Table A-3

Description	Value	Source
Percentage of All Drums > 20 PE-Ci	2.7%	Drum Percentile of Waste Stream RF-TT0491 (Av. = 18.9 PE-Ci/ Drum)
Percentage of All Drums > 2.7 PE-Ci*	36%	Drum Percentile of Waste Stream MD-T012 (Av. = 2.7 PE-Ci/ Drum)
Percentage of All Drums > 2.7 PE-Ci, given they are < 20 PE-Ci	37%	= 0.364/(1-0.027)

* Average Loading of 8 Pe-Ci/drum is obtained for a population between 2.7 and 20 PE-Ci.

Seven Drums Damaged (Refer to Sheet 2)

Number of Drums with TRU Loading > 20 PE-Ci (Assumed = 80 PE-Ci)	Remaining Drums Having TRU Loading > 2.7 PE-Ci (Average = 8 PE-Ci)	Assumed MAR (PE-Ci) in Loading Combination *Reasonable Maximum	Probability of Damaging the Combination of Drums During Waste Handling	Probability of Damaged Drums Having TRU Loading ≤ MAR
3	Any Number (0-4)	> 240	6.2E-04	99.998%
2	Any Number (0-5)	> 160	1.3E-02	99.9%
1	**6**	**128***	**4.4E-04**	**98.6%**
1	5	120	4.4E-03	98.6%
1	4	112	1.8E-02	98%
1	3	104	4.1E-02	96%
1	2	96	5.2E-02	92%
1	1	88	3.5E-02	87%
1	0	80	9.6E-03	84%
0	Any Number (0-7)	Low	8.3E-01	83%

Four Drums Damaged (Refer to Sheet 3)

Number of Drums with TRU Loading > 20 PE-Ci (Assumed = 80 PE-Ci)	Remaining Drums Having TRU Loading > 2.7 PE-Ci (Average = 8 PE-Ci)	Assumed MAR (PE-Ci) in Loading Combination *Reasonable Maximum	Probability of Damaging the Combination of Drums During Waste Handling	Probability of Damaged Drums Having TRU Loading ≤ MAR
3	Any Number (0-1)	> 240	7.7E-05	100%
2	Any Number (0-2)	> 160	4.1E-03	99.99%
1	**3**	**104***	**5.2E-03**	**99.6%**
1	2	96	2.6E-02	99%
1	1	88	4.4E-02	96%
1	0	80	2.4E-02	92%
0	Any Number (0-4)	Low	9.0E-01	90%

Two Drums Damaged (Refer to Sheet 4)

Number of Drums with TRU Loading > 20 PE-Ci (Assumed = 80 PE-Ci)	Remaining Drums Having TRU Loading > 2.7 PE-Ci (Average = 8 PE-Ci)	Assumed MAR (PE-Ci) in Loading Combination *Reasonable Maximum	Probability of Damaging the Combination of Drums During Waste Handling	Probability of Damaged Drums Having TRU Loading ≤ MAR
2	0	> 160	7.3E-04	100.0%
1	**1**	**88***	**2.0E-02**	**99.9%**
1	0	80	3.3E-02	98%
0	2	Low	9.5E-01	95%

Table A-5 Random Binomial Sampling from the Distribution of All Equivalent 55 Gallon Waste Containers (Sheet 2 of 8)

Scenarios Where 7 Drums are Damaged

Heaviest Loaded Drum**

Number Drums, n > 20 PE-Ci	Total Drums Damaged	P(Single Drum > 20 PE-Ci)	P(n drums > 20 PE-Ci)	P(≥n drums > 20 PE-Ci)
7	7	2.7E-02	1.0E-11	1.0E-11
6	7	2.7E-02	2.6E-09	2.6E-09
5	7	2.7E-02	2.9E-07	2.9E-07
4	7	2.7E-02	1.7E-05	1.7E-05
3	7	2.7E-02	6.2E-04	6.3E-04
2	7	2.7E-02	1.3E-02	1.4E-02
1	7	2.7E-02	1.6E-01	1.7E-01
0	7	2.7E-02	8.3E-01	1.0E+00

Given the remaining drums are < 20 PE-Ci**

Number Drums, m > 2.7 PE-Ci	Total Remaining Drums	P(Single Drum > 2.7 PE-Ci)	P(m drums > 2.7 PE-Ci)	P(≥m drums > 2.7 PE-Ci)
6	6	3.7E-01	2.7E-03	2.7E-03
5	6	3.7E-01	2.8E-02	3.0E-02
4	6	3.7E-01	1.2E-01	1.5E-01
3	6	3.7E-01	2.6E-01	4.0E-01
2	6	3.7E-01	3.2E-01	7.2E-01
1	6	3.7E-01	2.2E-01	9.4E-01
0	6	3.7E-01	6.0E-02	1.0E+00

Considering all drums in the MAR group**

Number Drums, n > 20 PE-Ci	Number drums, m > 2.7 PE-Ci	P(n drums >20 PE-Ci	P(≥m drums > 2.7 PE-Ci)	Joint Probability
3	Any Number (0-4)	6.2E-04	1.0E+00	6.2E-04
2	Any Number (0-5)	1.3E-02	1.0E+00	1.3E-02
1	6	1.6E-01	2.7E-03	4.4E-04
1	5	1.6E-01	2.8E-02	4.4E-03
1	4	1.6E-01	1.2E-01	1.8E-02
1	3	1.6E-01	2.6E-01	4.1E-02
1	2	1.6E-01	3.2E-01	5.2E-02
1	1	1.6E-01	2.2E-01	3.5E-02
1	0	1.6E-01	6.0E-02	9.6E-03
0	Any Number (0-6)	8.3E-01	1.0E+00	8.3E-01

**See Sheets 5 & 6 for a discussion of the calculation.

Table A-5 Random Binomial Sampling from the Distribution of All Equivalent 55 Gallon Waste Containers (Sheet 3 of 8)

Scenarios Where 4 Drums are Damaged

Heaviest Loaded Drum**

Number Drums, n > 20 PE-Ci	Total Drums Damaged	P(Single Drum > 20 PE-Ci)	P(n drums > 20 PE-Ci)	P(≥n drums > 20 PE-Ci)
4	4	2.7E-02	5.3E-07	5.3E-07
3	4	2.7E-02	7.7E-05	7.7E-05
2	4	2.7E-02	4.1E-03	4.2E-03
1	4	2.7E-02	9.9E-02	1.0E-01
0	4	2.7E-02	9.0E-01	1.0E+00

Given the remaining drums are < 20 PE-Ci**

Number Drums, m > 2.7 PE-Ci	Total Remaining Drums	P(Single Drum > 2.7 PE-Ci)	P(m drums > 2.7 PE-Ci)	P(≥m drums > 2.7 PE-Ci)
3	3	3.7E-01	5.2E-02	5.2E-02
2	3	3.7E-01	2.6E-01	3.2E-01
1	3	3.7E-01	4.4E-01	7.5E-01
0	3	3.7E-01	2.5E-01	1.0E+00

Considering all drums in the MAR group**

Number Drums n > 20 PE-Ci	Number drums, m > 2.7 PE-Ci	P(n drums >20 PE-Ci	P(≥m drums > 2.7 PE-Ci)	Joint Probability
2	Any Number (0-2)	4.1E-03	1.0E+00	4.1E-03
1	3	9.9E-02	5.2E-02	5.2E-03
1	2	9.9E-02	2.6E-01	2.6E-02
1	1	9.9E-02	4.4E-01	4.4E-02
1	0	9.9E-02	2.5E-01	2.4E-02
0	Any Number (0-4)	9.0E-01	1.0E+00	9.0E-01

**See Sheets 5 & 6 for a discussion of the calculation.

Table A-5 Random Binomial Sampling from the Distribution of All Equivalent 55 Gallon Waste Containers (Sheet 4 of 8)

Scenarios Where Two Drums Are Damaged

Heaviest Loaded Drums**

Number Drums, n > 20 PE-Ci	Total Drums Damaged	P(Single Drum > 20 PE-Ci)	P(n drums > 20 PE-Ci)	P(≥n drums > 20 PE-Ci)
2	2	2.7E-02	7.3E-04	1.0E+00
1	2	2.7E-02	5.3E-02	9.99E-01
0	2	2.7E-02	9.5E-01	9.5E-01

Given the remaining damaged drums are < 20 PE-Ci**

Number Drums, m > 2.7 PE-Ci	Total Remaining Drums	P(Single Drum > 2.7 PE-Ci)	P(m drums > 2.7 PE-Ci)	P(≥m drums > 2.7 PE-Ci)
1	1	3.7E-01	3.7E-01	3.7E-01
0	1	3.7E-01	6.3E-01	1.0E+00

Considering all drums in the MAR group**

Number Drums, n > 20 PE-Ci	Number drums, m > 2.7 PE-Ci	P(n drums >20 PE-Ci	P(≥m drums > 2.7 PE-Ci)	Joint Probability
2	0	7.3E-04	1.0E+00	7.3E-04
1	1	5.3E-02	3.7E-01	2.0E-02
1	0	5.3E-02	6.3E-01	3.3E-02
0	Any Number (0-2)	9.5E-01	1.0E+00	9.5E-01

**See Sheets 5 & 6 for a discussion of the calculation.

Table A-5 - Random Binomial Sampling from the Distribution of All Equivalent 55 Gallon Waste Containers (Sheet 5 of 8)

Scenarios Where 21 Drums are Damaged

Heaviest Loaded Drum**

Number Drums, n > 20 PE-Ci	Total Drums Damaged	P(Single Drum > 20 PE-Ci)	P(n drums > 20 PE-Ci)	P(≥n drums > 20 PE-Ci)
7	21	2.7E-02	8.3E-07	8.3E-07
6	21	2.7E-02	1.4E-05	1.5E-05
5	21	2.7E-02	1.9E-04	2.0E-04
4	21	2.7E-02	2.0E-03	2.2E-03
3	21	2.7E-02	1.6E-02	1.8E-02
2	21	2.7E-02	9.1E-02	1.1E-01
1	21	2.7E-02	3.3E-01	4.4E-01
0	21	2.7E-02	5.6E-01	1.0E+00

Given the remaining drums are < 20 PE-Ci**

Number Drums, m > 2.7 PE-Ci	Total Remaining Drums	P(Single Drum > 2.7 PE-Ci)	P(m drums > 2.7 PE-Ci)	P(≥m drums > 2.7 PE-Ci)
20	20	3.7E-01	2.9E-09	2.9E-09
19	20	3.7E-01	9.6E-08	9.9E-08
18	20	3.7E-01	1.5E-06	1.6E-06
17	20	3.7E-01	1.5E-05	1.7E-05
16	20	3.7E-01	1.1E-04	1.3E-04
15	20	3.7E-01	5.9E-04	7.1E-04
14	20	3.7E-01	2.5E-03	3.2E-03
13	20	3.7E-01	8.2E-03	1.1E-02
12	20	3.7E-01	2.2E-02	3.4E-02
11	20	3.7E-01	5.0E-02	8.3E-02
10	20	3.7E-01	9.2E-02	1.7E-01
9	20	3.7E-01	1.4E-01	3.1E-01
8	20	3.7E-01	1.7E-01	4.9E-01
7	20	3.7E-01	1.8E-01	6.7E-01
6	20	3.7E-01	1.5E-01	8.2E-01
5	20	3.7E-01	1.0E-01	9.2E-01
4	20	3.7E-01	5.3E-02	9.7E-01
3	20	3.7E-01	2.1E-02	9.9E-01
2	20	3.7E-01	5.8E-03	1.0E+00
1	20	3.7E-01	1.0E-03	1.0E+00
0	20	3.7E-01	8.5E-05	1.0E+00

Table A-5 - Random Binomial Sampling from the Distribution of All Equivalent 55 Gallon Waste Containers (Sheet 6 of 8)

Scenarios Where 28 Drums are Damaged

Heaviest Loaded Drum**

Number Drums, n > 20 PE-Ci	Total Drums Damaged	P(Single Drum > 20 PE-Ci)	P(n drums > 20 PE-Ci)	P(≥n drums > 20 PE-Ci)
9	28	2.7E-02	3.1E-08	3.1E-08
8	28	2.7E-02	5.1E-07	5.4E-07
7	28	2.7E-02	7.0E-06	7.5E-06
6	28	2.7E-02	8.0E-05	8.7E-05
5	28	2.7E-02	7.5E-04	8.4E-04
4	28	2.7E-02	5.6E-03	6.5E-03
3	28	2.7E-02	3.3E-02	3.9E-02
2	28	2.7E-02	1.4E-01	1.7E-01
1	28	2.7E-02	3.6E-01	5.4E-01
0	28	2.7E-02	4.6E-01	1.0E+00

Given the remaining drums are < 20 PE-Ci**

Number Drums, m > 2.7 PE-Ci	Total Remaining Drums	P(Single Drum > 2.7 PE-Ci)	P(m drums > 2.7 PE-Ci)	P(≥m drums > 2.7 PE-Ci)
28	28	3.7E-01	1.1E-12	1.1E-12
27	28	3.7E-01	5.2E-11	5.3E-11
26	28	3.7E-01	1.2E-09	1.2E-09
25	28	3.7E-01	1.7E-08	1.8E-08
24	28	3.7E-01	1.8E-07	2.0E-07
23	28	3.7E-01	1.4E-06	1.6E-06
22	28	3.7E-01	9.1E-06	1.1E-05
21	28	3.7E-01	4.8E-05	5.9E-05
20	28	3.7E-01	2.1E-04	2.7E-04
19	28	3.7E-01	7.8E-04	1.1E-03
18	28	3.7E-01	2.5E-03	3.5E-03
17	28	3.7E-01	6.8E-03	1.0E-02
16	28	3.7E-01	1.6E-02	2.7E-02
15	28	3.7E-01	3.3E-02	6.0E-02
14	28	3.7E-01	6.0E-02	1.2E-01
13	28	3.7E-01	9.3E-02	2.1E-01
12	28	3.7E-01	1.3E-01	3.4E-01
11	28	3.7E-01	1.5E-01	4.9E-01
10	28	3.7E-01	1.5E-01	6.4E-01
9	28	3.7E-01	1.3E-01	7.8E-01
8	28	3.7E-01	1.0E-01	8.8E-01
7	28	3.7E-01	6.5E-02	9.4E-01
6	28	3.7E-01	3.4E-02	9.8E-01
5	28	3.7E-01	1.5E-02	9.9E-01
4	28	3.7E-01	5.2E-03	1.0E+00
3	28	3.7E-01	1.4E-03	1.0E+00
2	28	3.7E-01	2.7E-04	1.0E+00
1	28	3.7E-01	3.4E-05	1.0E+00
0	28	3.7E-01	2.0E-06	1.0E+00

Table A-5 Random Binomial Sampling from the Distribution of All Equivalent 55 Gallon Waste Containers, Sheet 7 of 8

Notes:
The frequency of accident scenarios calculated in this SAR is based on the entire throughput of waste containers that will be handled at the WIPP. The consequences of accident scenarios calculated in this SAR assumes that the drums involved have the distributions of drums with conservative TRU waste loading profiles that satisfy the guidelines of DOE-STD-3009-94 and its draft appendix, which state that the consequences should "represent a reasonable maximum for a given process or activity, as opposed to artificial maximums unrepresentative of actual conditions." To meet these guidelines, two drum loads are used for consequence calculations, 80 PE-Ci and 8 PE-Ci. For scenarios resulting in damaged drums, the following drum loadings were assumed. The justification for the selection of these loading values are given in Section 5.1.2.1.

Total Number of Drums Damaged	No. of Drums with Loading = 80 PE-Ci of TRU Waste	No. of Drums with Loading = 8 PE-Ci of TRU Waste	Maximum Reasonable MAR (PE-Ci)
7	1	6	128
4	1	3	104
2	1	1	88

Based on the sort of the BIR given in Table A-3, which lists the waste stream information available in the BIR, only a small fraction of the drums that are currently stored at generator sites have TRU waste concentrations that approach or exceed these loadings. For the purpose of demonstrating that this selection will result in conservatively estimated consequences, this table calculates the probability that any given group of drums damaged in the assumed accident will contain the loading of TRU waste used for the consequence calculations.

Assumptions - To accomplish the calculation, the following assumptions are used:

- The waste containers are loaded for shipment randomly with respect to their radionuclide content. This assumption is reasonable, because waste containers are not normally stored by waste stream or content at the generator sites.

- The probability of selecting a given set of drums is a constant value determined from the fraction of equivalent 55 gallon drums that are in the range of TRU waste content reported in the BIR. This assumption is reasonable, since the BIR is the best information currently available to the WIPP regarding the distribution of TRU waste concentration within waste containers.

- The population from which the drums are selected is sufficiently large that the probability of selecting another drum in the same range of loading will not be affected by previous selections. Since the population consists of over 250,000 drums, this assumption is reasonable.

- Based on the above information, a binomial sampling process may be modeled, in which the probability of selecting a drum from a given range of drum loadings is a constant value over all trials.

Table A-5 Random Binomial Sampling from the Distribution of All Equivalent 55 Gallon Waste Containers, Sheet 8 of 8

Calculations -

Sheet 1 presents the probabilities that individual drums will be within specified ranges of TRU waste content and states where they were obtained from within Table A-3. It also summarizes the results of the sampling calculations . Sheets 2 through 4 show the detailed calculations for each quantity of drums that may be damaged during a postulated accident.

Sheet 1 summarizes the calculations for the three quantities of drums that can be damaged. Each summary is sorted from high to low MAR. The combination of drums that produce the MAR is given in the first two columns. The forth column relates the probability of that specific combination of drums being damaged, given that total quantity of drums are damaged. The fifth column expresses the probability of damaging a group of drums having the indicated MAR or less. The highlighted rows indicate the combination of drums that consitute the "reasonable maximum" MAR assumed for accident consequence assessment in Section 5.2 of the Safety Analysis Report. It can be seen from the fifth column that the "reasonable maximum" MAR is greater than the quantity of TRU waste that is expected to be found in over 98% of the combinations of drums damaged in an accident, which makes it a conservative assumption.

The binomial calculations are accomplished in the top two tables of Sheets 2 through 4 using the BINOMDIST of the Excel program, which is explained below:

BINOMDIST(number_s,trials,probability_s,cumulative= FALSE) (Result given in Column 4)

where

number_s — Number of drums within PE-Ci range (eg. > 20 PE-Ci) (Column 1)

trials — Total number of damaged drums (Column 2)

probability_s — Probability an individual drum is within the PE-Ci range (eg. P(drum > 20 PE-Ci) (Column 3)

cumulative — Set to FALSE to indicate calculation of only one combination of drums. (The cumulative probability was obtained by summing Column 4 within Column 5)

The top tables on Sheets 2 through 4 calculate the probability of having any number of drums containing TRU waste >20 PE-Ci/drum in a random group of damaged drums, based on the binomial sampling.

The second table shows the probability that any number of the remaining drums will have > 2.7 PE-Ci. The 2.7 PE-Ci was selected, because the MAR assumed a conversative average drum of 8 PE-Ci. According to Table A-3, the average TRU waste loading of all the drums between 20 and 2.7 PE-Ci is 8 PE-Ci.

The third table shows the joint probability of damaging various combinations of >20 PE-Ci and average 8 PE-Ci drums. This table forms the input to Sheet 1.

APPENDIX - B
Plutonium-239 Equivalent Activity

The concept of Plutonium-239 Equivalent Activity (PE-Ci) is intended to eliminate the dependency of radiological analyses on specific knowledge of the radionuclide composition of a transuranic waste stream. A unique radionuclide composition and/or distribution is associated with virtually every transuranic waste generator and storage site. By normalizing all radionuclides to a common radiotoxic hazard index, radiological analyses can be conducted for the WIPP facility, which are essentially independent of these variations. Plutonium-239, as a common component of virtually all defense transuranic wastes, was selected as the radionuclide to which the radiotoxic hazard of other transuranic radionuclides could be indexed.

Operational releases from the WIPP facility, including both routine and accident related, are airborne. There are no significant liquid release pathways during the operational phase of the facility. This, and the fact that transuranic radionuclides primarily represent inhalation hazards, allows a valid relationship to be established, which normalizes the inhalation hazard of a transuranic radionuclide to that of Pu-239 for the purpose of the WIPP radiological analyses. In effect, the radiological dose consequences of an airborne release of a quantity of transuranic radioactivity with a known radionuclide distribution will be essentially identical to that of a release of that material expressed in terms of a quantity of Pu-239.

To obtain this correlation, the 50-year effective whole-body dose commitment or dose conversion factor (DCF) for a unit intake of each radionuclide will be used.

For a known radioactivity quantity and radionuclide distribution, the Pu-239 equivalent activity is determined using radionuclide specific weighting factors. The Pu-239 equivalent activity (AM) can be characterized by:

$$AM = \sum_{i=1}^{K} A_i/WF_i$$

where K is the number of TRU* radionuclides, A_i is the activity of radionuclide i, and WF_i is the PE-Ci weighting factor for radionuclide i.

WF_i is further defined as the ratio:

$$WF_i = E_o/E_i$$

where, E_o (rem/μCi) is the 50-year effective whole-body dose commitment due to the inhalation of Pu-239 particulates with a 1.0 μm AMAD (Activity Median Aerodynamic Diameter) and a W pulmonary clearance class, and E_i (rem/μCi) is the 50-year effective whole-body dose commitment due to the inhalation of radionuclide particulates with a 1.0 μm AMAD and the pulmonary clearance class resulting in the highest 50-year effective whole-body dose commitment.

The values of E_o and E_i may be obtained from DOE/EH-0071.[1] Weighting factors calculated in this manner are presented in Table B-1 for selected radionuclides of interest.

---

*TRU as designated in this equation refers to any radionuclide with an atomic number greater than 92 and including U-233.

Table B-1, PE-Ci Weighting Factors for Selected Radionuclides

Radionuclide	Pulmonary Clearance Class*	Weighting Factor
U-233	Y	3.9
Np-237	W	1.0
Pu-236	W	3.2
Pu-238	W	1.1
Pu-239	W	1.0
Pu-240	W	1.0
Pu-241	W	51.0
Pu-242	W	1.1
Am-241	W	1.0
Am-243	W	1.0
Cm-242	W	30.0
Cm-244	W	1.9
Cf-252	Y	3.9

*(D) Daily; (W) Weekly, (Y) Yearly

References for Appendix B

1. DOE/EH-0071, Internal Dose Conversion Factors for Calculation of DOSE to the Public, July 1988.

APPENDIX - C
HAZOP SESSION SUMMARY TABLE

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRANSPORTER

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
1) Transporter at Front Gate	Exceeds Acceptance Criteria (WAC)	Technician or instrumentation error Shift of internal shielding Shipment sent by Generator above WAC limits for dose rate	Potential inability to perform radiation survey and security checks Potential inability to bring transporter on site Potential to block primary vehicle access into site Potential to delay unloading transporter Potential for personnel radiation exposure Potential to expose dosimeters located in the security building Potential for sabotage of facility Potential to remove TRUPACT-II or transporter from service Potential for notification to DOE, DOT and the State of violation of the shipping requirements Potential for DOE\DOT investigation into the violation	Generator processes provide for shipping in accordance with the WAC requirements Radiation survey upon arrival provides early detection Instruments are periodically calibrated Training and qualification of health physics personnel conducting surveys Instrument calibration programs are periodically audited Health physics qualification programs are periodically audited WIPP conducts periodic audits on the Generator processes TRUPACT-II certified as a DOT Type B shipping container	0,3	2, 3
1) Transporter at Front Gate	No Notice of Arrival	Generator fails to notify facility of shipment	Potential inability to perform radiation survey and security checks Potential inability to bring transporter on site Potential to block primary vehicle access into site Potential to delay unloading transporter Potential for personnel radiation exposure Potential to expose dosimeters located in the security building Potential for sabotage of facility	Notification from TRANSCOM Physical fence partitions transporter from personnel Physical manifest for transporter received prior to transporter arrival at site Physical data on waste form and dose rate on TRUPACT-II contents Procedure of receipt of transporter at the gate Radiation survey of transporter and TRUPACT-II Procedures in place for reading dosimeters on a periodic basis Administrative control for inspection of transporter enroute and before leaving Generator DOT physical inspection of transporter to manifest at state lines WAC shipping requirements		2, 1

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRANSPORTER

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
1) Transporter at Front Gate	Shipping Papers Do Not Correlate	Generator's personnel error in matching manifest papers to shipment Transporter driver connects to incorrect trailer at Generator site	Potential to delay unloading transporter Potential to notify Generator that paperwork is incorrect for shipment received	Periodic paperwork checks by DOT as transporter crosses state lines during transit WIPP performs audits of Generator's shipping procedures on a periodic basis		1, 3
1) Transporter at Front Gate	TRUPACT-II Damage	Vehicle accident Road debris Sabotage Rifle fire	Potential to delay unloading transporter Potential for personnel radiation exposure Potential to expose dosimeters located in the security building Potential inability to perform normal operations Potential to lose continuing usage of a TRUPACT-II container Potential to contaminate surface Potential need to decontaminate area or contain contamination Potential economic loss	TRUPACT-II certification as a DOT Class B shipping container Radiation surveys are performed on incoming shipments Hourly inspections enroute are performed by the drivers Driver training and qualification Procedures in place for placing TRUPACT-II in a safe condition WAC shipping requirements		3, 1
1) Transporter at Front Gate	Transporter Breakdown	Mechanical or electrical failure Operator error No fuel	Potential for delay in positioning and unloading the trailer	Alternate means available to position the trailer		1, 3
1) Transporter at Front Gate	Transporter Fire	Diesel fuel line breaks spraying diesel fuel on hot manifold Electrical fire Brake defect Collision with another vehicle	Potential to delay unloading transporter Potential to lose use of the access gate Potential to lose guard house in a fire Potential to rupture fuel tank Potential for explosion Potential for personnel injury or fatality Potential to lose security vehicles in a fire Potential to release combustion products to the environment Potential to contaminate water used to control fire Potential environmental concern Potential for smoke entering the mine Potential economic loss	Transporter driver required qualification Fire extinguisher available on transporter Frequent inspection of transporter Site fire fighting personnel available to minimize loss Provisions in place for alternate site access Procedures in place to shutdown ventilation preventing smoke from entering the mine Procedures in place to monitor fire water run-off Emplacement dikes surround perimeter of site to capture fire water TRUPACT-II design	0,2	4, 2

* The first number indicates consequence, and the second indicates the relative probability.   NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRANSPORTER

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
1) Transporter at Front Gate	Waste Ignites	Lightning strikes the TRUPACT II		The TRUPACT II is approved by DOE, therefore, its safety is already justified by the TRUPACT SAR		
1) Transporter at Front Gate	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRANSPORTER

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
2)Transfer Trailer from Gate to Unloading Position	Damage To Trailer Jockey During Hook Up	Mechanical/electrical failure of trailer jockey Operator error in adjusting the 5th wheel plate elevation on the trailer jockey	Potential to delay unloading trailer Potential to damage trailer Potential to drop the trailer Potential for TRUPACT-II to slip from trailer Potential to disrupt facility operations	Operator certification provides for proper use of the trailer jockey Preventative maintenance of the trailer jockey Outside trucking services available to position the trailer Tie-downs prevent TRUPACT-II from slipping from trailer		1, 3
2)Transfer Trailer from Gate to Unloading Position	Jockey and Trailer Low Speed Accident	Mechanical or electrical failure Operator error	Potential to damage the waste handling building, trailer and/or jockey Potential to lose the negative pressure in the waste handling building Potential to lose the negative pressure boundary of the air lock Potential to slow down or stop unloading operations Potential for collision with another trailer Potential for fire Potential for personnel injury Potential to release combustion products to the environment Potential to slip TRUPACT-II from trailer Potential for collision with another vehicle	Operator training and qualifications provide for proper operation of equipment Vehicle preventative maintenance provides for proper equipment operation Tie-downs prevent TRUPACT-II from slipping from trailer Trailer jockey has fire suppression equipment installed TRUPACT-II design Low speed during equipment operation TRUPACT-II handling area is restricted to people and equipment Emergency Response Team available	0,4	2, 4
2)Transfer Trailer from Gate to Unloading Position	Trailer Jack Failure During Unhooking	Mechanical failure of the trailer jack stand Operator error during unhooking operation Inclement weather	Potential to delay unloading trailer Potential to drop trailer Potential to damage tractor Potential to damage trailer Potential for TRUPACT-II to disengage from the trailer Potential to disrupt facility operations	Transporter driver required qualification Trailer maintenance and inspection programs provide assurance for proper operation of the jacks TRUPACT-II tie-downs are designed to restrain the TRUPACT-II to the trailer TRUPACT-II design	0,3	2, 3
2)Transfer Trailer from Gate to Unloading Position	Transporter Breakdown	Mechanical or electrical failure Empty fuel tank	Potential slight delay in positioning trailer	Alternate means available to move trailer		1, 3

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRANSPORTER

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
2)Transfer Trailer from Gate to Unloading Position	Transporter Crashes Through Gate	Transporter brake system fails Driver error	Potential to damage the access gates Potential to damage sections of the facility Potential for personnel injury or fatality Potential economic loss	Drivers are trained, and qualified for proper transporter operation Transporter is equipped with emergency brakes Transporter maintenance provides for proper equipment operation Access road has a 90 degree turn immediately prior to approaching the main access gate, minimum speeds achieved Access roads are level	0,1	4, 1
2)Transfer Trailer from Gate to Unloading Position	Transporter/ Trailer Low Speed Accident	Operator error Mechanical or electrical failure Pedestrian inadvertently in roadway Restricted access path	Potential to delay unloading trailer Potential for personnel injury Potential to upset trailer Potential to damage trailer Potential to damage fire protection post indicator valves Potential to reduce fire protection capacity to some buildings Potential to slip load from trailer Potential to damage TRUPACT-II Potential for collision with another vehicle Potential economic loss	TRUPACT-II certification as a DOT Type B shipping container Driver training and qualification Trailer designed to withstand low speed impacts Site limits vehicle speed through facility Barricades around post indicator valves Dual fire protection loop	0,4	2, 4
2) Transfer Trailer from Gate to Unloading Position	Waste Ignites	Lightning strikes the TRUPACT II		The TRUPACT II is approved by DOE, therefore, its safety is already justified by the TRUPACT SAR		
2)Transfer Trailer from Gate to Unloading Position	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRAILER

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
3) Unloading of the Trailer	Failure to Properly Disconnect Trailer	Operator error in disconnecting trailer jockey from trailer	Potential to damage trailer Potential to lose continuing usage of trailer Potential for maintenance on trailer Potential to delay unloading trailer	Operators are trained and qualified to operate the equipment safely Preventative maintenance is performed on the trailer and the trailer jockey to provide reliable equipment operation Operator follows procedure during the unhooking operation		1, 3
3) Unloading of the Trailer	Loose surface contamination detected	Shipment sent by generator above WAC limits TRUPACT-II failure	Delay in waste handling operations Spread of loose surface contamination Decontamination required	Generator processes provide for shipping in accordance with the WAC requirements Radiation survey upon arrival provides early detection Instruments are periodically calibrated Training and qualification of health physics personnel conducting surveys Instrument calibration programs are periodically audited Health physics qualification programs are periodically audited WIPP conducts periodic audits on the Generator processes TRUPACT-II certified as a DOT Type B shipping container		1,3
3) Unloading of the Trailer	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
4) Transfer TRUPACT-II from Trailer to TRUDOCK	Failure to Remove TRUPACT From Trailer	Operator error Mechanical or electrical failure of fork lift Failure to remove tie-downs	Potential to delay unloading trailer Potential to damage TRUPACT-II Potential to damage trailer	Operator training and qualification Procedures are in place to perform operation Preoperational check list used during operation		1, 2
4) Transfer TRUPACT-II from Trailer to TRUDOCK	Failure to Remove Tie-downs	Operator error Mechanical Failure	Potential to stretch and break tie-downs	Operator training and qualification Operating procedures are in place to perform this operation		1, 3
4) Transfer TRUPACT-II from Trailer to TRUDOCK	Improper Stabilization of Trailer	Operator error	Potential for trailer to roll Potential for personnel injury Potential to damage trailer jockey Potential to damage fence, building or other trailers Potential to damage fire water post indicator valve Potential to lose fire protection water in the trailer staging area Potential economic loss	Traffic barricades stationed around post indicator valves Operator training and qualification Procedures in place to perform operation Trailer brake has fail safe mode of operation Trailer staging area is level prohibiting trailer from rolling	0,3	2, 3
4) Transfer TRUPACT-II from Trailer to TRUDOCK	Improper Transit to TRUDOCK	Operator error Mechanical/electrical failure of fork lift Collision with another vehicle, a pedestrian, building, or air lock door Air lock door interlock failure Air lock door(s) fail to fully open TRUDOCK doors fail to fully open	Potential to slightly damage TRUPACT-II Potential to damage fork lift Potential to damage Waste Handling Building Potential to damage air lock Potential for personnel injury Potential to damage TRUDOCK Potential to lose ventilation in the air lock Potential to damage air lock duct work Potential to activate the fire protection system in the air lock	Operator training and qualification TRUPACT-II design and certification as a DOT Class B container Spotter used during transit Low battery indicator on the fork lift Equipment preventative maintenance program provides for reliable equipment operation Backup fork lift available Alternate air locks are available Procedures are in place to perform operation Air lock duct work may be isolated Air lock fire protection may be isolated Fire watches may be used to supplement fire protection loss	0,3	2, 3

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
4) Transfer TRUPACT-II from Trailer to TRUDOCK	Misalignment of Fork Lift to TRUPACT-II	Operator error Failure to remove TRUPACT-II fork lift access covers Fork lift mechanical or electrical failure	Potential to knock TRUPACT-II off trailer Potential for personnel injury or fatality Potential to damage TRUPACT-II Potential to damage trailer Potential to damage fork lift	Operator training and qualification Second person used during the operation to spot the fork lift properly Procedures are in place to perform operation TRUPACT-II design mitigates damage Preoperational checks of equipment prior to use Work practices minimize unnecessary personnel from the work area Area is a radiological controlled area during the handling of waste Forklift is equipped with two television cameras and monitors to aid in positioning	0,2	4, 2
4) Transfer TRUPACT II from Trailer to TRUDOCK	Waste Ignites	Lightning strikes the TRUPACT II		The TRUPACT II is approved by NRC, therefore, its safety is already justified by the TRUPACT SAR		
4) Transfer TRUPACT-II from Trailer to TRUDOCK	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
5) Removal of Outer Containment Vessel (OCV) Lid	Failure to Lift OCV Lid	Locking ring fails to rotate OCV lid binds Crane mechanical or electrical failure Crane lift wire rope fails	Potential to delay unloading operations Potential to damage TRUPACT-II	Operator training and qualification Preoperational checks are used prior to starting the process Procedures are in place to perform operation Overhead crane fails as is on loss of power ACGLF provided with indicating light when engaged in pallet Crane over designed with a by factor of 5 Duplicate lifting fixtures are available Preventative maintenance checks on crane, wire rope, ACGLF, and hook are performed monthly Generator ships in accordance with the WAC shipping limitations Radiological surveys identify radiation levels and contamination levels as found WIPP lifting practices comply with DOE hoisting and rigging regulations		1, 3
5) Removal of Outer Containment Vessel (OCV) Lid	Failure to Move OCV Lid to Lid Stand	Radioactive contamination found inside the TRUPACT-II Crane mechanical or electrical failure Crane lift wire rope fails	Potential to lose use of TRUDOCK Potential to reclose TRUPACT-II and send shipment back to generator Potential for spot decontamination Potential to drop OCV lid Potential to damage OCV lid Potential for personnel injury or fatality Potential to damage TRUDOCK	Operator and health physics technician training and qualification Procedures are in place to perform operation Overhead crane fails as is on loss of power ACGLF provided with position indicating light Crane over designed by factor of 5 Duplicate lifting fixtures are available Preventative maintenance checks on crane, cables, ACGLF, and hook are performed monthly Generator ships in accordance with the WAC shipping limitations Radiological surveys identify radiation levels and contamination levels above WAC WIPP lifting practices comply with DOE hoisting and rigging regulations Generator checks shipment prior to departure WIPP Waste Information System (WWIS) data received from the Generator Second TRUDOCK available Preoperational checks	0,2	4, 2

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
5) Removal of Outer Containment Vessel (OCV) Lid	Failure to Prep OCV Lid For Removal	Operator error Jammed access plug	Potential to delay unloading operation Potential to perform maintenance on access port	Operator training and qualification Maintenance procedures for rework of the access plug		1, 3
5) Removal of Outer Containment Vessel (OCV) Lid	Failure to Pull Vacuum on OCV Lid	Mechanical/electrical failure of the vacuum system Operator error Failure to remove access plug Leak in TRUPACT-II Loss of HVAC system	Potential inability to remove the OCV lid Potential to delay unloading operations	TRUPACT-II certification as a DOT Class B container TRUPACT-II container integrity is checked during annual maintenance by WIPP personnel Operator training and qualification Redundant HVAC system available to support operations Backup vacuum pumps are available		1, 3
5) Removal of Outer Containment Vessel (OCV) Lid	Failure to Verify System Conditions	Operator error	Potential to violate administrative controls/operating procedures Potential to lose negative pressure in the Waste Handling Building Potential to delay waste handling operations	Operator training and qualification Procedures are in place to check and verify system conditions Conduct of Operations provides guidelines for activities Local audible and visual alarm when inadequate negative pressure exists in the Waste Handling Building	0,3	2, 3
5) Removal of Outer Containment Vessel (OCV) Lid	Missing Security Seals	Generator fails to install seals Seal(s) lost in transit	Potential to delay unloading operations	DOT checks presence of seals during inspections at the state lines Design of the security seal minimizes inadvertent loss Procedures require checking for the seals		1, 3

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
5) Removal of Outer Containment Vessel Lid (OCV)	Crane load swing while moving OCV Lid to OCV Lid Stand	Improper balance of load Operator error Equipment malfunction	Potential for personnel injury or fatality Potential to delay operations Potential to damage WHB	ACGLF provided with position indicating light Preventative maintenance checks on ACGLF WIPP lifting practices comply with DOE hoisting and rigging regulations Operator training and qualifications Procedures are in place to perform operations QA Pre-operational checks of equipment prior to use	0,2	4,2
5) Removal of Outer Containment Vessel (OCV) Lid	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
6) Removal of Inner Containment Vessel (ICV) Lid	Failure to Establish Vent Hood Operation	Loss of HVAC in the CH bay Loss of ventilation at the TRUDOCK Damper out of position Valve fails	Potential to delay unloading operations	Verification of vent flow is required Valve positions are verified Operator training and qualification Periodic preventative maintenance performed on equipment Periodic equipment checks during the process Procedures are in place to perform process Redundant trains available in the CH HVAC system	0,4	1, 4
6) Removal of Inner Containment Vessel (ICV) Lid	Failure to Lift the ICV Lid	Locking ring fails to rotate Lid binds Crane mechanical or electrical failure Crane lift wire rope fails	Potential to delay unloading operations Potential to damage TRUPACT-II	Operator training and qualification Procedures are in place to perform operation Overhead crane fails as is on loss of power ACGLF provided with indicating light when engaged in pallet Crane over designed by factor of 5 Duplicate lifting fixtures are available Preventative maintenance checks on crane, cables, ACGLF, and hook are performed monthly Generator ships in accordance with the WAC shipping limitations Radiological surveys identify radiation levels and contamination levels as found WIPP lifting practices comply with DOE hoisting and rigging regulations Emergency Response/Recovery Plan Preoperational checks		1, 3

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
6) Removal of Inner Containment Vessel (ICV) Lid	Failure to Move ICV Lid to ICV Lid Stand	Radioactive contamination found inside the TRUPACT-II Crane mechanical or electrical failure Crane lift wire rope fails Airborne contamination found	Potential to lose use of TRUDOCK Potential to reclose the TRUPACT-II and send shipment back to generator Potential for spot decontamination Potential to drop ICV lid Potential to damage ICV lid Potential for personnel injury or fatality Potential to damage TRUDOCK Potential to contaminate the area Potential need to decontaminate area Potential to sound alarms on the continuous air monitors (CAM) Potential need to issue Report of Occurrence on activation of CAM alarms Potential personnel radiation exposure Potential environmental concern Potential economic loss	Operator and Health Physics technician training and qualification Procedures are in place to perform operation Overhead crane fails as is on loss of power ACGLF provided with position indicating light Crane over designed by factor of 5 Duplicate lifting fixtures are available Monthly preventative maintenance checks on crane, cables, ACGLF, and hook Generator ships in accordance with the WAC shipping requirements WIPP lifting practices comply with DOE hoisting and rigging regulations WIPP WWIS data received from generator Radiological surveys identify radiation levels and contamination levels above WAC Generator checks shipment prior to departure Abnormal operation procedures available for guidance Vent hood design and use Radiological instrumentation alarms Emergency Response/Recovery Plan Preoperational checks	0,2	4, 2
6) Removal of Inner Containment Vessel (ICV) Lid	Failure to Prep ICV Lid For Removal	Operator error	Potential to delay unloading operations	Operator training and qualification Procedures are in place to perform operation		1, 3
6) Removal of Inner Containment Vessel (ICV) Lid	Failure to Pull Vacuum on ICV Lid	Mechanical or electrical failure of the vacuum system Operator error Leak in TRUPACT-II Loss of HVAC system	Potential inability to remove the ICV lid Potential to delay unloading operations	TRUPACT-II certification as a DOT Class B container TRUPACT-II container integrity is checked during annual maintenance by WIPP personnel Operator training and qualification Redundant HVAC system available to support operations Backup vacuum pumps are available		1, 3

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
6) Removal of Inner Containment Vessel (ICV) Lid	Radiological Assessment > Background	Possible airborne contamination	Potential to delay unloading of the TRUPACT-II Potential to reclose the TRUPACT-II, spot decon or send shipment back to generator Potential to replace tool and filter due to internal contamination	Health Physics survey confirms contamination levels Health Physics personnel training and qualification Simplistic design of filter and sample rig Procedures are in place to perform process Generator conforms to shipping per WAC regulations Ventilation system prefilter and HEPA filter available for removing radioactive material from exhaust stream WAC shipping limits	0,4	2, 4
6) Removal of Inner Containment Vessel Lid (ICV)	Crane load swing while moving ICV Lid to ICV Lid Stand	Improper balance of load Operator error Equipment malfunction	Potential for personnel injury or fatality Potential to delay operations Potential to damage WHB	ACGLF provided with position indicating light Preventative maintenance checks on ACGLF WIPP lifting practices comply with DOE hoisting and rigging regulations Operator training and qualifications Procedures are in place to perform operations QA Pre-operational checks of equipment prior to use		1,3
6) Removal of Inner Containment Vessel (ICV) Lid	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
7) TRUPACT-II Internal Condition	Fire in TRUPACT-II	Spontaneous ignition in a waste container due to corrosion, chemical breakdown or anaerobic decomposition or pyrophoric interaction	Potential to shut down operations Potential to damage TRUPACT-II Potential to damage overhead crane Potential to rupture waste container Potential to spread contamination Potential need to decontaminate area Potential to damage TRUDOCK Potential for explosion Potential for personnel injury or fatality Potential to damage WHB Potential to lose containment Potential to release radioactive material Potential for personnel radiation exposure Potential to release combustion products to the environment Potential environmental concern Potential to notify DOE, EPA, and State of environmental violation Potential for adverse media attention Potential to shutdown site operations Potential for site evacuation Potential economic loss	Generator ships waste in accordance to WAC shipping criteria Waste containers are characterized Fissile loading is known Minimum liquids contained in Waste containers Waste containers are vented thru carbon filters Waste containers, due to storage prior to shipment, are more stable and lessens the likelihood of fire Waste container integrity is tested TRUPACT-II integrity On-site emergency responders available Building has fire suppression capability Waste containers are designed and certified as DOT Class A containers Building ventilation is filtered through prefilters and HEPA filters ICV lid can be reinstalled to aid in controlling fire in TRUPACT-II Smoke may be visible through hoses on vacuum systems Portable fire fighting equipment available Fire hose station available Limited combustibles in the area Building design is noncombustible Building design has two hour fire rating Emergency response team available Fire suppression system Vent hood system in place	3,3	4, 3
7) TRUPACT-II Internal Condition	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II PAYLOAD

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
8) Transfer of Payload from TRUDOCK to Facility Pallet	Failure To Place Load On Facility Pallet	Operator error Equipment failure Loss of power	Potential to misposition waste container on facility pallet Potential to delay operations	Operator training and qualification Maintenance procedures available Spotters used during transit of payload Preventative maintenance program in place Procedures used to perform operation Preoperational checks of equipment prior to use Adequate lighting in area Backup power available		1, 3
8) Transfer of Payload from TRUDOCK to Facility Pallet	Failure of Lifting Equipment	Mechanical or electrical failure of lifting equipment Operator error	Potential to drop the load Potential to damage CAMS Potential to damage TRUDOCK Potential to rupture waste container Potential for personnel injury or fatality Potential to release radioactive material Potential to contaminate surface Potential need to decontaminate area Potential for personnel radiation exposure Potential to delay operations Potential for fire Potential for explosion Potential to shutdown operations Potential to release combustion products to the environment Potential to damage Waste Handling Building Potential to lose containment Potential environmental concern Potential to notify DOE, EPA, and State of environmental violation Potential for adverse media attention Potential for site evacuation Potential economic loss	Generator ships waste in accordance to WAC Operator training and qualification Procedures are in place to perform operation Overhead crane fails as is on loss of power ACGLF provided with position indicating light Crane over designed by factor of 5 Duplicate lifting fixtures are available Monthly preventative maintenance checks on crane, wire rope, ACGLF, and hook Waste containers are designed and certified as DOT Class A containers Seven packs are wrapped restricting free motion Ventilation is designed to contain rad releases through use of HEPA filters WHB has fire suppression systems and portable fire extinguishers and hose station available Emergency response team on site WIPP lifting practices comply with DOE Hoisting and Rigging regulations Limited combustibles in area Building design is noncombustible	2,3	4, 3

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II PAYLOAD

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
8) Transfer of Payload from TRUDOCK to Facility Pallet	Failure to Secure Load	Operator error Damaged securing devices	Potential to lose load during transit Potential to drop the load Potential to damage CAMS Potential to damage TRUDOCK Potential to rupture waste container Potential for personnel injury or fatality Potential to release radioactive material Potential to contaminate surface Potential need to decontaminate area Potential for personnel radiation exposure Potential to delay operations Potential for fire Potential for explosion Potential to shutdown operations Potential to release combustion products to the environment Potential to damage Waste Handling Building Potential to lose containment Potential environmental concern Potential to notify DOE, EPA, and State of environmental violation Potential for adverse media attention Potential for site evacuation Potential economic loss	Generator ships waste in accordance to WAC Operator training and qualification Preventative maintenance Preoperational checks of equipment prior to use Equipment is designed as fail safe Waste containers are certified as DOT Class A containers Seven packs are wrapped restricting free motion Ventilation is designed to contain rad releases through use of HEPA filters WHB has fire suppression systems, fire extinguishers and hose station Emergency response team on site WIPP lifting practices comply with DOE Hoisting and Rigging regulations Limited combustibles in area Building design is noncombustible Waste Handling Building is a controlled area, thus minimizing worker exposure to contamination	2,3	4, 3
8) Transfer of Payload from TRUDOCK to Facility Pallet	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II PAYLOAD

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
9) Transfer Facility Pallet to Conveyance Car	Fork Lift Improper Engagement of Load	Operator error Fork lift mechanical or electrical failure	Potential to puncture waste container Potential to lose load Potential to damage TRUDOCK Potential to rupture waste container Potential to release radioactive material Potential need to decontaminate area Potential for fire Potential for explosion Potential for personnel injury or fatality Potential to shutdown operations Potential to damage fork lift Potential to damage Waste Handling Building Potential to release combustion products to the environment Potential to lose containment Potential environmental concern Potential to notify DOE, EPA, and State of environmental violation Potential adverse media attention Potential site evacuation Potential economic loss Potential loss of remote alarms	Generator ships waste in accordance to WAC Operator training and qualification Maintenance procedures available Spotters used during engagement and transit of payload Preventative maintenance program in place Procedures used to perform operation Preoperational checks of equipment prior to use Adequate lighting in area Backup power available Fire suppression systems Emergency response team available Building construction Waste containers are DOT Type A HEPA filtration in place Tine design prevents puncture Stretchwrap and tie-downs Emergency Response/Recovery Plan	2,3	4, 3

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II PAYLOAD

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
9) Transfer Facility Pallet to Conveyance Car	Mislocation On the Conveyance Car	Operator error Fork lift mechanical or electrical failure Air lock door failure	Potential to puncture waste container Potential to lose load Potential to rupture waste container Potential to release radioactive material Potential need to decontaminate area Potential for fire Potential for explosion Potential for personnel injury or fatality Potential to damage fork lift Potential to damage building Potential to release combustion products to environment Potential to notify proper authorities of release Potential vehicle collision Potential building collision Potential to damage the CMS monitor Potential to lose remote alarms Potential to lose air lock door interlock Potential to damage conveyance car Potential to damage conveyance room door seal Potential to lose secondary egress from underground Potential for adverse media attention Potential environmental concern Potential economic loss	Generator ships waste in accordance to WAC Waste containers are certified as DOT Class A containers Seven packs are wrapped restricting free motion Ventilation designed to contain rad releases through HEPA filters Operator training and qualification Fire suppression, fire extinguishers, hose station available Spotters are used during load movements Restricted access to qualified personnel Local alarms on CAM's and ventilation system Air intake and salt shafts are available for egress from underground Reinforced shield door and thick concrete containment walls Air lock doors are interlocked Tie-down straps and lateral straps Emergency Response/Recovery Plan	2,3	4, 3

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II PAYLOAD

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
9) Transfer Facility Pallet to Conveyance Car	Moving Accident	Operator error Fork lift mechanical or electrical failure	Potential to puncture waste container Potential to lose load Potential to rupture waste container (on facility pallet, waste container in temporary waste handling building storage, site generated waste container) Potential to release radioactive material Potential need to decontaminate area Potential for fire Potential for explosion Potential for personnel injury or fatality Potential to damage fork lift Potential to damage building Potential to damage TRUDOCK Potential to release combustion products to the environment Potential to notify DOE, EPA, and State of environmental violation Potential vehicle collision Potential building collision Potential for adverse media attention Potential for site evacuation Potential economic loss Potential to damage the CMS monitor Potential loss of remote alarms	Generator ships waste in accordance to WAC Operator training and qualification Spotters are used during load movements Preventative maintenance on equipment Waste containers are designed and certified as DOT Class A containers Seven packs are wrapped restricting free motion Ventilation is designed to contain rad releases through use of HEPA filters WHB has fire suppression systems, fire extinguishers and hose station Emergency response team on site Limited combustibles in area Building design is noncombustible Tie-down straps and lateral straps Emergency Response/Recovery Plan Forklift tine design prevents puncture	2,3	4, 3

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II PAYLOAD

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
9) Transfer Facility Pallet to Conveyance Car	Fork Lift Improper Engagement of Load	Operator Error	Possible Ignition of Drum if the Waste Container is Punctured	Generator ships waste in accordance to WAC Operator training and qualification Maintenance procedures available Spotters used during engagement and transit of payload Preventative maintenance program in place Procedures used to perform operation Fire suppression systems Emergency response team available Building construction Waste containers are DOT Type A HEPA filtration in place Tine design prevents puncture Stretchwrap and tie-downs Emergency Response/Recovery Plan	2,3	4,3
9) Transfer Facility Pallet to Conveyance Car	Mislocation on the Conveyance Car	Operator Error	Possible Ignition of Drum if the Waste Container is Punctured	Generator ships waste in accordance to WAC Waste containers are certified as DOT Class A containers Seven packs are wrapped restricting free motion Ventilation designed to contain rad releases through HEPA filters Operator training and qualification Fire suppression, fire extinguishers, hose station available Spotters are used during load movements Restricted access to qualified personnel Local alarms on CAM's and ventilation system Air intake and salt shafts are available for egress from underground Reinforced shield door and thick concrete containment walls Tie-down straps and lateral straps Emergency Response/Recovery Plan	2,3	4,3

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II PAYLOAD

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
9) Transfer Facility Pallet to Conveyance Car	Moving Accident	Operator Error	Possible Ignition of Drum if the Waste Container is Punctured	Generator ships waste in accordance to WAC Operator training and qualification Spotters are used during load movements Preventative maintenance on equipment Waste containers are designed and certified as DOT Class A containers Seven packs are wrapped restricting free motion Ventilation is designed to contain rad releases through use of HEPA filters WHB has fire suppression systems, fire extinguishers and hose station Emergency response team on site Limited combustibles in area Building design is noncombustible Tie-down straps and lateral straps Emergency Response/Recovery Plan Forklift tine design prevents puncture	2,2	4,2
9) Transfer Facility Pallet to Conveyance Car	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II PAYLOAD

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
10) Transfer Conveyance Car Load onto the Waste Cage	Driving Conveyance Car Into Empty Shaft	Operator error Equipment malfunction	Potential loss of operations Potential to damage equipment Potential to rupture waste container Potential to have a fire in waste shaft Potential to drop load down shaft Potential to contaminate the underground Potential need to decontaminate area Potential to fill underground with smoke Potential for explosion Potential for personnel injury or fatality Potential to release combustion products to the environment Potential environmental concern Potential to notify DOE, EPA, and State of environmental violation Potential to evacuate the underground Potential economic loss Potential for adverse media attention	Generator ships waste in accordance to WAC Operator training and qualification Position sensors on conveyance car automatically stop car prompting operator to use bypass Shaft tender in attendance Rail extensions engage cage rails to the floor to enable transferring the car Procedures are in place to perform operation Front wheels dropping off the track will high center the car stopping car movement Waste containers are designed and certified as DOT Class A containers Emergency Response/Recovery Plan	3,1	4, 1
10) Transfer Conveyance Car Load onto the Waste Cage	Failure of Conveyance Car	Mechanical or electrical failure	Potential to delay operations Potential to lose conveyance car Potential loss of operations	Maintenance programs Preventative maintenance program Preoperational checks Car can be manually removed from waste cage Operator training and qualification Durability of conveyance car		1, 3

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II PAYLOAD

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
10) Transfer Conveyance Car Load onto the Waste Cage	Moving Accident	Failure to raise car lift table Failure to lower pins on the waste car chairs Alignment of waste cage with the tracks Operator error Mechanical or electrical failure	Potential to lose load Potential to rupture waste container Potential to release radioactive material Potential need to decontaminate area Potential for fire Potential for explosion Potential for personnel injury or fatality Potential to release combustion products to environment Potential to notify DOE, EPA, and State of environmental violation Potential environmental concern Potential for adverse media attention Potential for waste hoist cage collision Potential to damage the chairs Potential to damage the facility pallet Potential to delay operations Potential economic loss	Operator training and qualification Procedures available to perform operation Preoperational checks prior to use Maintenance programs Preventative maintenance programs in place Car speed very slow Waste containers are stretch wrapped Load is strapped down Positive engagement of pallet to chairs Engineering design Restricted access Shaft tender, spotter and operator in attendance Table height interlock design Alignment system Fire suppression system WAC Emergency Response/Recovery Plan	2,3	4, 3
10) Transfer Conveyance Car Load onto the Waste Cage	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: WASTE HOIST

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
11) Waste Hoist	Waste Hoist Failure	Wire rope failure Power loss Overtravel-up or -down	Potential loss of facilities Potential to lose waste emplacement capabilities Potential for personnel injury or fatality Potential to release radioactive material Potential to contaminate underground Potential unfiltered release Potential to release combustion products to the environment Potential to drop car into shaft Potential for fire Potential for explosion Potential to loss all electrical power in mine Potential to lose plant air line and air services Potential to lose underground air locks and lighting Potential to evacuate underground personnel Potential need to decontaminate the underground Potential to notify DOE, EPA, and State of environmental violation Potential environmental concern Potential for adverse media attention Potential economic loss	Waste hoist is held by six wire ropes, each capable of holding load Catch gear in head frame to hold load Redundant brake systems available Four independent valve failures required to fail brakes Waste hoist design fails towards the "cage up" condition Controls are redundant Control system has elevation check mechanisms Maintenance procedures Maintenance program Weekly inspections Qualified personnel to operate NDT on ropes and bolts Acoustics emissions to check for fatigued parts Independent verification on shaft inspections by MSHA Vendor inspects annually Visual inspection of structural steel assemblies Preoperational checks before handling any loads including upper and lower limits and dump valves and backups are functioning Full power used to check the brakes 130 foot sump at bottom of shaft below mine level Other shafts available for egress Personnel underground trained in use of safety equipment Alternate source of power to the mine Exhaust filtration available Ventilation can be secured Gate and barriers established during hoist movement Plate out and depletion in mine Portable fire fighting equipment underground Transporter has built in fire suppression Rescue tools and equipment available Self rescuers available Underground has limited combustibles Brake system tested at full power Emergency Response/Recovery Plan	3,1	4, 1

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: WASTE HOIST

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
11) Waste Hoist	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: TRUPACT-II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
14) Shielded Holding Room	Failure to Transfer Waste Containers	Mechanical or electrical failure Operator error	Potential to drop the load Potential to rupture waste container Potential for personnel injury or fatality Potential to release radioactive material Potential to spread contamination Potential need to decontaminate area Potential for personnel radiation exposure Potential to delay operations Potential for fire Potential for explosion Potential for off site release Potential to notify DOE, EPA, and State of environmental violation Potential for adverse media attention Potential to release combustion products to the environment Potential environmental concern Potential economic loss	Generator ships waste in accordance to WAC Procedures available to perform operations Operator training and qualification Preventative maintenance on equipment Equipment is designed as fail safe Design of waste container as DOT Class A container Seven packs are wrapped restricting free motion (containerized) preventing loss of waste containers Ventilation is designed to contain rad releases WHB has fire suppression systems, portable fire extinguishers and hose station available Emergency response team is on site WIPP lifting practices comply with DOE Hoisting and Rigging regulations Stretchwrap	1,3	4, 3
14) Shielded Holding Room	Fire in Waste Container	Spontaneous combustion	Potential to spread fire and smoke through ventilation Potential to damage ventilation duct work Potential to lose negative pressure in Shielded Holding Room Potential to release radioactive material Potential for personnel radiation exposure Potential need to decontaminate area Potential for smoke to be released to the environment Potential for smoke to enter mine Potential for underground evacuation	Generator ships waste in accordance to WAC Room not occupied Fire detection system available Ventilation system continually vents air through HEPA filtration devices Fire suppression system available Construction of room has a 3 hr fire rating Alarm in CMS HEPA filtration designed not to ignite Double HEPA filtration (room and main exhaust filters) Procedures for compensatory fire protection measures Weekly inspection performed in room Periodic check of sprinklers and detectors Site emergency response team	3,3	2, 1
14) Shielded Holding Room	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: NATURAL EVENTS

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
15) Natural Events	Range Fire	Range fire	Potential to stop site operations Potential for smoke to enter the mine shaft Potential for underground evacuation Potential for smoke to enter facility buildings	CMS shuts down mine ventilation systems Interior buildings available for relocation of personnel Fire break installed Mutual aid agreements with the local communities for fire fighting assistance Emergency response team Memorandum of Understanding with Department of Interior for fire fighting assistance	0,4	2, 4
15) Natural Events	Seismic Event (Design Basis Event)	Earthquake	Potential to stop operations Potential to lose site utilities Potential to drop waste container Potential to rupture waste container Potential to release radioactive material Potential to release combustion products to the environment Potential for personnel radiation exposure Potential for fire Potential for explosion Potential for personnel injury or fatality Potential to breach electrical switchgear or circuits Potential to notify DOE, EPA, and State of environmental violation Potential environmental concern Potential economic loss Potential for adverse media attention Possible Ignition of Drum if the Waste Container is Punctured	Low probability of earthquake Building is designed for DBE Procedures in place to shutdown equipment Waste container, and TRUPACT-II integrity Generator ships waste in accordance to WAC CH bay overhead crane is seismically qualified Waste containers certified as Type A containers Fire suppression system Emergency response/Recovery Plan	2,1	4, 1

* The first number indicates consequence, and the second indicates the relative probability.　　NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: NATURAL EVENTS

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
15) Natural Events	Tornado (Design Basis Event)	Tornado	Potential to stop operation Potential to lose site utilities Potential for personnel injury or fatality Potential for tornado driven missile through the WHB, impacting TRUPACT-II or waste container causing a breach Potential for fire Potential for explosion Potential to release radioactive material Potential to release combustion products to the environment Potential for radiation exposure Potential need to decontaminate area Potential to notify DOE, EPA, and State of environmental violation Potential environmental concern Potential for adverse media exposure Potential economic loss	Waste Handling Building designed to withstand tornados Procedures in place to warn personnel to stay inside permanent buildings TRUPACT-II and waste containers confine material Procedures require shutdown of operations CMR operator monitors weather channel Generator ships waste in accordance to WAC Waste containers certified as Type A containers Fire suppression system Emergency response/Recovery Plan	2,2	4, 2
15) Natural Events	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: EXTERNAL EVENTS

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
16) External Events	Aircraft Crashes Into WHB	Personnel error Equipment failure	Potential to lose Waste Handling Building Potential to breech TRUPACT-II Potential for fire Potential for personnel injury or fatality Potential to release radioactive material Potential for personnel radiation exposure Potential need to decontaminate area Potential to release combustion products to the environment Potential to notify DOE, EPA, and State of environmental violation Potential environmental concern Potential for adverse media attention Potential economic loss Possible Ignition of Drum if the Waste Container is Punctured	Physical location of site is remote Air space above facility is not part of normal flight patterns Restricted flight pattern within a 500 foot radius of site Generator ships waste in accordance to WAC Waste containers certified as Type A containers Emergency Response/Recovery Plan	3,1	4, 1
16) External Events	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: ABNORMAL OPERATION

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
17) Abnormal Operation (Accident Status)	Cold Weather Natural Ventilation Pressure	Cold weather caused Natural Ventilation Pressure (NVP)	Potential to stop waste handling operations Potential to, in the event of an accident, spread airborne contamination to the environs Potential to cause deterioration of braking and electronic systems for the waste shaft hoist during prolonged exposure to salt Potential for waste shaft hoist to fail	Operator training and qualification Engineering designs Procedures Test and balance Shaft pressures are monitored at the CMR Alarms for pressure problems WIPP ventilation simulator used for guidance Underground ventilation remote monitoring control system (monitors air flows and d/p's and enable CMR operator to adjust dampers to control flow) Mine weather stations to monitor natural ventilation pressure(temp, relative humidity and barometric pressure) Isolation of mine splits Backup power available to operate fans for flow through the panel area		3, 1

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: ABNORMAL OPERATION

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
17) Abnormal Operation (Accident Status)	Hot Weather Natural Ventilation Pressure	Hot weather caused Natural Ventilation Pressure (NVP)	Potential to leak radiation outside radiological controlled area Potential for personnel radiation exposure Potential to release radioactive material Potential need to decontaminate area Potential to notify DOE, EPA, and State of environmental violation Potential environmental concern Potential for adverse media attention Potential to stop waste handling operations Potential to, in the event of an accident, spread airborne contamination to the environs Potential to cause deterioration of braking and electronic systems for the waste shaft hoist during prolonged exposure to salt Potential for waste shaft hoist to fail	Operator training and qualification Engineering design waste shaft hoist systems Preventative maintenance procedures Test and balance Monitoring at bulkhead 309 Bulkhead 309 redesign (recent) to pressurize the chamber between the walls of the 309 bulkhead using fans Procedures to maintain differential pressures in the mine WIPP ventilation simulator used for guidance Underground ventilation remote monitoring control system (monitors air flows and d/p's and enable CMR operator to adjust dampers to control flow) Mine weather stations to monitor natural ventilation pressure(temp, relative humidity and barometric pressure) Isolation of mine splits Backup power available to operate fans for flow through the panel area Alarms for pressure problems		3, 1

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: ABNORMAL OPERATION

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
17) Abnormal Operation (Accident Status)	Loss of Fire Protection	Loss of power Loss of 180,000 gallon fire water storage tanks DBE tornado	Potential inability to fight fires Potential excessive loss of facility Potential for personnel injury or fatality Potential to release radioactive material Potential need to decontaminate area Potential to release combustion products to environment Potential to notify DOE, EPA, and State of environmental violation Potential environmental concern Potential for adverse media attention Potential economic loss	Design and construction of fire suppression Two on site fire water storage tanks containing 180,000 gallons (One storage tank capacity sufficient for DBF) Two fire pumps, one electrical and one diesel, available Limited amount of combustibles on site and in Waste Handling Building WHB fire design and compartmentalized fire areas WHB segregated from other structures Emergency response fire fighting capability Fire truck and fire fighting equipment Assistance from surrounding communities All fire related systems, training, inspection, and testing are in accordance to NFPA and NEC regulations On-site fire trucks Procedures available for control of hot work Inspections and functional tests of system performed on a periodic basis Independent assessments by customer Fire detection systems available 24 hour battery backup for fire detection system available in Waste Handling Building	0,2	4, 2
17) Abnormal Operation (Accident Status)	Loss of HVAC systems	Loss of compressed air Loss of electrical power Operator error	Potential to stop operations Potential to release radioactive material Potential for personnel radiation exposure Potential for underground evacuation Potential need to decontaminate the facility	Redundant compressors available Backup diesel generator (2) power available for selected loads Operator training and qualification Maintenance programs in place Preventative maintenance programs Adequate separation exists between alternate compressors	0,2	3, 2

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: ABNORMAL OPERATION

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
17) Abnormal Operation (Accident Status)	Loss of On-Site Communication	Excavation work Loss of site power loss of UPS Equipment malfunction RF interference Loss of telephone system causes loss of paging system	Potential to lose TRANSCOM Potential to lose control of an accident Potential to delay evacuation Potential inability to communicate for off site assistance Potential to lose meteorological data Potential to lose off site notification capability Potential inability to notify headquarters of an event	Preventative maintenance system checks Redundant and multiple means to communicate UPS systems available with backup battery power Microwave/ground line for off site communication Procedures in place for notification of casualties Emergency and security vehicles equipped for broadcast	0,1	4, 1
17) Abnormal Operation (Accident Status)	Loss of Power (localized) On Site	Operator error Equipment failure Excavation work External causes	Potential to release radioactive materials to environment Potential to contaminate mine Potential to shutdown operations Potential inability to control underground ventilation Potential for underground evacuation Potential need to decontaminate Potential to lose fire water Potential to lose lighting Potential to lose CMS indication	Multiple paths of routing power Operator training and qualification Maintenance programs in place Preventative maintenance programs Thermography availability Backup Diesel generators (2) Uninterrupted Power Supplies (UPS) available with backup battery for important loads Waste Handling Equipment designed to be fail-safe in the event of power loss Operators trained to reconfigure power distribution to plant Diesel fire pump available Alternate means to remove personnel (secondary egress) from mine Emergency Response/Recovery Plan	0,2	3, 2

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: ABNORMAL OPERATION

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
17) Abnormal Operation (Accident Status)	Loss of Utility Power	Interruption of electrical service	Potential to shutdown operations Potential inability to control underground ventilation Potential to release radioactive material Potential for underground evacuation Potential need to decontaminate surface and underground areas Potential to lose fire water Potential to lose lighting Potential to lose CMS indication	Backup diesel generator (2) power system available UPS available with backup battery for important loads Diesel fire pump available Operators trained to reconfigure power distribution to plant Alternate means to remove personnel (secondary egress) from mine Waste Handling Equipment designed to be fail-safe in the event of power loss Emergency Response/Recovery Plan	0,2	3, 2
17) Abnormal Operation (Accident Status)	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
18) Waste Transfer Cage to Transporter	Transporter Failure	Transporter mechanical or electrical defect	Potential inability to start transporter Potential inability to unload cage Potential to tie up the shaft Potential to slow down operations	A backup transporter is available Preoperational checks Monthly preventative maintenance schedules	0,4	1, 4
18) Waste Transfer Cage to Transporter	Transporter Fire	Injector line breaks spraying diesel fuel onto exhaust Hydraulic system failure Brakes overheating	Potential for diesel engine fire on transporter Potential to slow down operations Potential to shutdown operations Potential for underground evacuation Potential for personnel injury or fatality Potential for heat damage to slip sheets Potential to melt bands holding waste containers onto pallet Potential for recovery operation Potential environmental concern Potential to damage waste container Potential to release Transuranic (TRU) waste material from waste container to environment Potential for airborne contamination Potential for personnel radiation exposure Potential for surface contamination Potential need to decontaminate surface and underground areas Potential for heat radiation into waste container and increased VOC emissions Potential for adverse media attention Potential to weaken the drifts ceiling Potential to release combustion products to the environment Potential economic loss	Fire suppression system with linear thermal detection capability available on transporter Dry chemical system to auto dump when activated from heat sensor Auto-manual operation of fire suppression system Inspection monthly by Emergency Service Tech (EST) Vendors check fire suppression equipment on periodic basis Operator training for fire scenarios Qualification of operators Limited quantity of diesel fuel contained in transporter Portable fire extinguishers available Braided hydraulic lines (steel jacketed) Preoperational checks Quarterly inspections Fire resistant hydraulic fluid Minimal amount of combustibles in area Low sulphur fuel used Isolated ventilation path Periodic exhaust temperature checks Few sources of ignition Emergency response teams available Assembly areas with safety equipment WAC criteria Manual shift to HEPA filtered exhaust Waste containers certified as Type A containers	2,1	4, 1

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
18) Waste Transfer Cage to Transporter	Transporter Mishaps	Operator inattentive in operating transporter Transporter mechanical defect	Potential to damage cage Potential to damage transporter Potential to push pallets through back of cage Potential to knock waste containers from facility pallet Potential to rupture waste containers Potential to release Transuranic (TRU) waste material from waste container to environment Potential for airborne contamination Potential for personnel radiation exposure Potential for underground evacuation Potential for surface contamination Potential for recovery operation Potential inability to transport waste Potential for personnel injury or fatality Potential for shutdown of operations Potential environmental concern Potential for spontaneous ignition Potential for explosion Potential for adverse media attention Potential to weaken the drifts ceiling Potential to release combustion products to the environment Potential economic loss	Qualified operators Preoperational procedures Whole operation proceduralized Spotter for operator Lock pins on opposite sides of facility pallets Transporter has a speed governor Distance to travel to cage is too short for transporter to pick up much speed Waste containers are secured to facility pallet Waste is above transporter to prevent ramming with transporter Cannot drive off cage with transporter WAC criteria Isolated ventilation path Fire suppression system with linear thermal detection system available on transporter Dry chemical system to auto dump when activated from sensing system Auto-manual operation of fire suppression system Vendor checks fire suppression equipment on a periodic basis Operator training for fire scenarios Portable fire extinguishers available Manual shift to HEPA filtered exhaust Assembly areas with safety equipment Waste containers certified as Type A containers Emergency Response/Recovery Plan	2,1	4, 1

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
18) Waste Transfer Cage to Transporter	Transporter Screw System Failure	Leak in transporter hydraulic screw system Metal fatigue	Potential to lose hydraulic fluid from the screw drive system Potential inability to operate screw drive system Potential inability to pull waste pallet onto transporter Potential to tie-up waste transfer cage Potential to slow down operations Potential to shutdown operations Potential need to readjust pallet on platform or transporter Potential to recover pallet	Preventative maintenance Preoperational checks Operator training Backup transporter available		1, 3
18) Waste Transfer Cage to Transporter	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
19) Transport of Waste from Transfer Cage to Disposal Room	Air Lock Failure (415 and 416)	Loss of air lock control	Potential for damper to fail open or closed Potential for ventilation deficiencies Potential for lower differential pressure in mine Potential to shutdown operations	Preventative maintenance performed on a periodic basis Preoperational checks before handling waste Ventilation fan line up Surveillance Bulkhead design is fail-as-is	0,4	1, 4
19) Transport of Waste from Transfer Cage to Disposal Room	Waste Container Hold-down Failure	Mechanical failure Operator error Uneven loading Tie-down failure for 7 pack Z clamp failure for SWB	Potential to damage waste containers Potential for fire Potential to release Transuranic (TRU) waste materials from waste containers to the environment Potential to release combustion products to the environment Potential for personnel radiation exposure Potential for surface contamination Potential for recovery operation Potential for underground evacuation Potential environmental concern Potential to shutdown operations Potential for adverse media attention Potential for personnel injury or fatality Potential economic loss	Per procedure, operators are trained to inspect tie downs prior to transporting waste pallets Slow travel speed Emergency response teams available Safety training Assembly areas with safety equipment WAC criteria CMR operator initiated shift to HEPA filtered exhaust Waste containers certified as Type A containers Stretchwrap and tie-downs	2,1	4, 1
19) Transport of Waste from Transfer Cage to Disposal Room	Loss of Electrical Power	Loss of site commercial power	Potential to lose ventilation fans Potential to lose ventilation Potential to shutdown operations Potential to evacuate underground personnel	Diesel generators (2) available for standby power UPS backup on all CAMs that initiate mine filtration to ensure radiation monitoring capabilities Isolated ventilation path	0,4	1, 4
19) Transport of Waste from Transfer Cage to Disposal Room	Loss of Plant Air	Plant air compressor mechanical or electrical defect	Potential inability to supply plant air to bulkhead pneumatic cylinders Potential inability to automatically operate bulkhead doors Potential to slow down operations	Doors can be manually operated Preventative maintenance Facility operations surveillance Preoperational checks Backup compressor available Ability to isolate and use portable compressors		1, 3

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
19) Transport of Waste from Transfer Cage to Disposal Room	Loss of Ventilation Fans	Mechanical or electrical failure	Potential to lose ventilation Potential to lose containment Potential disruption of operations Potential for underground work stoppage Potential for underground evacuation	Preventative maintenance performed on a periodic basis Backup ventilation fans available Dampers set to fail in a safe operational mode Selective configuration control to pull air where needed Periodic inspections of fans Vibration monitors available on the two larger sized ventilation fans and alarmed to CMR	0,4	1, 4
19) Transport of Waste from Transfer Cage to Disposal Room	Vehicular Collision	Operator inattentive in operating transporter Transporter mechanical defect	Potential for collision with another vehicle, bulkhead, personnel, or high voltage equipment Potential to damage vehicle Potential to spill battery acid/oil Potential to shutdown operations Potential for fire Potential for personnel injury or fatality Potential damage to waste containers Potential to release Transuranic (TRU) waste material from waste containers to environment Potential for personnel radiation exposure Potential for surface contamination Potential for recovery operation Potential to damage bulkhead Potential to weaken drifts ceiling Potential to shutdown diesel activities Potential to release combustion products to the environment Potential for underground evacuation Potential to upset differential pressure Potential environmental concern Potential for adverse media attention Potential for credibility damage Potential economic loss Possible ignition of drum if the waste container is punctured	Qualification of operators in vehicles use Pallets securely fixed to transporter Conduct of operations Safety procedures in place Major intersections have stop signs Limited access to bulkheads in planned path of transporters Access to area is restricted during waste handling operations Lighted intersections Mine operations are closely supervised WAC criteria Portable fire extinguishers available Minimal amount of combustibles in area Isolated ventilation path CMR operator initiated shift to HEPA filtered exhaust Waste containers certified as Type A containers Stretchwrap and tie-downs Transporter equipped with low speed governor By procedure, no other vehicles other than transporter will be in motion along waste disposal route. Emergency Response/Recovery Plan	3,1	4, 1

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
19) Transport of Waste from Transfer Cage to Disposal Room	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
20) Disposal Room Waste Handling Operations	Diesel Fire in Unloading Area	Injector line breaks spraying diesel fuel onto exhaust	Potential for diesel engine fire on transporter or forklift Potential to slow down operations Potential to shutdown operations Potential for underground evacuation Potential for personnel injury or fatality Potential for heat damage to slip sheets Potential to melt bands holding waste containers on pallet Potential to rupture waste containers Potential to release Transuranic (TRU) waste material from waste containers to the environment Potential for airborne contamination Potential for personnel radiation exposure Potential for recovery operation Potential to release combustion products to the environment Potential environmental concern Potential for heat concentration due to ventilation Potential to weaken the drifts ceiling Potential for adverse media attention Potential economic loss	Fire suppression system with linear thermal detection capability available on transporter Dry chemical system to auto dump when activated from heat sensor Auto-manual operation of fire suppression system Inspection monthly by Emergency Service Tech (EST) Vendors check fire suppression equipment on periodic basis Operator training for fire scenarios Qualification of operators Limited quantity of diesel fuel contained in transporter Portable fire extinguishers available Braided hydraulic lines (steel jacketed) Preoperational checks Quarterly inspections Fire resistant hydraulic fluid Minimal amount of combustibles in the area Low sulphur fuel used Isolated ventilation path Periodic exhaust temperature checks Few sources of ignition Emergency response teams available Safety training Assembly areas with safety equipment Manual shift to HEPA filtered exhaust WAC criteria	2,1	4, 1

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
20) Disposal Room Waste Handling Operations	Fork Lift Accident	Operator inattentive in fork lift operation Fork lift mechanical failure	Potential to ram fork lift into stacked waste containers Potential to puncture waste containers with BRUDI lift fixture Potential to dislodge waste containers from facility pallet Potential to exceed waste container safe drop height Potential to release Transuranic (TRU) waste material from waste containers to environment Potential for airborne contamination Potential for personnel radiation exposure Potential for underground evacuation Potential for surface contamination Potential for recovery operation Potential inability to transport waste Potential for shutdown of operations Potential environmental concern Potential for personnel injury or fatality Potential for fire Potential for explosion Potential for adverse media attention Potential to weaken the drifts ceiling Potential to release combustion products to the environment Potential economic loss Possible ignition of drum if the waste container is punctured	Qualification of operators in operation of fork lifts Operator training Procedures in place Preventative maintenance performed on periodic basis on fork lift Spotter available during operations Preoperational checks prior to handling waste containers Emergency assembly areas available with safety equipment CMR operator initiated shift of HEPA exhaust filtration available Design of the BRUDI Design of the SWB handling fixture Electric fork lift limits speed Area lighting available during placement Health Physics available during placement Established ventilation flows during placement Boundaries established for radioactive materials Fire suppression system with linear thermal detection available Dry chemical system available Auto-manual operation of fire suppression system available Vendors check fire suppression system periodically Operator training for fire scenarios Portable fire extinguishers available Emergency response teams available Safety training Waste containers certified as Type A containers Stretchwrap	3,1	4, 1

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
20)Disposal Room Waste Handling Operations	Fork Lift Failure	Fork lift electrical or mechanical defect Hydraulic leak in lifting mechanism	Potential inability to start fork lift Potential to lose hydraulic fluid Potential to lose lifting capability Potential inability to unload transporter and stack waste containers Potential to lose hydraulic power when placing waste containers on stack Potential for waste containers to be hung up partially between fork lift and stack Potential to recover partially stacked waste containers Potential to slow down operations	Fork lift capable of controlled manual lowering Backup fork lift available Preventative maintenance Preoperational checks per shift Hydraulic controls return-to-neutral when released		1, 3
20) Disposal Room Waste Handling Operations	Transporter Mishap	Operator error Transporter mechanical failure	Potential to drive transporter into stacked waste containers Potential to knock waste containers off of stack Potential to damage waste containers Potential to release Transuranic (TRU) waste material from waste containers to the environment Potential for airborne contamination Potential for personnel radiation exposure Potential for underground evacuation Potential for surface contamination Potential for recovery operation Potential inability to transport waste Potential to shutdown operations Potential environmental concern Potential to reduce ventilation Potential to shift ventilation filtration modes Possible ignition of drum if the waste container is punctured	Operator training and qualification Procedures in place Transporter keeps its distance to previously stacked waste containers Spotter used when backing transporter Preventative maintenance WAC criteria Preoperational checks Manual shift to HEPA filtered exhaust Waste containers certified as Type A containers Stretchwrap Emergency Response/Recovery Plan	3,1	4, 1

* The first number indicates consequence, and the second indicates the relative probability.   NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
20) Disposal Room Waste Handling Operations	Backfill Operation Mishap	Operator error in backfill operation Lifting mechanism mechanical failure	Release of Magnesium Oxide to work area Slowdown of operations Potential to knock waste containers off of stack during backfill emplacement Potential to damage waste containers with lift mechanism or other backfill equipment Potential to release Transuranic (TRU) waste material from waste containers to the environment from breached waste container Potential for airborne contamination Potential for personnel radiation exposure Potential for recovery operation Potential to shift ventilation filtration modes Potential for Worker Injury/Fatality Possible ignition of drum if the waste container is punctured	Backfill equipment design Operator training and qualification Procedures in place Spotter used when backfilling Preventative maintenance WAC criteria Preoperational checks Manual shift to HEPA filtered exhaust M_gO not a hazardous material Emergency Response/Recovery Plan	3 ,3	4,3
20) Disposal Room Waste Handling Operations	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
21) Refueling Activities	Refueling Vehicle Mishap	Tank leakage or spill Hose break during refueling Isolation valve inadvertently opened or leaking	Potential to release diesel fuel to environment Potential for fire Potential for personnel injury or fatality Potential for underground evacuation Potential to shutdown operations Potential environmental concern Potential for adverse media attention Potential to weaken the drifts ceiling Potential to release combustion products to the environment Potential economic loss	Fuel dispensing is controlled by procedures All fuel tanks have bladders Fire suppression systems on all waste handling equipment Portable fire extinguishers on all vehicles Service vehicles have spill mitigation apparatus Training of personnel to dispense fuel Emergency response teams available Safety training Assembly areas with safety equipment WAC criteria Waste containers certified as Type A containers	0,1	4, 1
21) Refueling Activities	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
22)Disposal Room	Failure and Fallout of Roof Bolt	Bolt strength exceeded	Potential for personnel injury or fatality Potential to shutdown operations Potential to damage equipment Potential for adverse media attention	Low frequency of occurrence Daily inspections Protective equipment worn by underground personnel includes hard hats Area covered by mesh	0,3	4, 3
22) Disposal Room	Floor Distortion	Floor failure due to heaves and buckles Normal traffic	Potential to slow down operations Potential to reconstitute floor Potential to stick fork lift in floor drop area especially along edges Potential need to pull fork lift free Potential to drop load Potential to damage waste container Potential to rupture waste container Potential to release Transuranic (TRU) waste from waste containers to the environment Potential for airborne contamination Potential for personnel radiation exposure Potential for surface contamination Potential for recovery operation Potential inability to transfer waste Potential environmental concern	Floor surveyed and prepared before filling room Waste handling supervisor performs periodic inspections of storage room Procedure exists for performing room inspections MSHA inspections WAC criteria CMR operator initiated shift to HEPA filtered exhaust Established ventilation flows during waste emplacement Waste containers certified as Type A containers Stretchwrap and tie-downs Emergency Response/Recovery Plan	2,1	4, 1

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
22) Disposal Room	Roof Collapse During Emplacement	Deterioration of roof	Potential to damage waste containers Potential to release Transuranic (TRU) waste material from waste containers to environment Potential for airborne contamination Potential for personnel radiation exposure Potential for underground evacuation Potential for recovery operation Potential for shutdown of operations Potential environmental concern Potential to lose storage room or panel Potential for personnel injury or fatality Potential to damage equipment Potential for radiological release Potential to lose project credibility Potential to release combustion products to the environment Potential for adverse media attention Potential economic loss	Predictive monitoring program Per procedure, rooms are checked before any waste containers are received and immediately prior to waste container disposal Instrumented and monitored extensively per DOE and external organization assessments and regulations Support systems specifically designed to handle conditions expected and may be instrumented and tied into monitoring and analysis Mine Safety and Health (MSHA) require shiftly work place inspections Bimonthly visual and instrument inspections and assessments Annual ground control plan and long term 5 year ground control plan All inspection plans are rolled over Inspections performed on a shift by shift basis Room closure on a room-by-room basis CMR operator initiated shift to HEPA filtered exhaust Waste containers certified as Type A containers Stretchwrap and slipsheets Emergency Response/Recovery Plan	2,3	4, 3
22) Disposal Room	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

SYSTEM/VESSEL: CH TRU Waste System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
23) Life of Facility Area	Failure and Fallout of Roof Bolt	Bolt strength exceeded	Potential for personnel injury or fatality Potential to shutdown operations Potential to damage equipment Potential for adverse media attention	Low frequency of occurrence Daily inspections Protective equipment worn by underground personnel include hard hats Area covered by mesh	0,3	2, 3
23) Life of Facility Area	Floor Distortion	Floor failure due to heaves and buckles Normal traffic	Potential to slow down operations Potential to reconstitute floor Potential to stick fork lift in floor drop area especially along edges Potential need to pull fork lift free Potential to damage waste container Potential to rupture waste container Potential to release Transuranic (TRU) waste from waste container to the environment Potential for airborne contamination Potential for personnel radiation exposure Potential for surface contamination Potential for recovery operation Potential inability to transfer waste Potential environmental concern	Floor surveyed periodically Drift inspections are performed periodically MSHA inspections WAC criteria Established ventilation flows during waste emplacement CMR operator initiated shift to HEPA filtered exhaust Waste containers certified as Type A containers Stretchwrap and tie-downs Emergency Response/Recovery Plan	2,3	2, 3

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
23) Life of Facility Area	Roof Collapse Life of Facility	Deterioration of roof outside the disposal area	Potential to damage waste containers Potential to release Transuranic (TRU) waste material from waste containers to environment Potential for airborne contamination Potential for personnel radiation exposure Potential for underground evacuation Potential for recovery operation Potential for shutdown of operations Potential environmental concern Potential to lose facility areas Potential to lose egress Potential for personnel injury or fatality Potential to damage equipment Potential for radiological release Potential to lose project credibility Potential for adverse media attention Potential economic loss	Instrumented and monitored extensively per DOE and external organization assessments and regulations Support systems specifically designed to handle conditions expected and will be instrumented and tied into monitoring and analysis (MSHA) require weekly inspections Bimonthly visual and instrument inspections and assessments Annual ground control plan and long term 5 year ground control plan All inspection plans are rolled over Inspections performed on a shift by shift basis Accessibility for maintenance CMR operator initiated shift to HEPA filtered exhaust WAC criteria Emergency response teams available Assembly areas with safety equipment Waste containers certified as Type A containers Stretchwrap and tie-downs	2,2	4, 2
23) Life of Facility Area	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
24) Waste Criteria	Excessive H2 Emissions	Generation of Hydrogen gas from Transuranic (TRU) waste material exceeds expected values	Potential to exceed VOC emission thresholds per RCRA/NMD Potential environmental concern Potential to violate permit Potential to receive fines and criminal penalties for violating permit Potential to lose permit Potential for fire Potential for explosion Potential to release radioactive material Potential to release combustion products to the environment Potential for personnel injury or fatality Potential for recovery operation Potential for underground evacuation Potential for adverse media attention	Ventilation available MSHA regulations followed WAC limits Operator safety training Qualification of operators Portable fire extinguishers available Separate ventilation exhaust path Emergency response teams available Assembly areas with safety equipment CMR operator initiated shift to HEPA filtered exhaust	2,1	4, 1
24) Waste Criteria	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
25) Natural Events Underground	Earthquake	Earthquake occurrence	Potential to lose electrical power Potential to lose ventilation fans Potential for sensitive instrumentation to fail Potential for underground evacuation Potential to shutdown operations Potential ground fall Potential for personnel injury or fatality Potential to flood mine Potential to rupture waste containers Potential for fire Potential for explosion Potential release of radioactive material Potential for personnel radiation exposure Potential for recovery operation Potential for surface contamination Potential for airborne contamination Potential for adverse media attention Potential to release combustion products to the environment Potential economic loss	Site was selected because of low seismic conditions Regional seismic activities monitored Diesel generators available for standby power UPS systems available for radiation monitoring Shaft collars are sealed Drift ceilings support system Miner training and evacuation training Facility designed for DBE	2,1	4, 1
25) Natural Events Underground	Natural Disaster - Tornado	Tornado occurrence	Potential to lose site power Potential to lose ventilation fans Potential to lose ventilation Potential for underground evacuation Potential to shutdown operations Potential for adverse media attention	Diesel generators (2) available for standby power UPS system available for radiation monitoring Multiple ventilation fans available CMR monitors weather conditions Diesel powered hoist and bullet for personnel egress from the mine Mutual agreement with other mines for assistance WHB designed for DBT Multiple egress paths available from the mine	0,2	3, 2
25) Natural Events Underground	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
26) UPS System, Electric Carts	UPS & Electric Cart Charging Mishaps	Overcharge of electrical battery Electrical contact sparking	Potential to buildup hydrogen in battery Potential to release H2 from battery to the environment Potential for explosion Potential for personnel injury or fatality Potential for fire Potential for release of combustion products to the environment Potential for recovery operation Potential for underground evacuation Potential for adverse media attention Potential economic loss	Preventative Maintenance Procedures UPS batteries are factory sealed and contain pressure reliefs Ventilation system dilutes hydrogen concentration UPS are enclosed units Cart operator training Portable fire extinguishers on all carts	0,2	4, 2
26) UPS System, Electric Carts	_All Other Deviations		NAHI			
27) Waste Container Fire	Waste Container Fire	Spontaneous ignition in a waste container due to corrosion, chemical breakdown, anaerobic decomposition or pyrophoric interaction	Potential for fire in waste shaft station Potential to lose waste shaft station Potential for fire in disposal room Potential to damage waste containers Potential to release Transuranic (TRU) waste material from waste containers to the environment Potential to release combustion products to the environment Potential to shutdown operations Potential for personnel radiation exposure Potential for surface contamination Potential ingestion of radioactive material Potential for underground evacuation Potential for recovery operation Potential for explosion Potential for adverse media attention Potential environmental concern Potential economic loss	Waste Acceptance Criteria No propagation expected Environment is stable	3,3	4, 3

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
27) Waste Container Fire	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
28) Disposal Room Completion	Changes to Lighting & Air Services	Operator inattentive while disconnecting temporary lighting Operator inattentive while working with ladder Temporary lighting or ladder equipment failure	Potential for personnel injury or fatality Potential to damage equipment Potential to slow down or stop operations Potential for adverse media attention	Maintenance operations proceduralized or controlled Equipment inspections Equipment design Operator and electrician training Electricians disconnect temporary lighting	0,2	4, 2
28) Disposal Room Completion	_All Other Deviations		NAHI			
29) Room Finalization (Closure) Proceed to the Next Room	Industrial Accident	Maintaining or closing (emplacing ventilation barriers or barricades) one room while emplacing waste in an adjoining room	Potential to generate dust Potential to damage cams Potential to increase maintenance Potential to slow down operations Potential to setoff false alarms Potential for personnel injury or fatality Potential for adverse media attention	Established procedures for ground control Operator training and qualification Ventilation system design Ventilation system operating procedures	0,2	4, 2
29) Room Finalization (Closure) Proceed to the Next Room	_All Other Deviations		NAHI			
30) External Events	External Events		No Hazards Identified			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
31) Closed Room	Waste Container Internal Fire in closed room	Spontaneous ignition in a waste container due to corrosion, chemical breakdown, anaerobic decomposition or pyrophoric interaction	Potential to damage waste containers Potential to release Transuranic (TRU) waste material from waste containers to the environment Potential to release combustion products to the environment Potential to shutdown operations Potential for personnel radiation exposure Potential for surface contamination Potential ingestion of radioactive material Potential for underground evacuation Potential for recovery operation Potential for explosion Potential for adverse media attention Potential environmental concern Potential economic loss	Room barricade systems Ventilation cut off to closed room Waste Acceptance Criteria No propagation expected Environment is stable Shift to HEPA filtration Backfill	2, 1	2, 1
31) Closed Room	Excessive Buildup of Explosive Gasses in closed room	Generation of Methane, or Hydrogen gas from Transuranic (TRU) waste material exceeds expected values	Potential to exceed VOC emission thresholds per RCRA/NMD Potential environmental concern Potential to violate permit Potential to receive fines and criminal penalties for violating permit Potential to lose permit Potential for fire Potential for explosion Potential to release radioactive material Potential to release combustion products to the environment Potential for personnel injury or fatality Potential for recovery operation Potential for underground evacuation Potential for adverse media attention	Room barricade systems Ventilation cut off to closed room Waste Acceptance Criteria MSHA regulations followed Shift to HEPA filtration Backfill	2, 1	2, 1

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
31) Closed Room	Roof Fall in closed room	Deterioration of roof	Potential to damage waste containers Potential to release Transuranic (TRU) waste material from waste containers to environment Potential for airborne contamination Potential for personnel radiation exposure Potential for underground evacuation Potential for recovery operation Potential for shutdown of operations Potential environmental concern Potential to lose disposal room or panel Potential for personnel injury or fatality Potential to damage equipment Potential for radiological release Potential to lose project credibility Potential to release combustion products to the environment Potential for adverse media attention Potential economic loss	Room barricade systems Backfill Ventilation cut off to closed room Room closure on a room-by-room basis CMR operator initiated shift to HEPA filtered exhaust	2, 1	2, 1
32) Panel Closure Operations	Industrial Accident	Equipment or human error	Potential to generate dust Potential to damage cams Potential to increase maintenance Potential to slow down operations Potential to setoff false alarms Potential for personnel injury or fatality Potential for adverse media attention	Established procedures for ground control Operator training and qualifications Ventilation system design Ventilation system operating procedures	0, 2	4, 2

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
32) Panel Closure	Waste Container Internal Fire in closed panel	Spontaneous ignition in a waste container due to corrosion, chemical breakdown, anaerobic decomposition or pyrophoric interaction	Potential to damage waste containers Potential to release Transuranic (TRU) waste material from waste containers to the environment Potential to release combustion products to the environment Potential to shutdown operations Potential for personnel radiation exposure Potential for surface contamination Potential ingestion of radioactive material Potential for underground evacuation Potential for recovery operation Potential for explosion Potential for adverse media attention Potential environmental concern Potential economic loss	Panel Closure systems Backfill Ventilation cut off to closed panel Waste Acceptance Criteria No propagation expected Environment is stable Shift to HEPA filtration	1, 1	1, 1
32) Panel Closure	Excessive Buildup of Explosive Gasses in closed panel	Generation of Methane, or Hydrogen gas from Transuranic (TRU) waste material exceeds expected values	Potential to exceed VOC emission thresholds per RCRA/NMD Potential environmental concern Potential to violate permit Potential to receive fines and criminal penalties for violating permit Potential to lose permit Potential for fire Potential for explosion Potential to release radioactive material Potential to release combustion products to the environment Potential for personnel injury or fatality Potential for recovery operation Potential for underground evacuation Potential for adverse media attention	Panel Closure systems Backfill Ventilation cut off to closed panel Waste Acceptance Criteria No propagation expected Environment is stable Shift to HEPA filtration	1 ,1	1, 1

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Waste Handling System

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
32) Panel Closure	Roof Fall in closed panel	Deterioration of roof	Potential to damage waste containers Potential to release Transuranic (TRU) waste material from waste containers to environment Potential for airborne contamination Potential for personnel radiation exposure Potential for underground evacuation Potential for recovery operation Potential for shutdown of operations Potential environmental concern Potential to lose disposal room or panel Potential for personnel injury or fatality Potential to damage equipment Potential for radiological release Potential to lose project credibility Potential to release combustion products to the environment Potential for adverse media attention Potential economic loss	Panel Closure systems Backfill Ventilation cut off to closed panel Waste Acceptance Criteria No propagation expected Environment is stable Shift to HEPA filtration	1, 2	1, 2
32) Panel Closure	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Site-Derived Waste

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
33) Preliminary Actions	Use of faulty container, filters, or plugs	Operator error Defective material	Potential to release radioactive material Potential to release hazardous material Potential for explosion Potential for personnel exposure to radiation	QA Operator training and qualification Receiving inspection Procedures WAC criteria	1,2	2,2
	Inadequate WHO staff available	Medical event	N/A	Procedures	1,1	1,1
	Waste contains prohibited materials	Operator error Unauthorized addition of waste	Potential for fire Potential for explosion Potential for toxicological exposure Potential for radiological exposure	Procedures Operator training and qualification WAC criteria Personnel access controls Radiological controls	1,1	3,1
34) Liquid Waste Collection	Liquids mix with solids to form sludge	Design of sump is a confined space	Confined space	Procedures Operator training and qualification	1,1	2,1
	Loss of power to wet vacuum	Power outage Equipment failure	N/A		1,1	1,1
35) Solidification of liquid waste	Personnel and Container Radiation Limits Exceeded	Equipment failure Human error	Potential for personnel exposure to radiation	Procedures Operator training and qualification Warning equipment Preventative maintenance program	1,1	1,1
36) Local Solid Waste Collection	Personnel and Container Radiation Limits Exceeded	Equipment failure Human error	Potential for personnel exposure to radiation	Procedures Operator training and qualification Warning equipment Preventative maintenance	1,1	1,1
	Failure to lift drum	Power failure Equipment failure Operator error	Potential to delay operations	Operator training and qualification Preventative maintenance program Redundant power Procedures Pre-Op check QA	0,2	0,2

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Site-Derived Waste

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
36) Local Solid Waste Collection	Lifting Equipment Failure, including Rigging	Operator error Equipment failure Power failure Improper attachment of rigging	Potential for delay of operations Potential to release radioactive material Potential to release hazardous material Potential to drop the load Potential to rupture waste container Potential for personnel injury Potential for personnel radiation exposure	Type A container Operator training and qualification Preventative maintenance program Spotters WAC criteria Procedures Pre-Op check QA Waste container integrity WHB exhaust HEPA filter Shift to HEPA filtration Emergency response plan and team	2,2	2,2
	Failure to Secure Load	Operator error Damaged securing devices	Potential to lose load during transit Potential to drop the load Potential to rupture waste container Potential for personnel injury Potential to release radioactive material Potential to contaminate surface Potential for personnel radiation exposure Potential to delay operations Potential environmental concern Potential to notify DOE, EPA, and State of environmental violation Potential for adverse media attention. Potential economic loss	Type A container Operator training and qualification Fail safe equipment design Preventative maintenance program Spotters Stretch wrapping Tie-down strapping WAC criteria Procedures Pre-op checks QA Waste Container integrity WHB fire suppression system Building Exhaust HEPA Filtered Emergency Response Plan and Teams	2,2	3,2

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Site-Derived Waste

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
36) Local Solid Waste Collection	Vehicular Collision	Operator inattentive in operating forklift Forklift mechanical defect	Potential for collision with another vehicle, bulkhead, personnel, or high voltage equipment Potential to damage vehicle Potential to spill battery acid/oil Potential to shutdown operations Potential for personnel injury Potential damage to waste containers Potential to release Transuranic (TRU) waste material from waste containers to the environment Potential for personnel radiation exposure Potential for surface contamination Potential to damage bulkhead Potential to weaken drifts in ceiling Potential to shutdown diesel activities Potential for underground evacuation Potential to upset differential pressure Potential environmental concern	Qualification of operators in vehicles use Conduct of operations Safety procedures in place Major intersections have stop signs Limited access to bulkheads in planned path of transporters Access to area is restricted during waste handling operations Lighted intersections Mine operations are closely supervised WAC criteria Portable fire extinguishers available Isolated ventilation path CMR operator initiated shift to HEPA filtered exhaust Waste containers certified as Type A containers Stretchwrap Emergency Response/Recovery Plan	2,1	3,1
37) Site-Derived Waste Storage Area Operations	Prohibited Items are in container	Operator error Unauthorized addition of waste	Potential for fire Potential for explosion Potential for toxicological exposure Potential for radiological exposure	Procedures Operator training and qualification WAC criteria Personnel access controls Radiological controls	1,1	3,1
	Container, bag, etc. Damaged	Operator error Defective material	Potential to release radioactive material Potential to release hazardous material Potential pressure buildup	QA Operator training and qualification Receiving inspection Procedures WAC criteria	1,1	2,1
	Overloaded bag	Operator error	Potential to release radioactive material Potential to release hazardous material	QA Operator training and qualification Procedures	1,2	1,2

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: CH TRU Site-Derived Waste

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
	Exceeds any part of the criteria for WAC	Operator error Unauthorized addition of waste	Potential for fire Potential for explosion Potential for chemical exposure Potential for radiological exposure	Procedures Operator training and qualification WAC criteria Personnel access controls Radiological controls	1,1	3,1

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Removal of a TDOP from a TRUPACT II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
38) Removal of Outer Containment Vessel (OCV) Lid	Failure to Lift OCV Lid	Locking ring fails to rotate OCV lid binds Crane mechanical or electrical failure Crane lift wire rope fails	Potential to delay unloading operations Potential to damage TRUPACT-II	Operator training and qualification Pre-operational checks are used prior to starting the process Procedures are in place to perform operation Overhead crane fails as is on loss of power ACGLF provided with indicating light when engaged in pallet Crane over designed with a by factor of 5 Duplicate lifting fixtures are available Preventative maintenance checks on crane, wire rope, ACGLF, and hook are performed monthly Generator ships in accordance with the WAC shipping limitations Radiological surveys identify radiation levels and contamination levels as found WIPP lifting practices comply with DOE hoisting and rigging regulations		1, 3
	Failure to Move OCV Lid to Lid Stand	Radioactive contamination found inside the TRUPACT-II Crane mechanical or electrical failure Crane lift wire rope fails	Potential to lose use of TRUDOCK Potential to reclose TRUPACT-II and send shipment back to generator Potential for spot decontamination Potential to drop OCV lid Potential to damage OCV lid Potential for personnel injury or fatality Potential to damage TRUDOCK	Operator and health physics technician training and qualification Preoperational checks Procedures are in place to perform operation Overhead crane fails as is on loss of power ACGLF provided with position indicating light Crane over designed by factor of 5 Duplicate lifting fixtures are available Preventative maintenance checks on crane, wire rope, ACGLF, and hook are performed monthly Generator ships in accordance with the WAC shipping limitations Radiological surveys identify radiation levels and contamination levels above WAC WIPP lifting practices comply with DOE hoisting and rigging regulations Generator checks shipment prior to departure WIPP Waste Information System (WWIS) data received from the Generator Second TRUDOCK available	0,2	4, 2

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Removal of a TDOP from a TRUPACT II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
38) Removal of Outer Containment Vessel (OCV) Lid	Failure to Prep OCV Lid For Removal	Operator error Jammed access plug	Potential to delay unloading operation Potential to perform maintenance on access port	Operator training and qualification Maintenance procedures for rework of the access plug		1, 3
	Failure to Pull Vacuum on OCV Lid	Mechanical/electrical failure of the vacuum system Operator error Failure to remove access plug Leak in TRUPACT-II Loss of HVAC system	Potential inability to remove the OCV lid Potential to delay unloading operations	TRUPACT-II certification as a DOT Class B container TRUPACT-II container integrity is checked during annual maintenance by WIPP personnel Operator training and qualification Redundant HVAC system available to support operations Backup vacuum pumps are available		1, 3
	Failure to Verify System Conditions	Operator error	Potential to violate administrative controls/operating procedures Potential to lose negative pressure in the Waste Handling Building Potential to delay waste handling operations	Operator training and qualification Procedures are in place to check and verify system conditions Conduct of Operations provides guidelines for activities Local audible and visual alarm when inadequate negative pressure exists in the Waste Handling Building	0,3	2, 3
	Missing Security Seals	Generator fails to install seals Seal(s) lost in transit	Potential to delay unloading operations	DOT checks presence of seals during inspections at the state lines Design of the security seal minimizes inadvertent loss Procedures require checking for the seals		1, 3
38) Removal of Outer Containment Vessel (OCV) Lid	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Removal of a TDOP from a TRUPACT II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
39) Removal of Inner Containment Vessel (ICV) Lid	Failure to Establish Vent Hood Operation	Loss of HVAC in the CH bay Loss of ventilation at the TRUDOCK Damper out of position Valve fails	Potential to delay unloading operations	Verification of vent flow is required Valve positions are verified Operator training and qualification Periodic preventative maintenance performed on equipment Periodic equipment checks during the process Procedures are in place to perform process Redundant trains available in the CH HVAC system	0,4	1, 4
	Failure to Lift the ICV Lid	Locking ring fails to rotate Lid binds Crane mechanical or electrical failure Crane lift wire rope fails	Potential to delay unloading operations Potential to damage TRUPACT-II	Operator training and qualification Preoperational checks Procedures are in place to perform operation Overhead crane fails as is on loss of power ACGLF provided with indicating light when engaged in pallet Crane over designed by factor of 5 Duplicate lifting fixtures are available Preventative maintenance checks on crane, wire rope, ACGLF, and hook are performed monthly Generator ships in accordance with the WAC shipping limitations Radiological surveys identify radiation levels and contamination levels as found WIPP lifting practices comply with DOE hoisting and rigging regulations Emergency Response/Recovery Plan		1, 3

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Removal of a TDOP from a TRUPACT II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
39) Removal of Inner Containment Vessel (ICV) Lid	Failure to Move ICV Lid to ICV Lid Stand	Radioactive contamination found inside the TRUPACT-II Crane mechanical or electrical failure Crane lift wire rope fails Airborne contamination found	Potential to lose use of TRUDOCK Potential to reclose the TRUPACT-II and send shipment back to generator Potential for spot decontamination Potential to drop ICV lid Potential to damage ICV lid Potential for personnel injury or fatality Potential to damage TRUDOCK Potential to contaminate the area Potential need to decontaminate area Potential to sound alarms on the continuous air monitors (CAM) Potential need to issue Report of Occurrence on activation of CAM alarms Potential personnel radiation exposure Potential environmental concern Potential economic loss	Operator and Health Physics technician training and qualification Preoperational checks Procedures are in place to perform operation Overhead crane fails as is on loss of power ACGLF provided with position indicating light Crane over designed by factor of 5 Duplicate lifting fixtures are available Monthly preventative maintenance checks on crane, cables, ACGLF, and hook Generator ships in accordance with the WAC shipping requirements WIPP lifting practices comply with DOE hoisting and rigging regulations WIPP WWIS data received from generator Radiological surveys identify radiation levels and contamination levels above WAC Generator checks shipment prior to departure Abnormal operation procedures available for guidance Vent hood design and use Radiological instrumentation alarms Emergency Response/Recovery Plan	0,2	4, 2
	Failure to Prep ICV Lid For Removal	Operator error	Potential to delay unloading operations	Operator training and qualification Procedures are in place to perform operation		1, 3
	Failure to Pull Vacuum on ICV Lid	Mechanical or electrical failure of the vacuum system Operator error Leak in TRUPACT-II Loss of HVAC system	Potential inability to remove the ICV lid Potential to delay unloading operations	TRUPACT-II certification as a DOT Class B container TRUPACT-II container integrity is checked during annual maintenance by WIPP personnel Operator training and qualification Redundant HVAC system available to support operations Backup vacuum pumps are available		1, 3

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Removal of a TDOP from a TRUPACT II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
39) Removal of Inner Containment Vessel (ICV) Lid	Radiological Assessment > Background	Possible airborne contamination	Potential to delay unloading of the TRUPACT-II Potential to reclose the TRUPACT-II, spot decon or send shipment back to generator Potential to replace tool and filter due to internal contamination	Health Physics survey confirms contamination levels Health Physics personnel training and qualification Simplistic design of filter and sample rig Procedures are in place to perform process Generator conforms to shipping per WAC regulations Ventilation system prefilter and HEPA filter available for removing radioactive material from exhaust stream WAC shipping limits	0,4	2, 4
39) Removal of Inner Containment Vessel (ICV) Lid	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Removal of a TDOP from a TRUPACT II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
40) TRUPACT-II Internal Condition	Fire in TRUPACT-II	Spontaneous ignition in a waste container due to corrosion, chemical breakdown or anaerobic decomposition or pyrophoric interaction	Potential to shut down operations Potential to damage TRUPACT-II Potential to damage overhead crane Potential to rupture TDOP Potential to spread contamination Potential need to decontaminate area Potential to damage TRUDOCK Potential for explosion Potential for personnel injury or fatality Potential to damage WHB Potential to lose containment Potential to release radioactive material Potential for personnel radiation exposure Potential to release combustion products to the environment Potential environmental concern Potential to notify DOE, EPA, and State of environmental violation Potential for adverse media attention Potential to shutdown site operations Potential for site evacuation Potential economic loss	Generator ships waste in accordance to WAC shipping criteria Waste containers are characterized Fissile loading is known Minimum liquids contained in Waste containers Waste containers are vented thru carbon filters Waste containers, due to storage prior to shipment, are more stable and lessens the likelihood of fire Waste container integrity is tested TRUPACT-II integrity On-site emergency responders available Building has fire suppression capability TDOP's are designed and certified as DOT Class 7A containers Building ventilation is filtered through prefilters and HEPA filters ICV lid can be reinstalled to aid in controlling fire in TRUPACT-II Smoke may be visible through hoses on vacuum systems Portable fire fighting equipment available Fire hose station available Limited combustibles in the area Building design is noncombustible Building design has two hour fire rating Emergency response team available Fire suppression system Vent hood system in place	3,3	4, 3
40) TRUPACT-II Internal Condition	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Removal of a TDOP from a TRUPACT II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
41) Transfer of Payload from TRUDOCK to Facility Pallet	Failure To Place Load On Facility Pallet	Operator error Equipment failure Loss of power	Potential to misposition waste container on facility pallet Potential to delay operations	Operator training and qualification Maintenance procedures available Spotters used during transit of payload Preventative maintenance program in place Procedures used to perform operation Preoperational checks of equipment prior to use Adequate lighting in area Backup power available		1, 3
	Failure of Lifting Equipment	Mechanical or electrical failure of lifting equipment Operator error	Potential to drop the TDOP Potential to damage CAMS Potential to damage TRUDOCK Potential to rupture TDOP Potential for personnel injury or fatality Potential to release radioactive material Potential to contaminate surface Potential need to decontaminate area Potential for personnel radiation exposure Potential to delay operations Potential for fire Potential for explosion Potential to shutdown operations Potential to release combustion products to the environment Potential to damage Waste Handling Building Potential to lose containment Potential environmental concern Potential to notify DOE, EPA, and State of environmental violation Potential for adverse media attention Potential for site evacuation Potential economic loss	Generator ships waste in accordance to WAC Operator training and qualification Procedures are in place to perform operation Overhead crane fails as is on loss of power ACGLF provided with position indicating light Crane over designed by factor of 5 Duplicate lifting fixtures are available Monthly preventative maintenance checks on crane, wire rope, ACGLF, and hook TDOP's are designed and certified as DOT Class 7A containers Ventilation is designed to contain rad releases through use of HEPA filters WHB has fire suppression systems and portable fire extinguishers and hose station available Emergency response team on site WIPP lifting practices comply with DOE Hoisting and Rigging regulations Limited combustibles in area Building design is noncombustible	2,3	4, 3

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Removal of a TDOP from a TRUPACT II

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
41) Transfer of Payload from TRUDOCK to Facility Pallet	Failure to Secure Load	Operator error Damaged securing devices	Potential to lose TDOP during transit Potential to drop the load Potential to damage CAMS Potential to damage TRUDOCK Potential to rupture TDOP Potential for personnel injury or fatality Potential to release radioactive material Potential to contaminate surface Potential need to decontaminate area Potential for personnel radiation exposure Potential to delay operations Potential for fire Potential for explosion Potential to shutdown operations Potential to release combustion products to the environment Potential to damage Waste Handling Building Potential to lose containment Potential environmental concern Potential to notify DOE, EPA, and State of environmental violation Potential for adverse media attention Potential for site evacuation Potential economic loss	Generator ships waste in accordance to WAC Operator training and qualification Preventative maintenance program Pre-operational checks of equipment prior to use Equipment is designed as fail safe TDOP's are certified as DOT Class 7A containers Ventilation is designed to contain rad releases through use of HEPA filters WHB has fire suppression systems, fire extinguishers and hose station Emergency response team on site WIPP lifting practices comply with DOE Hoisting and Rigging regulations Limited combustibles in area Building design is noncombustible Waste Handling Building is a controlled area, thus minimizing worker exposure to contamination	2,3	4, 3
41) Transfer of Payload from TRUDOCK to Facility Pallet	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Overpacking Procedure - 55-gallon drum into a 85-gallon overpack, TDOP, or SWB into a TDOP

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
42) Preparation of overpacking	Use of faulty overpacking, plugs or filters	Operator error Defective material	Potential for gas buildup Potential for pressure buildup Potential to release radioactive material Potential to release hazardous material Potential to rupture waste container Potential to contaminate surface Potential for personnel radiation exposure Potential to delay operations	Operator training and qualification QA Receiving inspection WAC criteria Procedures Building Exhaust HEPA Filtered Emergency Response Plan and Teams	2,1	2,1
	Failure to correctly insert plugs and filters	Operator error Defective material	Potential to release radioactive material Potential to release hazardous material Potential to contaminate surface Potential for personnel radiation exposure Potential to delay operations	Operator training and qualification Receiving inspection WAC criteria Procedures QA Building Exhaust HEPA Filtered Emergency Response Plan and Teams	2,1	2,1
42) Preparation of overpacking	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Overpacking Procedure - 55-gallon drum into a 85-gallon overpack, TDOP, or SWB into a TDOP

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
43) Loading drum into the overpack	Failure to lift drum	Power failure Equipment failure Operator error	Potential for delay of operations	Operator training and qualification Preventative maintenance program Procedures Pre-op checks QA Redundant power	0,2	0,2
43) Loading drum into the overpack	Lifting Equipment failure including Rigging	Operator error Power failure Equipment failure Improper attachment of rigging	Potential for personnel injury Potential to drop the load Potential to release radioactive material Potential to release hazardous material Potential to rupture waste container Potential to contaminate surface Potential for personnel radiation exposure Potential to delay operations	Type A container Operator training and qualification Preventative maintenance program Spotters WAC criteria Procedures Pre-op checks QA Drum integrity Waste Container integrity WHB Exhaust HEPA Filtered Shift to HEPA Filtration in the U/G Emergency Response Plan and Teams	2,2	2,2
43) Loading drum into the overpack	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Overpacking Procedure - 55-gallon drum into a 85-gallon overpack, TDOP, or SWB into a TDOP

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
44) Loading the SWB into TDOP	Load SWB and attach TDOP lid with at least one bolt	Operator error Equipment malfunction	Forklift collision with Upender Falls during insertion of SWB Bumping or Overloading the Upender by forklift Dropping SWB while transferring to TDOP Loaded TDOP and Upender tips over	Operator training Require the use of ladders or personnel lifts if necessary to install SWB Require drive train , support wheels, and cradle alignment inspection if Upender has been bumped hard or if the weight of the forks/forklift has been placed on the Upender or TDOP Provide safe method of handling a SWB in the orientation needed to load a TDOP Installation of Upender on Facility Pallet and leaving the pallet forklift inserted into the pallet	2,2	2,2
44) Loading the SWB into TDOP	Rotate to safe 45 degree transport position and install safety pin	Operator error Equipment malfunction	Failure to adequately secure and align TDOP Pinch points around chain drive and support wheels	Approved operating procedure Vee support on cradle hold down straps Safety guards over drive chain and support wheel pinch points Remote location of chain drive pinch point Warnings posted on safety guards	2,1	2,1
	Bolt TDOP lid. Release hold down straps and remove TDOP from Upender with forklift	Operator error Equipment malfunction	Falls during bolting lid and removing lid lifting eye Forklift collision with Upender Falls during removal of hold down straps Bumping or Overloading the Upender by forklift	Provide approved and tested TDOP lid handling fixtures Modify WIPP TDOP=s to be used for overpacking with lifting lugs welded on the lids Require drive train , support wheels, and cradle alignment inspection if Upender has been bumped hard or if the weight of the forks/forklift has been placed on the Upender or TDOP Require the use of ladders or personnel lifts Prohibit climbing on the Upender Operator training and fall prevention	2,2	2,2

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Overpacking Procedure - 55-gallon drum into a 85-gallon overpack, TDOP, or SWB into a TDOP

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
44) Loading the SWB into TDOP	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Overpacking Procedure - 55-gallon drum into a 85-gallon overpack, TDOP, or SWB into a TDOP

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
45) Seals	Faulty seals on the overpack	Operator error Defective material	Potential to release hazardous waste Potential to release radioactive material Potential to contaminate surface Potential need to decontaminate area Potential for personnel radiation exposure Potential to delay operations	Type A container Operator training and qualification Receiving inspection WAC criteria Procedures Pre-op checks QA WHB Exhaust HEPA Filtered Shift to HEPA Filtration in the U/G Emergency Response Plan and Teams	2,1	2,1
	Failure to seal liner/bag properly	Operator error Defective material	Potential to release radioactive material Potential to release hazardous material Potential to contaminate surface Potential for personnel radiation exposure Potential to delay operations	Type A container Operator training and qualification WAC criteria Procedures QA Building Exhaust HEPA Filtered Emergency Response Plan and Teams	2,1	2,1
45) Seals	Failure to secure lid to overpack properly	Operator error Defective material Equipment Failure	Potential to release radioactive material Potential to release hazardous material Potential to contaminate surface Potential for personnel radiation exposure Potential to delay operations	Type A container Operator training and qualification WAC criteria Procedures QA Building Exhaust HEPA Filtered Emergency Response Plan and Teams	2,1	2,1
45) Seals	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Overpacking Procedure - 55-gallon drum into a 85-gallon overpack, TDOP, or SWB into a TDOP

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
46) Radiation Check	Excess external radiation	Technician or instrumentation error Shift of internal shielding Shipment sent by Generator above WAC limits for dose rate	Potential for notification to DOE Potential for DOE investigation into the violation Potential to delay operations Potential for personnel radiation exposure	Radiation survey upon arrival provides early detection Instruments are periodically calibrated Training and qualification of health physics personnel conducting surveys Instrument calibration programs are periodically audited Health physics qualification programs are periodically audited	1,3	1,3
46) Radiation Check	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Overpacking Procedure - 55-gallon drum into a 85-gallon overpack, TDOP, or SWB into a TDOP

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
47) Transfer in the WHB of the overpack to the facility pallet	Failure to place load on facility pallet	Operator error Equipment failure Loss of power	Potential to misposition waste container on facility pallet Potential to delay operations	Operator training and qualification Preventative maintenance program Spotters Procedures Pre-op checks Adequate lighting in area Backup power available	0,3	1,3
	Failure of Lifting Equipment	Mechanical or electrical failure of lifting equipment Operator error	Potential to drop the load Potential to rupture waste container Potential for personnel injury Potential to release radioactive material Potential to contaminate surface Potential for personnel radiation exposure Potential to delay operations Potential environmental concern Potential to notify DOE, EPA, and State of environmental violation Potential for adverse media attention. Potential economic loss	Generator ships waste in accordance to WAC Operator training and qualification Procedures are in place to perform operation Forklift fails as is on loss of power Duplicate lifting fixtures are available Preventative maintenance checks on forklift Waste containers are designed and certified as DOT Class A containers Ventilation is designed to contain radiological releases through use of HEPA filters Emergency response team on site WIPP lifting practices comply with DOE	2,1	3,1

* The first number indicates consequence, and the second indicates the relative probability.

NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Overpacking Procedure - 55-gallon drum into a 85-gallon overpack, TDOP, or SWB into a TDOP

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
47) Transfer in the WHB of the overpack to the facility pallet	Failure to Secure Load	Operator error Damaged securing devices	Potential to lose load during transit Potential to drop the load Potential to rupture waste container Potential for personnel injury Potential to release radioactive material Potential to contaminate surface Potential for personnel radiation exposure Potential to delay operations Potential environmental concern Potential to notify DOE, EPA, and State of environmental violation Potential for adverse media attention. Potential economic loss	Type A container Operator training and qualification Fail safe equipment design Preventative maintenance program Spotters Stretch wrapping Tie-down strapping WAC criteria Procedures Pre-op checks QA Drum integrity Waste Container integrity WHB fire suppression system Building Exhaust HEPA Filtered Emergency Response Plan and Teams	2,1	3,1
47) Transfer in the WHB of the overpack to the facility pallet	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

HAZOP SESSION SUMMARY TABLE

SYSTEM/VESSEL: Overpacking Procedure - 55-gallon drum into a 85-gallon overpack, TDOP, or SWB into a TDOP

Node or Line #	Deviation/ Guide Word	Possible Cause (Scenario)	Potential Hazard or Operability Consequences	Existing Safeguards	* Hazard Rank	* Total Rank
48) Transfer in the U/G from the overpack site to the disposal room	Vehicular Collision	Operator inattentive in operating forklift Forklift mechanical defect	Potential for collision with another vehicle, bulkhead, personnel, or high voltage equipment Potential to damage vehicle Potential to spill battery acid/oil Potential to shutdown operations Potential for personnel injury Potential damage to waste containers Potential to release Transuranic (TRU) waste material from waste containers to the environment Potential for personnel radiation exposure Potential for surface contamination Potential to damage bulkhead Potential to weaken drifts in ceiling Potential to shutdown diesel activities Potential for underground evacuation Potential to upset differential pressure Potential environmental concern	Qualification of operators in vehicles use Conduct of operations Safety procedures in place Major intersections have stop signs Limited access to bulkheads in planned path of transporters Access to area is restricted during waste handling operations Lighted intersections Mine operations are closely supervised WAC criteria Portable fire extinguishers available Isolated ventilation path CMR operator initiated shift to HEPA filtered exhaust Waste containers certified as Type A containers Stretchwrap Emergency Response/Recovery Plan	2,1	3,1
48) Transfer in the U/G from the overpack site to the disposal room	_All Other Deviations		NAHI			

* The first number indicates consequence, and the second indicates the relative probability. NAHI - No Additional Hazards Identified

This page intentionally left blank

APPENDIX D
Determination of Frequencies for Selected Accidents

Table D-1, Documentation of Basic Event Variables Used in the Quantification of CH Waste Accident Frequencies

ID	Description	Value	Units	Source/Comments
f_crane_drop	WHB 6 Ton crane drop accident rate per lift.	3.4E-06	/lift	WIPP/WID-96-2196, October 1996, Waste Isolation Pilot Plant, TRUDOCK Crane System Analysis. Dominant failure modes are hook/cable failure and human error. Drop due to loss of power to crane at 4.3E-01/yr and brake failure is a very small contributor.
f_forklift_coll_site	Frequency of forklift equipment failures producing waste container punctures, considering all the forklift operations accomplished during a typical operational year at a typical operational DOE site.	1.3E-02	/site-year	INEL-94/0228, Table B-1, p. B-10. Estimate based on very broad arguments on a site wide basis. This value forms the basis for frequency of forklift collisions per operating hour, f_forklift_op
f_forklift_coll	Frequency of forklift hardware failures (brake failure, accelerator stuck) resulting in collisions with waste drum packages during waste handling operations.	2.6E-06	/op hr	Scoping estimate based on estimate of a typical site year. = f_forklift_coll_site/ (10 forklifts * 2000 operational hours/year * 25% usage factor for each forklift). At WIPP pre-operational checks are accomplished before each shift.
f_forklift_drop_site	Frequency of forklift equipment failures producing waste container drops, considering all the forklift operations accomplished during a typical operational year at a typical operational DOE site.	4.3E-03	/site-year	INEL-94/0228, Table B-1, p. B-10. Estimate based on very broad arguments on a site wide basis.
f_forklift_drop	Frequency of forklift hardware failures (lifting mechanism, suspension, structure) resulting in drops of waste drum packages during waste handling operations.	8.6E-07	/op hr	Scoping estimate based on estimate of a typical site year. = f_forklift_drop_site/ (10 forklifts * 2000 operational hours/year * 25% usage factor for each forklift). At WIPP pre-operational checks are accomplished before each shift.
f_hoist_brake	Failure of hoist braking system, given loss of power to hoist lifting equipment.	1.3E-07	/demand	WIPP/WID-96-2178, Rev 0, WIPP Waste Hoist Brake System Analysis, Average unavailability of brake system based on anticipated annual usage, (see p. A3-18 of report for top event unavailability definition)
f_ign_est	Spontaneous ignition rate for non-WAC verified and non-process specific waste, based on WIPP interpretation of DOE experience	5.3E-05	$/m^3$-yr	Based on applicable experience since 1970. Refer to Tables D-2 and D-3 for evidence used to estimate this frequency.
f_LOSP	Frequency of loss of off-site power to the WIPP site	2.2E-01	/year	Based on 3 events at the WIPP site during the past 13 years. Refer to Table D-12 for evidence used to estimate this frequency.
f_Loss_pwr_hoist	Frequency of loss of on-site power distribution to critical lifting equipment, e.g. the hoist and 6-ton crane.	4.3E-01	/year	Based on 3 LOSP and 3 onsite losses during past 13 years. Refer to Table D-12 for evidence used to estimate this frequency.

Table D-1, Documentation of Basic Event Variables Used in the Quantification of CH Waste Accident Frequencies

ID	Description	Value	Units	Source/Comments
f_roof_hardware	Mechanical failure of either the bolts or resin. As the hardware is straightforward and represents mature technology the likelihood of failure is judged to be dominated by the delivery of flawed materials that are not detected.	1.0E-03	/room	Estimate based on errors during both manufacturing and acceptance of materials. Use product of NUREG/CR-1278, error of omission, Table 20-6, (1) for manufacture and H_check for acceptance to estimate an upper bound.
f_roof_unk	Roof Fall Due to Unanticipated / Unobservable Failure Mechanisms This models the estimated frequency of a roof fall without any prior indications in monitored drifts.	2.6E-05	/year	Refer to the discussion in SAR Section 5.2, CH11 Underground Roof Fall, Roof Fall Initiating Event, Unanticipated/Unobservable Mechanisms. (Estimate shown is the mean value of lognormal distribution with median = 1E-05 and RF = 10)
Factor_events_cor	Correction factor to account for the less than complete detectability of spontaneous ignition events within drums in interim storage..	10		See Section 5.2.3.1 and Table D-2 for a discussion of the evidence and reasoning for the selection of this correction factor.
H_check	HEP for Checker Fail to Detect Operator Error, given not completely independent in time, no immediate safety concerns	1.0E-01	/demand	NUREG/CR-1278, Table 20-22, Item (1), median value
H_com	HEP for commission of error in accomplishing clear and unambiguous tasks	1.0E-03	/demand	NUREG/CR-1278, Inferred from median values HEPs of errors of commission normally associated with clear and unambiguous tasks: Table 20-10, Items (2)&(6); Table 20-11, Items (1)&(2); Table 20-12, Items (3)&(9), Table 20-13 Item (1)
H_filter_UG1	HEP for failure to transfer to underground filtration mode, given a release of TRU waste in the underground during active emplacement of waste. Approximately 2 minutes available to act before material transits from U/G to the surface.	1.0E-01	/demand	WSRC-TR-93-5816, Action 2. Estimate for failure take immediate action. A potential release is considered a compelling signal to act. High mean value selected, because of the potential for injuries compete for attention and limited time.
H_filter_UG2	HEP for failure to transfer to underground filtration mode, given a release of TRU waste in the underground following sustained combustion in a drum. Approximately 2 minutes available to act before material transits from U/G to the surface.	1.0E+00	/demand	Due to the difficulty in detecting and recognizing this event when it occurs within the drum stack, no credit is taken for manual shift to filtration before a significant portion of the release occurs.
H_forklift_drop	HEP for failure to control a forklift during a waste handling operations, resulting in a drop	1.0E-05	/operation	WSRC-TR-93-5816. Action 25. Low value used because the forklift is used in a consistent and repetitious manner for waste transfers, and favorable working conditions must exist for waste handling operations to proceed.

Table D-1, Documentation of Basic Event Variables Used in the Quantification of CH Waste Accident Frequencies

ID	Description	Value	Units	Source/Comments
H_forklift_punct	HEP for failure to control a forklift during a waste handling operations, resulting in a puncture	5.0E-06	/operation	WSRC-TR-93-5816. Action 26. Low value used because the forklift is used in a consistent and repetitious manner for waste transfers, and favorable working conditions must exist for waste handling operations to proceed.
H_High_dep	Conditional failure likelihood to accomplish a subsequent action, given high dependence with failure of a previous task.	5.0E-01	/demand	NUREG/CR-1278, Table 20-18
H_WAC_generic	HEP for failure to verify that drum conforms to WAC - unrepackaged stored waste, generic process	1.0E-01	/demand	Estimate derived from consideration of that failure requires a combination of administrative errors, or errors of omission and/or commission during routine actions.
H_WAC_new	HEP for failure to verify that drum conforms to WAC - wastes that will generated in the future	1.0E-04	/demand	Estimate based on judgement that future generation processes will be subject to close control and checking. See discussion of likelihood for accident CH1 in Section 5.2.3.1 of the SAR for full justification.
H_WAC_repack	HEP multiplier for failure to verify that drum conforms to WAC - wastes that will repackaged prior to shipment to WIPP	1.0E-01	None	Estimate based on reasoning similar to NUREG-1278, Table 20-22, Item (1). Repackaging reduces fraction of unverified drums by a factor associated with checking routine tasks with written materials.
L_combust_gen	Likelihood that sufficient combustibles will be available within a waste drum to support a sustained	1.0E+00	/event	It is assumed that if a drum ignites there will be sufficient combustibles to generate enough energy breach the drum.
L_drum_15	Likelihood that at least one drum is breached, given 7-pack fall from 15 feet	1.0E+00	/event	Ref.: Deremer, K. PLG-1121. Drum is part of stacked seven packs and may be crushed by weight of other drums. All mechanisms considered, including lid dislodgment. No credit for shrink wrap.
L_drum_10	Likelihood that at least one drum is breached, given dual 7-pack fall from 10 feet.	6.2E-01	/event	Ref.: Deremer, K. PLG-1121. Drum is part of stacked seven packs and may be crushed by weight of other drums. All mechanisms considered, including lid dislodgment. No credit for shrink wrap.
L_drum_07	Likelihood that at least one drum is breached, given 7-pack fall from 7 feet.	3.0E-01	/event	Ref.: Deremer, K. PLG-1121. Drum is part of a seven pack and may be crushed by weight of other drums. All mechanisms considered, including lid dislodgment. No credit for shrink wrap.
L_drum_05	Likelihood that at least one drum is breached, given 7-pack fall from 5 feet.	8.5E-02	/event	Ref.: Deremer, K. PLG-1121. Drum is part of a seven pack and may be crushed by weight of other drums. All mechanisms considered, including lid dislodgment. No credit for shrink wrap.
L_drum_punct	Likelihood that a drum is punctured, given that forklift tines collides with it at one of a spectrum of operational speeds.	1.0E+00	/collision	Worst case assumption based on use of WSRC-TR-93-5816, Action 26, for human error for puncture. That variable assumes that puncture is achieved.

Table D-1, Documentation of Basic Event Variables Used in the Quantification of CH Waste Accident Frequencies

ID	Description	Value	Units	Source/Comments
L_filter_UG1	Likelihood of failure to auto-transfer to underground filtration mode, given a puff release of TRU waste in the underground	1.0E+00	/demand	Worst Case Assumption. No credit taken for the ability of the time integrated control logic to prevent a puff release.
L_filter_UG2	Likelihood of failure to auto-transfer to underground filtration mode, given a gradual release of TRU waste in the underground	1.0E+00	/demand	Worst Case Assumption. No credit taken for autoshift, because approximately 13 minutes required between time of first detection at station A and actual shift to filtration.
L_filter_WHB	Likelihood the on-line HEPA filter is open or bypassed, given a release of TRU waste in the WHB, and is therefore unavailable to accomplish its function. (Primary cause is human error that leaves the HEPA filter in an undetected bypassed condition.)	1.0E-04	/event	This condition requires alignment error at the filter and lack of monitoring by the CMRO. Given the HEPA filter is required to be online and the delta-p across the HEPA filter is monitored in the CMR, the estimate is judged to be conservative.
L_oxidant	Likelihood that sufficient oxidant will be available within a waste drum to support a sustained fire	4.2E-03	/event	DOE/WIPP 87-005, p. 39. See SAR Section 5.2.
N_7pack_wk	Throughput for CH waste per week (4ea 7packs/ facility pallet * 7 facility pallets per day * 4 days/ week.)	112	/week	Ref.: SAR Section 4.3.1, which references statement by the RCRA permit. **This basic event controls all the CH waste handling rates quantified in the accident analysis.**
N_7pack_yr	Number of equivalent 7-packs placed per year (= N_7pack_wk * 52 weeks)	5,824	/year	Ref.: SAR Section 4.3.1. The waste handling rate used for accident analysis is based on the maximum planned throughput. The 25% contingency estimated for maintenance and transition time from one room to another is not used here.
N_drum_panel	Number of equivalent 55 gallon drums that can be stored in one panel	81,000	/panel	Ref.: SAR Section 4.3.1, which references statement by the RCRA permit.
N_drum_room	Number of equivalent 55 gallon drums that can be stored in one room (= N_drum_panel/7)	11,571	/room	Drums equally divided among 7 rooms
N_events	Number of events used to estimate the spontaneous ignition frequency for TRU waste drums that have been improperly certified as conforming to the WIPP WAC.	40	events	=N_obs_events * Factor_events_cor. See Section 5.2.3.1 for a discussion of the reasoning using this correction factor in the estimate of the spontaneous ignition frequency in improperly certified TRU waste.
N_obs_events	Number of events associated with the long term storage of TRU waste at the generator sites that can be considered indications of the potential for spontaneous ignition in drums at the WIPP.	4	events	Refer to Table D-3 for a discussion of fire that have been included and excluded from qualifying events.
N_room_yr	Average number of rooms that will be filled per year based on expected throughput = (7 * N_7pack_yr) / (N_drum_room)	3.5	/year	Derived from the estimated throughput of waste per year.

Table D-1, Documentation of Basic Event Variables Used in the Quantification of CH Waste Accident Frequencies

ID	Description	Value	Units	Source/Comments
N_TRUPACT_yr	Number of TRUPACT II shipments to the WIPP per year (= N_7pack_yr/2)	2,912	/year	Calculated based on 2 ea. 7-packs per TRUPACT
T_crane_op	Average time that a TRUPACT load will be suspended on the TRUPACT crane.	0.2	hours	Based on current training activities, operations personnel estimate that time to transfer waste is about 10-15 minutes.
T_forklift_UG	Average time that a forklift requires to transfer one seven-pack from the transporter to the stack in the U/G.	0.1	hours	Based on current training activities, operations personnel estimate that time that BRUDI load will be off the ground is about 5 minutes.
T_forklift_WHB	Average time that a forklift requires to transfer one facility pallet to the hoist transfer room.	0.2	hours	Based on current training activities, operations personnel estimate that time to transfer waste is about 10-15 minutes.
T_hoist_op	Average time that the hoist supports waste during one transfer operation to the underground horizon.	0.2	hours	Ref.: WIPP/WID-96-2178, p.3-3 estimates 8.6 min. cycle time per lift at 500 ft/min. Time rounded to 0.2 hours to account for any additional brake release time that might be required.
Tot_storage_exp	Total time integrated exposure of TRU waste to spontaneous ignition.	7.6E+05	m^3-years	Accounts for the accumulated storage experience of the TRU waste volume at all generator sites since 1970. See Table D-2 for the derivation of this variable.
Vol_CH_UG_room	Maximum volume of CH waste that can be stored in one actively ventilated U shaped panel room with its associated access drifts in which drums are stored.	3,007	m^3	Maximum volume of CH waste currently permitted for storage at WIPP apportioned to 8 panels containing 7 rooms each.
Vol_CH_WHB	Maximum stored volume of CH waste in the Waste Handling Building (= 7 facility pallets * 28 drums/pallet * 0.208 m^3/drum)	40.8	m^3	WIPP RCRA Part B Application, p. D-7 states that a maximum of 7 facility pallets may be left in the storage area.
Vol_CH_WIPP	Total volume of CH TRU waste authorized for disposal at the WIPP	1.7E+05	m^3	= Vol_TOT_WIPP - Vol_CH_WIPP
Vol_drum	Maximum volume for waste inside a 55 gallon drum	0.208	m^3	WIPP SEIS-II App B , p. B-12
Vol_RH_WIPP	Total volume of RH waste anticipated for disposal at the WIPP	7,080	m^3	WIPP RCRA Part B Application, p. D-16
Vol_TOT_WIPP	Total volume of combined RH and CH TRU waste authorized for disposal at the WIPP (=6.2E06 ft^3 * 0.0283 m^3/ft^3)	1.75E+05	m^3	Limit established by Public Law102-579
X_CH_active	Drift length of one actively ventilated U shaped opening in which CH waste is placed, consisting of a panel room with its associated access drifts.	566	feet	Room length is 300 feet. Pillars are 100 feet thick. Therefore, entry ways are 133 feet on each end.
X_UG_active	Total drift length of all active openings in the UG horizon. (4.5 miles)	25,380	feet	WID/WIPP Engineering Memo HA:96:3555, dated June 28, 1996, Subject: LINEAR FOOTAGE OF OPENINGS IN THE UNDERGROUND BEFORE AND AFTER NORTHEND

Table D-2, Estimate of Generic Spontaneous Ignition Frequency Based on DOE Waste Storage Experience

Variable Name	Description	Formula	Resulting Value	Comments
f_ign_est	Spontaneous ignition rate for non-WAC verified and non-process specific waste, based on WIPP interpretation of DOE experience	=N_events/Tot_storage_exp	5.3E-05 /m^3-yr	Based on interpretation of applicability of incidents and the assumed total exposure of TRU waste that could generate those incidents.
N_events	Number of events used to estimate the spontaneous ignition frequency for TRU waste drums that have been improperly certified as conforming to the WIPP WAC.	=N-obs_events * Factor_events_cor	40	Section 5.2.3.1 for a discussion of the reasoning using this correction factor in the estimate of the spontaneous ignition frequency in improperly certified TRU waste.
Factor_events_cor	Correction factor to account for the less than complete detectability of spontaneous ignition events within drums in interim storage..		10	See Section 5.2.3.1 for a discussion of the evidence and reasoning for the selection of this correction factor.
N_obs_events	Number of events associated with the long term storage of TRU waste at the generator sites that can be considered indications of the potential for spontaneous ignition in drums at the WIPP.		4	Refer to Table D-3 for a discussion of fire that have been included and excluded from qualifying events.
Tot_storage_exp	Total time integrated exposure of TRU waste to spontaneous ignition.	=Vol_CH_stored* (Yr_Current -Yr_0) /2	7.6E+05 m^3-yr	Waste can be exposed to spontaneous ignition only for the period for which it is stored, and not all of it is generated at the same time. Waste is assumed to have been generated at a constant rate between 1970 and the present year.
Vol_CH_stored	Total Volume of TRU CH Waste Currently in Storage at all sites		5.85E+04 m^3	See Appendix A for a listing of all final waste forms and the documentation of this cumulative total volume. Appendix A is based on a TWBIR Query, June 1996.
Yr_0	Begin time for generation of TRU waste		1970	Assumed first year in which TRU waste was generated. This is the first year used for the search of fire incidents.
Yr_Current	Current time		1996	

Table D-3, Applicability of DOE Unusual Occurrences Involving Fires, Explosions and Overpressure

NOTES:

The table on the following sheets summarizes the evidence and reasoning used to include or exclude unusual occurrences involving fires, explosions, and overpressure in waste containers for the quantification of the spontaneous ignition frequency of drums that may have been improperly certified to conform to the WIPP WAC when delivered to the WIPP. Evaluation of Incidents that produced fires at other DOE facilities. For the operational safety of WIPP, it is important to have confidence that DOE wide procedures for certifying waste to the WIPP WAC have profited from the lessons learned from all these incidents. However, for the purpose of quantifying the susceptibility of the population of improperly certified drums that will be delivered to the WIPP, the following questions and evaluation criteria are used to evaluate unusual occurrences:

- What was the intended function of the container at the time of the incident?
- To what extent are the composition of materials and TRU inventory of the populations of containers in which the fires occurred similar to a population of drums that would be considered for shipment to the WIPP?
- What were the circumstances under which the containers were stored compared to conditions that would be associated with the handling and interim storage of TRU waste forms that would be considered for shipment to the WIPP?

To qualify as direct evidence of problems in the population of drums to be emplaced at the WIPP, the answers to the above questions should lead one to identify some association with a drum population in long term interim storage awaiting ultimate disposal. For example, temporary storage of turnings and fines that are byproducts of fabrication steps and are awaiting recycling back into feed material will most likely involve pyrophoric plutonium or uranium metal. Moreover, the storage configuration will be designed to maintain the metal in an unoxidized form, thus making it susceptible to spontaneous ignition. Material would normally have to be declared uneconomically recoverable to be designated for ultimate disposal. Therefore, an incident with material stored under these conditions is not indicative of the susceptibility of waste that would be delivered to the WIPP.

Table D-3, Applicability of DOE Unusual Occurrences Involving Fires, Explosions and Overpressure to the Susceptibility of Stored TRU Waste to Spontaneous Ignition at the WIPP

Event	Physical and Environmental Conditions at Time of Event	Consequence	Probable Cause	Applicability for Waste Delivered to WIPP Without Processing/ Repackaging	Applicable to the Population of TRU Waste Susceptible to Spontaneous Combustion at the WIPP?
6/1/70, INEL, Burial ground fire in 55-gal drum. Smoldering fire found during evening patrol.	Outside storage in sun, black drum, top of stack near center of array. Drum had been shipped from RFP. Contained a pyrophoric object that burst into flames during examination following fire, broken glass, dirt, rocks, paper, plastic, glass jars, etc.	Drum breached. Direct monitoring of air showed contamination spread was very low. Fire extinguished by lifting from stack and burying with bulldozer. No spread of contamination detected.	Probable origin of drum traced to an old natural uranium laboratory at RFP. No conclusions drawn other than the spontaneous ignition of uranium.	Drums filled in laboratories during periods of lesser control may still exist in long term interim storage at generator sites.	Yes. Judged to be part of the waste in interim long-term storage at generator sites that will be processed for shipment to the WIPP.
12/3/76, ANL-E, Explosion of 55-gal drum containing solid radioactive waste inside parked truck over night. Damage discovered in morning.	Drum had been placed inside the truck as a standard procedure to await pickup. It contained cardboard, shredded plastic bags, bagged-out plastic pouches, hot plates, rubber hose, etc. Beta-gamma activity was detected in the plastic pouches.	Drum breached, and the lid was blasted through the aluminum roof of the truck. Approximately half of the contents dispersed, being scattered within the truck. Radiation surveys of the truck and premises revealed no contamination.	Flammable organic solvent vapors accumulating in the void space of the sealed drum, ignited by static electricity discharge.	Drum would not qualify for shipment to the WIPP, as it was sealed and most likely contained a high concentration of organic vapors. Drum history and contents were unique.	Yes. Judged to be part of the waste in interim long-term storage at generator sites that will be processed for shipment to the WIPP.
8/17/78, Hanford, Distortion of 55-gal drums due to internal pressure buildup	Drums were sealed tight and awaiting burial. One drum contained 60 grams of Pu and 62 liters of solution, while the other contained 54 grams of Pu and 70 liters of solution. The solutions were contained in Speedy	No ignition occurred. Drums were enclosed in plastic bags and vented under controlled conditions.	Pressurization due to a reaction between nitric acid and organic compounds.	Drum would not qualify for shipment to the WIPP. Drums contained liquids now not permitted for shipment to WIPP. Drums did not contain vents.	No. Spontaneous ignition did not occur. Buildup of VOCs within a drum to the extent indicated here will be eliminated because all drums shipped to WIPP must have vents.
3/13/82, Hanford, Uranium-concrete billet fire.	Wooden pallet of concrete billet cans (did not involve waste containers to be used at WIPP). Pyrophoric uranium in the concrete.	Radiation surveys taken in general area indicated no contamination, but two fire fighters were contaminated on their face, hands, and clothes.	Inadequate process specifications, operating procedures, and training.	This incident does not involve waste in a configuration that would be shipped to the WIPP. It would have to be packaged in a suitable container after being certified to the WIPP WAC.	Yes. It is unknown if the containers cited in the report could have been packaged in 55 gallon drums for long term interim storage.
10/26/89, LANL, Uranium fire in a 30-gallon drum	Workers were opening the drum during the process of combining depleted pyrophoric uranium scrap for disposal.	Fire was smothered by placing the lid back on the drum. No radioactive contamination due to the fire.	The 30-gallon drum had been sent to processing without a protective fluid to isolate the uranium turnings from oxygen.	Not applicable. The material was not TRU waste. It was a known pyrophoric material that was being actively processed.	No. The fire occurred during active processing of known pyrophoric materials. It does not resemble the long term storage configurations that will be processed for WIPP.

Table D-3, Applicability of DOE Unusual Occurrences Involving Fires, Explosions and Overpressure to the Susceptibility of Stored TRU Waste to Spontaneous Ignition at the WIPP

Event	Physical and Environmental Conditions at Time of Event	Consequence	Probable Cause	Applicability for Waste Delivered to WIPP Without Processing/ Repackaging	Applicable to the Population of TRU Waste Susceptible to Spontaneous Combustion at the WIPP?
6/30/83, 1 PM, LLNL, Fire in bags of dry waste temporary piled in a toxic waste holdup area exposed directly to the summer sun awaiting packaging in drums.	Refuse bags piled in the toxic waste holdup area. The bags were not in drums and were exposed to the summer sun for approximately 3 hours prior to the fire.	Although the report did not specify whether the waste was low level or TRU, no radioactivity was detected runoff water used to fight the fire or the immediate vicinity.	Empty drums had not been delivered in time, and bags were piled to await them and was exposed directly to the sun.	Waste was not packaged. The lack of detection of radioactivity after the fact and mode of temporary storage indicate that it is highly unlikely to be TRU waste.	Yes. Because it was awaiting waste drums, the dry waste had the potential to be placed into drums that might contain TRU waste.
4/20/84, INEL, Fumes coming from a radioactive waste container. Material in the container ignited when the fumes were investigated.	Fuming nitric acid absorbed in a paper towel and discarded into a compactible radioactive waste container.	No mention whether radioactive materials were in the container. No contamination was released	Spontaneous ignition of a paper towel that had been used to absorb undiluted fuming nitric acid.	Not applicable. The fire was within a laboratory rather than a disposal area and involved materials prohibited by the WAC.	No. The fire occurred in a container in operational area that was reopened soon after waste was discarded into it. No correlation with long term storage conditions.
7/20/85, ORNL at Y-12, Fire involving thorium in a scrapped glove box.	A one gallon pail of thorium was left in a glove box that had been discarded in a salvage yard. During sorting operations, a forklift lifted the glove	Thorium fire.	Poor control of pyrophoric material. The reason for the presence of thorium in the glove box is not known.	Not applicable. The thorium was not packaged for long term disposal. The glovebox was still intact.	No. The material was not in containers designated for long term storage. The material involved was not TRU waste.
9/19/85, RFP, Pressurization of containers and release of plutonium.	Sealed container containing floor sweepings from the button breakout line. Sweepings contained plutonium fines.	Contamination of personnel and the facility.	Exothermic reaction was initiated between calcium metal and moisture present in the container.	Not applicable. This incident does not involve waste in a configuration applicable to TRU waste to be shipped to the WIPP.	No. Incident occurred with materials awaiting assay rather than containers designated for long term storage
Total of 8 Various Events Reported in DOE Safety Notice DOE/NS-0013, Issue No. 93-1, February 1993.	All recent incidents involved flammable chemical and organic materials being stored in conditions not associated with TRU waste storage.	Various	Normal hazards associated with storing flammable liquids.	The processes and storage configurations are not applicable to TRU waste that could be delivered to the WIPP.	No. The processes and storage configurations are not applicable to TRU waste that could be delivered to the WIPP.

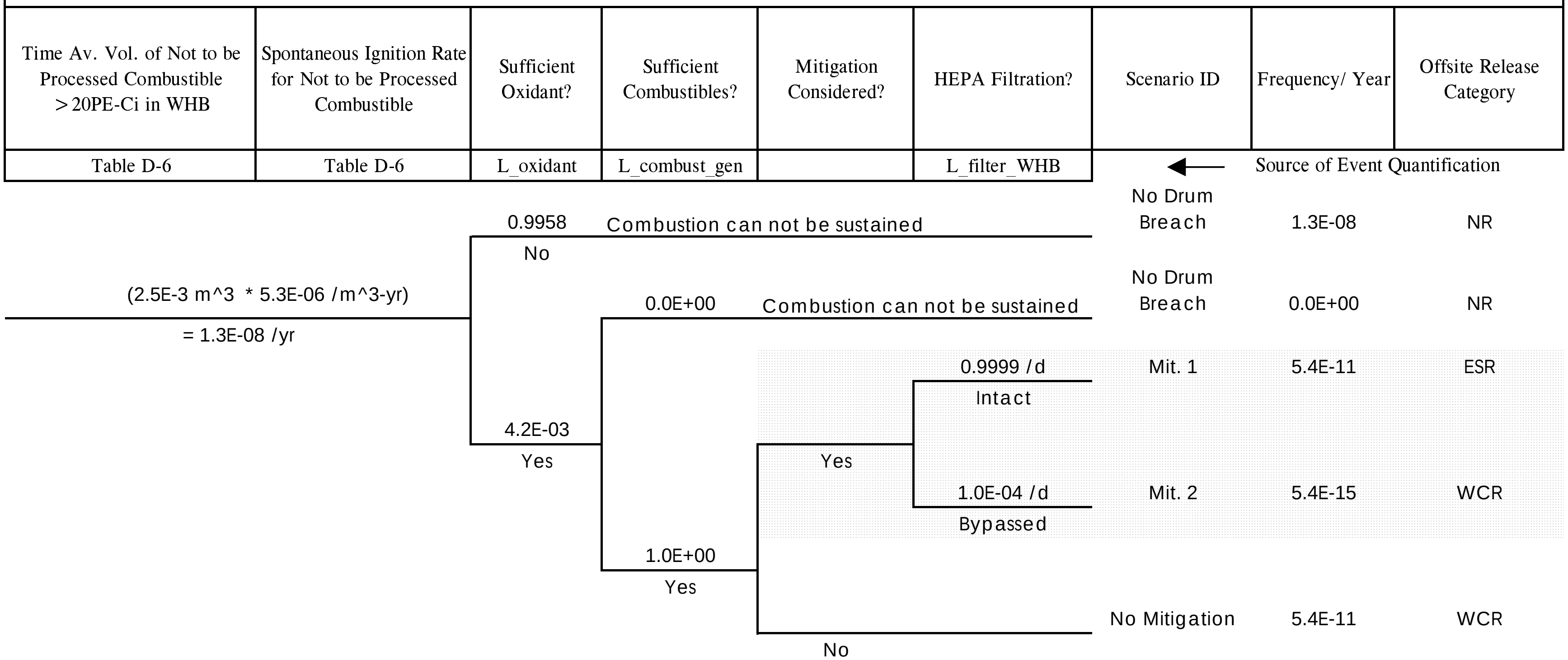
Table D-4, Extract of Baseline Inventory Report for Use in Accident Frequency Quantification

	Currently Stored TRU Waste Summarized by Final Waste Form See Table A-2 for Individual Waste Stream Data					Distribution of Radionuclide Concentrations of Stored TRU Waste *PE-Ci concentrations are waste stream averaged						
						Overall Average PE-Ci /Drum	Not to be Processed/Repackaged Before WIPP Disposal			To be Processed/Repackaged Before WIPP Disposal		
Final Waste Form Consolidated by Generator Site	Stored Volume, m^3	Equivalent Number 55 Gal Drums	Percent of Total Stored Volume	Total PE-Ci	Percent of Total PE-CI		PE-Ci* < 8	8 < PE-Ci* < 20	20 < PE-Ci*	PE-Ci* < 8	8 < PE-Ci* < 20	20 < PE-Ci*
Combustible	5,775	27,763	9.9%	52,857	4.3%	1.9	14.6%	0.5%	0.1%	83.0%	1.9%	0.0%
Filter	218	1,048	0.4%	7,217	0.6%	6.9	60.5%	31.4%	1.2%	6.6%	0.0%	0.3%
Graphite	512	2,461	0.9%	3,668	0.3%	1.5	22.3%	2.7%	0.0%	75.0%	0.0%	0.0%
Heterogeneous	23,016	110,655	39.3%	440,870	36.2%	4.0	5.7%	0.0%	0.0%	82.8%	5.7%	5.8%
Inorganic non-metal	2,928	14,079	5.0%	49,762	4.1%	3.5	7.9%	0.3%	0.0%	80.6%	8.8%	2.3%
Lead/cadmium metal	24	114	0.0%	85	0.0%	0.7	72.7%	0.0%	0.0%	27.3%	0.0%	0.0%
Salt waste	21	102	0.0%	1,712	0.1%	16.8	16.5%	8.4%	8.1%	23.6%	17.7%	25.6%
Soils	407	1,958	0.7%	5,192	0.4%	2.7	4.9%	0.0%	0.0%	70.7%	24.5%	0.0%
Solidified Inorganics	9,635	46,321	16.5%	183,911	15.1%	4.0	33.7%	0.1%	0.0%	64.1%	1.7%	0.4%
Solidified Organics	913	4,388	1.6%	3,131	0.3%	0.7	24.4%	0.1%	0.0%	75.5%	0.0%	0.0%
Uncategorized metal	10,836	52,098	18.5%	100,776	8.3%	1.9	6.2%	0.2%	0.1%	90.1%	2.7%	0.7%
Unknown	66	317	0.1%	3,567	0.3%	11.3	38.3%	0.0%	2.5%	34.9%	0.0%	24.3%
Various RF Residues	4,182	20,105	7.1%	366,439	30.1%	18.2	0.0%	0.0%	0.0%	0.0%	100.0%	0.0%
ALL WASTE FORMS	**58,533**	**281,410**	**100.0%**	**1,219,187**	**100.0%**	**4.3**	**11.7%**	**0.3%**	**0.0%**	**74.4%**	**11.0%**	**2.6%**

Table D-5, Assessment of Likelihoods that Waste Forms Now Designated for Disposal at the WIPP May be Susceptible to Spontaneous Ignition Due to Failure of Generator Site Controls

Final Waste Form	L(Failure Generator Sites to Control Pyrophorics)	Justification
Combustible	1.0E-01	Baseline Rate. A wide variety of materials can be classified combustible. It is assigned the baseline error rate for pyrophoric materials
Filter	1.0E-02	Approximately 95% filter material. Loaded filters judged to have had the opportunity to ignite either in place or upon initial exposure to air.
Graphite	1.0E-02	Approximately 95% graphite based solid materials, such as crucibles, graphite components, and pure graphite. Although potentially combustible, these items are judged to be easily separated from potentially pyrophoric materials.
Heterogeneous	1.0E-01	Baseline Rate. A wide variety of materials can be classified heterogeneous. It is assigned the baseline error rate for pyrophoric materials
Inorganic non-metal	1.0E-02	Approximately 95% inorganic nonmetals, such as glass and ceramics. These items are judged to be easily separated from potentially pyrophoric materials.
Lead/cadmium metal	1.0E-02	Approximately 95% by volume metal that contains bulk lead or cadmium, such as glove box parts. These items are judged to be easily separated from potentially pyrophoric materials.
Salt waste	1.0E-01	Baseline rate. Only 50% by volume required to be salts.
Soils	1.0E-02	Approximately 95% by volume soil material. This material would most likely consolidate to the extent that it would preclude the spontaneous ignition of any contaminate within it.
Solidified Inorganics	1.0E-01	Baseline rate. Only 50% by volume required to be inorganic process residues.
Solidified Organics	1.0E-01	Baseline Rate. Only 50% of contents by volume required to be solidified.
Uncategorized metal	1.0E-02	Approximately 95% or more, by volume, metal. This material judged to be easily separated from potentially pyrophoric materials.
Unknown	1.0E-01	Baseline rate. Must be processed and categorized before shipment.
Various Rocky Flats Residues	1.0E-04	This estimate is based on current plans to package Rocky Flats residues in pipe containers in 55-gallon drums. Therefore, this waste form is a special case for which there is high confidence that the generator site will maintain adequate control.

Figure D-1 CH1 - Spontaneous Ignition (Drum) in the Waste Handling Building. (Example Event Tree showing frequency at which containers of combustible waste not to be processed with concentrations of >20 PE-Ci are involved. See Tables D-7and D-8 for overall frequency calculation)



LEGEND:

NR: No Release
ESR: Extremely Small
SR: Small Release
WCR: IE Worst Case Release

Summary of Radiological Risk

Release Category	Consequence (Rem): Maximum Exposed Onsite Individual	Consequence (Rem): Maximum Exposed Offsite Individual	Frequency (per year): Credit for Mitigation Systems	Frequency (per year): No Credit for Mitigation Systems
NR	-	-	1.3E-08	1.3E-08
ESR	3.30E-05	3.90E-06	5.4E-11	-
SR	-	-	-	-
WCR	3.30E+01	3.80E+00	5.4E-15	5.4E-11
		Total Frequency	1.3E-08	1.3E-08

Table D-6, Initiating Event Logic for CH1 - Spontaneous Ignition (Drum) in the Waste Handling Building (Example for one specific Final Waste Form)

Variable Name	Description	Formula	Resulting Value	Comments
CH1_IE (Example)	Spontaneous ignition frequency of drums containing the "Combustible" final waste form with a TRU concentration > 20 PE-Ci/drum, not to be processed before certification.	= Vol_WHB_comb_not_p * f_ign_comb_not_p	1.3E-08 /yr	Illustrates the product of the two contributors to the initiating event frequency.
Vol_WHB_comb_not_p	Total volume weighted Material at Risk for spontaneous ignition of the "Combustible" final waste form with a TRU concentration > 20 PE-Ci/drum, not to be processed before certification.	Vol_CH_WHB* Vol%_comb_not_p	2.46E-03	This represents the equivalent volume of material present at all times. The small quantity of waste associated with this waste form will actually be susceptible in container size volumes for short periods of time over the life of the facility.
Vol_CH_WHB	Maximum Stored Waste Volume in the WHB (assumed stored all the time)	=Vol_CH_WHB (=7*28*vol_drum)	41 m^3	Maximum of 7 facility pallets anticipated to be present in the WHB at any one time.
Vol%_comb_not_p	Percent of Total Stored Volume of TRU Waste that consists of the "Combustible" final waste form with a TRU concentration > 20 PE-Ci/drum, not to be processed before certification.	= 9.9%* 0.06% from Table D-4, BIR Matrix	0.006%	Product of "Combustible" final waste form % of total volume with the % of "Combustible" waste that is greater than 20 PE-Ci
f_ign_comb_not_p	Spontaneous ignition rate for the "Combustible" final waste form with a TRU concentration > 20 PE-Ci/drum, not to be processed before certification.	= f_ign_est * WAC_comb_not_p	5.3E-06 /m^3-yr	Product of the variables listed below
f_ign_est	Spontaneous ignition rate for non-WAC verified and non-process specific waste	= f_ign_est	5.3E-05 /m^3-yr	Refer to Tables D-2 and D-3 for evidence used to estimate this frequency
WAC_comb_not_p	Likelihood that a waste container of the "Combustible" final waste form with a TRU concentration > 20 PE-Ci/drum, not to be processed before certification, will not conform to the WAC	Table D-7, Entry in subtable, Likelihood of Failure to Verify WAC	0.1	Only waste drums that may not conform to the WAC are susceptible to spontaneous ignition

Table D-7, Frequency of Sustained Combustion Event for Final Waste Forms Planned for Disposal at the WIPP

Frequency of Spontaneous Ignition per Cubic Meter of Waste Stored

Waste Categories	Likelihood of Failure to Verify WAC				Frequency of Spontaneous Ignition, Given WAC not Verified (per m^3-year)				Frequency of Spontaneous Ignition for TRU Waste Stored in the WIPP (per m^3-year)		
Final Waste Form Identification Code	Stored not to be Processed	Stored to be Processed	Projected to be Generated		Stored not to be Processed	Stored to be Processed	Projected to be Generated		Stored not to be Processed	Stored to be Processed	Projected to be Generated
Combustible	1.0E-01	1.0E-02	1.0E-04		5.3E-05	5.3E-05	5.3E-05		5.3E-06	5.3E-07	5.3E-09
Filter	1.0E-02	1.0E-03	1.0E-04		5.3E-05	5.3E-05	5.3E-05		5.3E-07	5.3E-08	5.3E-09
Graphite	1.0E-02	1.0E-03	1.0E-04		5.3E-05	5.3E-05	5.3E-05		5.3E-07	5.3E-08	5.3E-09
Heterogeneous	1.0E-01	1.0E-02	1.0E-04		5.3E-05	5.3E-05	5.3E-05		5.3E-06	5.3E-07	5.3E-09
Inorganic non-metal	1.0E-02	1.0E-03	1.0E-04		5.3E-05	5.3E-05	5.3E-05		5.3E-07	5.3E-08	5.3E-09
Lead/cadmium metal	1.0E-02	1.0E-03	1.0E-04	●	5.3E-05	5.3E-05	5.3E-05	=	5.3E-07	5.3E-08	5.3E-09
Salt waste	1.0E-01	1.0E-02	1.0E-04		5.3E-05	5.3E-05	5.3E-05		5.3E-06	5.3E-07	5.3E-09
Soils	1.0E-02	1.0E-03	1.0E-04		5.3E-05	5.3E-05	5.3E-05		5.3E-07	5.3E-08	5.3E-09
Solidified Inorganics	1.0E-01	1.0E-02	1.0E-04		5.3E-05	5.3E-05	5.3E-05		5.3E-06	5.3E-07	5.3E-09
Solidified Organics	1.0E-01	1.0E-02	1.0E-04		5.3E-05	5.3E-05	5.3E-05		5.3E-06	5.3E-07	5.3E-09
Uncategorized metal	1.0E-02	1.0E-03	1.0E-04		5.3E-05	5.3E-05	5.3E-05		5.3E-07	5.3E-08	5.3E-09
Unknown	1.0E-01	1.0E-02	1.0E-04		5.3E-05	5.3E-05	5.3E-05		5.3E-06	5.3E-07	5.3E-09
Various RF Residues	N/A	1.0E-04	N/A		5.3E-05	5.3E-05	5.3E-05		N/A	5.3E-09	N/A

Likelihood of Sustained Combustion per Cubic Meter of Waste Stored — Release due to Spontaneous Ignition

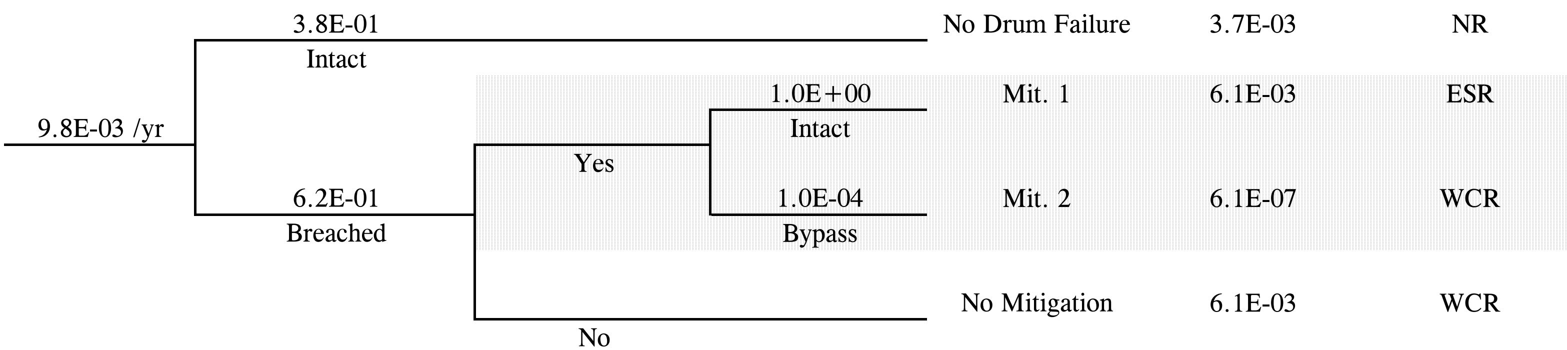
Waste Categories		Likelihood of Sufficient Oxidant				Likelihood of Sufficient Heat of Combustion (Combustibles), Given Spontaneous Ignition				Frequency of Internal Fire Caused Drum Breach per m^3-year of Waste Storage		
Final Waste Form Identification Code		Stored not to be Processed	Stored to be Processed	Projected to be Generated		Stored not to be Processed	Stored to be Processed	Projected to be Generated		Stored not to be Processed	Stored to be Processed	Projected to be Generated
Combustible		4.2E-03	4.2E-03	4.2E-03		1.0E+00	1.0E+00	1.0E+00		2.2E-08	2.2E-09	2.2E-11
Filter		4.2E-03	4.2E-03	4.2E-03		1.0E+00	1.0E+00	1.0E+00		2.2E-09	2.2E-10	2.2E-11
Graphite		4.2E-03	4.2E-03	4.2E-03		1.0E+00	1.0E+00	1.0E+00		2.2E-09	2.2E-10	2.2E-11
Heterogeneous		4.2E-03	4.2E-03	4.2E-03		1.0E+00	1.0E+00	1.0E+00		2.2E-08	2.2E-09	2.2E-11
Inorganic non-metal		4.2E-03	4.2E-03	4.2E-03		1.0E+00	1.0E+00	1.0E+00		2.2E-09	2.2E-10	2.2E-11
Lead/cadmium metal	●	4.2E-03	4.2E-03	4.2E-03	●	1.0E+00	1.0E+00	1.0E+00	=	2.2E-09	2.2E-10	2.2E-11
Salt waste		4.2E-03	4.2E-03	4.2E-03		1.0E+00	1.0E+00	1.0E+00		2.2E-08	2.2E-09	2.2E-11
Soils		4.2E-03	4.2E-03	4.2E-03		1.0E+00	1.0E+00	1.0E+00		2.2E-09	2.2E-10	2.2E-11
Solidified Inorganics		4.2E-03	4.2E-03	4.2E-03		1.0E+00	1.0E+00	1.0E+00		2.2E-08	2.2E-09	2.2E-11
Solidified Organics		4.2E-03	4.2E-03	4.2E-03		1.0E+00	1.0E+00	1.0E+00		2.2E-08	2.2E-09	2.2E-11
Uncategorized metal		4.2E-03	4.2E-03	4.2E-03		1.0E+00	1.0E+00	1.0E+00		2.2E-09	2.2E-10	2.2E-11
Unknown		4.2E-03	4.2E-03	4.2E-03		1.0E+00	1.0E+00	1.0E+00		2.2E-08	2.2E-09	2.2E-11
Various RF Residues		4.2E-03	4.2E-03	4.2E-03		1.0E+00	1.0E+00	1.0E+00		N/A	2.2E-11	N/A

Table D-8, Frequency of a Sustained Combustion Event Within the Waste Handling Building (per year of waste handling operation)

	Frequency of Drum Breach Due to Sustained Combustion		Waste Volume in WHB		Distribution of Radionuclide Concentrations of Stored TRU Waste *PE-Ci concentrations are waste stream averaged						Frequency of Sustained Combustion of stored waste (Events/year)			
Waste Categories	Per m^3-year of Storage		Apportioned to Each Final Waste Form		Not to be Processed/Repackaged Before WIPP Disposal			To be Processed/Repackaged Before WIPP Disposal			Combined Contribution of Processed and Non-Processed TRU Waste			
Final Waste Form Identification Code	Stored not to be Processed	Stored to be Processed	Vol. % of All Stored Waste	Material at Risk, m^3	PE-Ci* < 8	8 < PE-Ci* < 20	20 < PE-Ci*	PE-Ci* < 8	8 < PE-Ci* < 20	20 < PE-Ci*	PE-Ci* < 8	8 < PE-Ci* < 20	20 < PE-Ci*	Overall Frequency
Combustible	2.2E-08	2.2E-09	9.9%	4.0	14.6%	0.5%	0.06%	83.0%	1.9%		2.03E-08	5.7E-10	5.4E-11	2.1E-08
Filter	2.2E-09	2.2E-10	0.4%	0.2	60.5%	31.4%	1.2%	6.6%		0.3%	2.1E-10	1.1E-10	4.1E-12	3.1E-10
Graphite	2.2E-09	2.2E-10	0.9%	0.4	22.3%	2.7%		75.0%			2.3E-10	2.2E-11		2.6E-10
Heterogeneous	2.2E-08	2.2E-09	39.3%	16.0	5.7%	0.03%	0.01%	82.8%	5.7%	5.8%	4.9E-08	2.1E-09	2.1E-09	5.4E-08
Inorganic non-metal	2.2E-09	2.2E-10	5.0%	2.0	7.9%	0.3%	0.04%	80.6%	8.8%	2.3%	7.2E-10	5.4E-11	1.2E-11	7.9E-10
Lead/cadmium metal	2.2E-09	2.2E-10	0.04%	0.02	72.7%			27.3%			2.8E-11			2.8E-11
Salt waste	2.2E-08	2.2E-09	0.04%	0.01	16.5%	8.4%	8.1%	23.6%	17.7%	25.6%	6.1E-11	3.3E-11	3.5E-11	1.3E-10
Soils	2.2E-09	2.2E-10	0.7%	0.3	4.9%			70.7%	24.5%		7.5E-11	1.5E-11		9.0E-11
Solidified Inorganics	2.2E-08	2.2E-09	16.5%	6.7	33.7%	0.1%	0.01%	64.1%	1.7%	0.4%	5.9E-08	4.4E-10	7.2E-11	6.0E-08
Solidified Organics	2.2E-08	2.2E-09	1.6%	0.6	24.4%	0.1%		75.5%			4.5E-09	2.0E-11		4.5E-09
Uncategorized metal	2.2E-09	2.2E-10	18.5%	7.5	6.2%	0.2%	0.1%	90.1%	2.7%	0.7%	2.5E-09	7.2E-11	3.0E-11	2.6E-09
Unknown	2.2E-08	2.2E-09	0.1%	0.0	38.3%		2.5%	34.9%		24.3%	4.2E-10		5.0E-11	4.7E-10
Various RF Residues	N/A	2.2E-11	7.1%	2.9					100.0%			6.4E-11		6.4E-11
Maximum Waste Volume in Waste Handling Building =				41	(= Vol_CH_WHB)					Totals of All Final Waste Forms	1.4E-07	3.5E-09	2.3E-09	1.4E-07
										Percent of Overall Frequency	95.9%	2.4%	1.6%	100%

Figure D-2, Event Tree for CH2 - Crane Drop of Waste Containers in Waste Handling Building

Crane drop of waste containers in WHB	Drums Breached?	Mitigation Considered?	HEPA Filtration?	Scenario ID	Frequency per Year	Offsite Release Category
Table D-9	L_drum_10		L_filter_WHB	← Source of Event Quantification		



LEGEND:

NR: No Release
ESR: Extremely Small Release
SR: Small Release
WCR: IE Worst Case Release

Summary of Radiological Risk

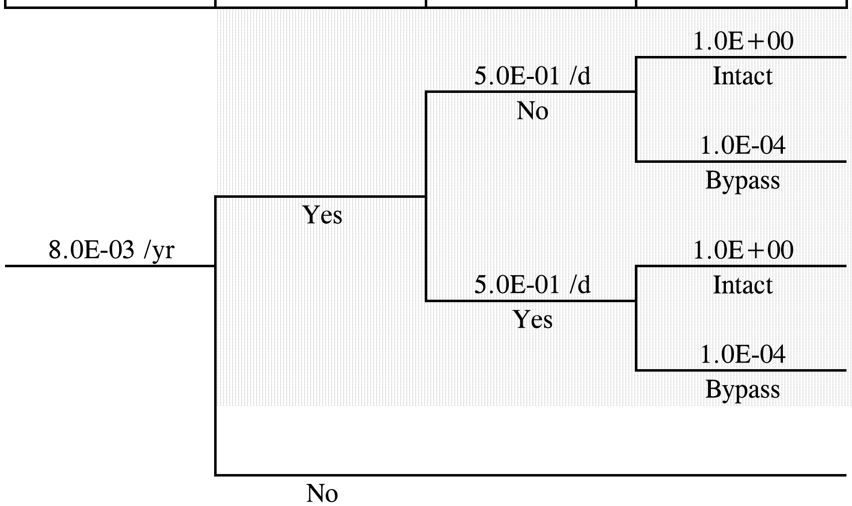
Release Category	Consequence (Rem)		Frequency (per year)	
	Maximum Exposed Onsite Individual	Maximum Exposed Offsite Individual	With Mitigation	No Mitigation
NR	-	-	3.7E-03	3.7E-03
ESR	2.70E-06	3.10E-07	6.1E-03	-
SR	-	-	-	-
WCR	2.70E+00	3.10E-01	6.1E-07	6.1E-03
		Total Frequency	9.8E-03	9.8E-03

Table D-9, Initiating Event Logic for CH2 - Crane Drop of Waste Containers in Waste Handling Building

Variable Name	Description	Formula	Resulting Value	Comments
CH2_IE	Frequency of 6-Ton crane drop accidents in the WHB per year involving waste containers.	= f_crane_drop * N_TRUPACT_yr	9.8E-03 /yr	Agrees with the overall results of DOE/WIPP-96-2196, September, 1996, Waste Isolation Pilot Plant, TRUPACT Crane System Analysis.
f_crane_drop	Crane drop rate per lift due to all mechanisms	= f_crane_drop	3.4E-06 /op	DOE/WIPP-96-2196, September, 1996, Waste Isolation Pilot Plant, TRUPACT Crane System Analysis. (Uses loss of power to the crane = 4.3E-01/yr)
N_TRUPACT_yr	Average number of CH Waste hoist transfers per year	= N_TRUPACT_yr	2912 op/yr	Based on current estimated throughput.

Figure D-3, CH3 - Puncture of Waste Containers by Forklift in Waste Handling Building

Puncture of Waste Containers by Forklift	Mitigation Considered?	Forklift Disengaged?	HEPA Filtration?	Scenario ID	Frequency per Year	Offsite Release Category
Table D-10		H_high_dep	L_filter_WHB	← Source of Event Quantification		
				Mit. 1	4.0E-03	ESR
				Mit. 2	4.0E-07	SR
				Mit. 3	4.0E-03	ESR
				Mit. 4	4.0E-07	WCR
				No Mitigation	8.0E-03	WCR



LEGEND:

NR: No Release
ESR: Extremely Small Release
SR: Small Release
WCR: IE Worst Case Release

Summary of Radiological Risk

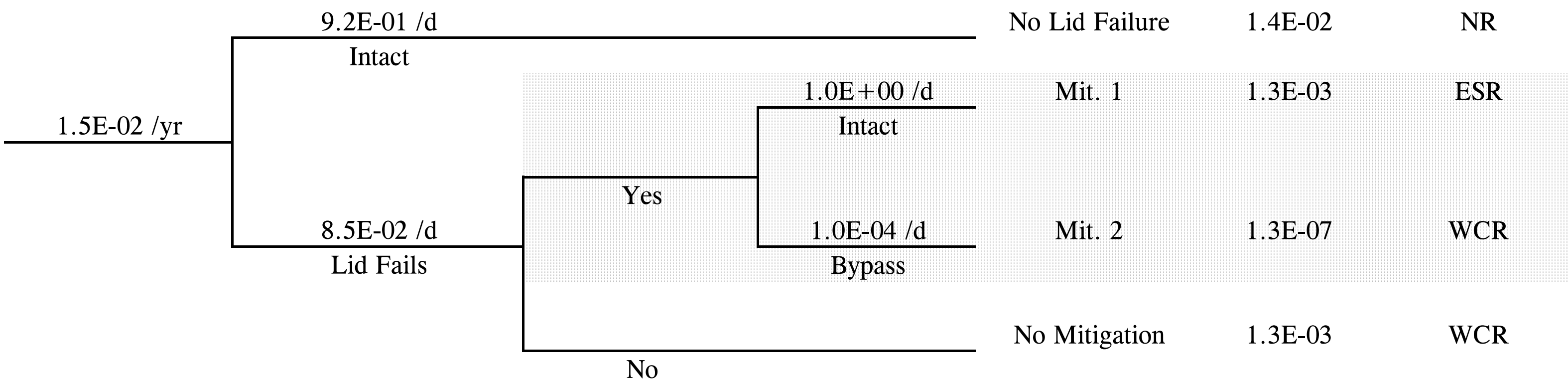
Release Category	Consequence (Rem)		Frequency (per year)	
	Maximum Exposed Onsite Individual	Maximum Exposed Offsite Individual	With Mitigation	No Mitigation
NR	-	-	-	-
ESR	2.00E-06	2.30E-07	8.0E-03	-
SR	-	-	4.0E-07	-
WCR	3.80E+00	4.40E-01	4.0E-07	8.0E-03
		Total Frequency	8.0E-03	8.0E-03

Table D-10, Initiating Event Logic for CH3 - Puncture of Waste Containers by Forklift in Waste Handling Building

Variable Name	Description	Formula	Resulting Value	Comments
CH3_IE	Puncture of Waste Containers by Forklift	=N_forklift_WHB* f_coll/op_WHB	8.0E-03 /yr	Product of number of forklift operations times the accident rate per operation.
N_forklift_WHB	Number of forklift operations in the WHB per year	= N_7pack_yr/4	1456 op/yr	In the WHB a forklift is used to transport a facility pallet containing 4 TRUPACT 7-packs
f_coll/op_WHB	Frequency of seven pack puncture from forklift during a waste handling operation in the WHB	= H_forklift + f_hardware	5.5E-06 /op	A puncture can occur due to either hardware failure or human error during the operation
H_forklift_punct	Puncturing collision of forklift with waste drums due to human error	=H_forklift_punct	5.0E-06 /op	The forklift transfer in the WHB is a standard operation done under excellent working conditions.
f_hardware	Puncturing collision with waste drums due to forklift hardware failure	= f_forklift_coll * T_forklift_WHB	5.2E-07 /op	Forklift hardware failures result from time-related mechanisms during operation, but only produce collisons during the time period when the forklift is handling waste.

Figure D-4, CH4 - Drop of Waste Containers by Forklift in Waste Handling Building

Initiating Event - Drum Drop	Drum Breached?	Mitigation Considered?	HEPA Filtration?	Scenario ID	Frequency per Year	Offsite Release Category
Table D-11	L_drum _05		L_filter_WHB	← Source of Event Quantification		



LEGEND:

NR: No Release
ESR: Extremely Small Release
SR: Small Release
WCR: IE Worst Case Release

Summary of Radiological Risk

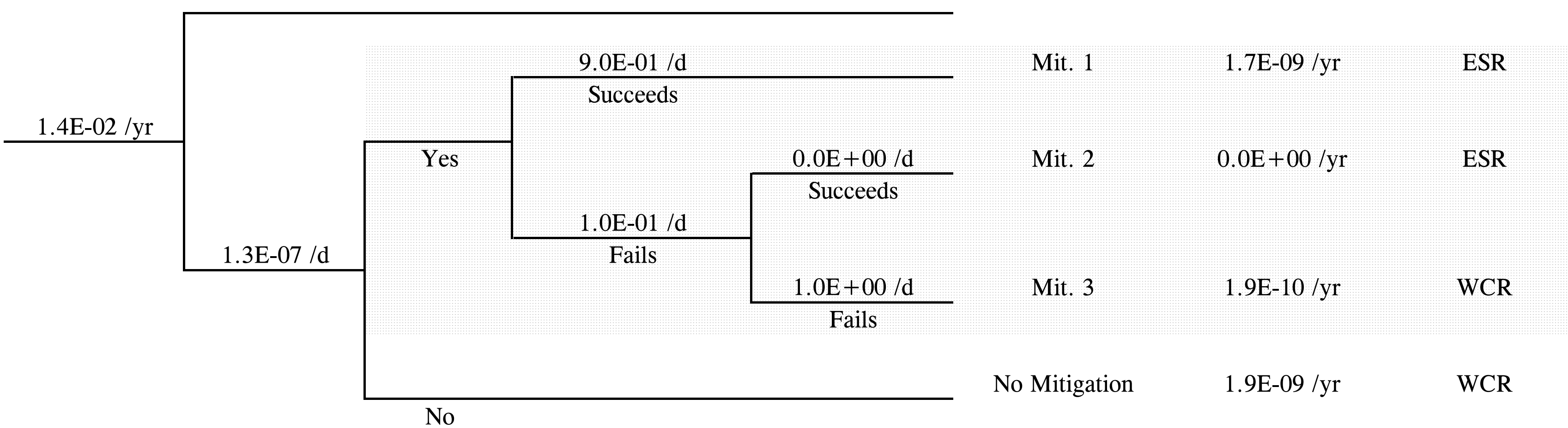
Release Category	Consequence (Rem)		Frequency (per year)	
	Maximum Exposed Onsite Individual	Maximum Exposed Offsite Individual	With Mitigation	No Mitigation
NR	-	-	1.4E-02	1.4E-02
ESR	8.60E-07	1.00E-07	1.3E-03	-
SR	-	-	-	-
WCR	8.60E-01	1.00E-01	1.3E-07	1.3E-03
		Total Frequency	1.5E-02	1.5E-02

Table D-11 Initiating Event Logic for CH4 - Drop of Waste Containers by Forklift in Waste Handling Building

Variable Name	Description	Formula	Resulting Value	Comments
CH4_IE	Drop of a drum seven-pack in the WHB	= N_forklift_WHB * f_7pack_WHB	1.5E-02 /yr	Product of number of forklift operations times the accident rate per operation.
N_forklift_WHB	Number of forklift operations in the WHB per year	= N_7pack_yr/4	1456 op/yr	In the WHB a forklift is used to transport a facility pallet containing 4 TRUPACT 7-packs
f_7pack_WHB	Frequency of seven pack drops from forklift during waste handling operations in the WHB	= H_forklift_drop + f_hardware	1.0E-05 /op	A drop can occur due to either hardware failure or human error during the operation.
H_forklift_drop	Drop of waste drums from the forklift due to human error	=H_forklift_drop	1.0E-05 /op	The forklift transfer in the WHB is a standard operation done under excellent working conditions. See Table D-1 for variable documentation.
f_hardware	Drop due to forklift hardware failure	= f_forklift_drop * T_forklift_WHB	1.7E-07 /op	Forklift hardware failures result from time-related mechanisms during operation, but only produce drops during the time period when the forklift is handling waste.

Figure D-5, Event Tree for CH5 - Waste Hoist Failure

Loss of Power to Hoist While Transporting Waste	Hoist Brake System Functions?	Mitigation Considered?	Manual Shift to Filtration?	Auto-Shift to Filtration?	Scenario ID	Frequency per Year	Offsite Release Category
Table D-12	f_hoist_brake		H_filter_UG1	L_filter_UG1	← Source of Event Quantification		



LEGEND:

NR: No Release
ESR: Extremely Small Release
SR: Small Release
WCR: IE Worst Case Release

Summary of Radiological Risk

Release Category	Consequence (Rem)		Frequency (per year)	
	Maximum Exposed Onsite Individual	Maximum Exposed Offsite Individual	With Mitigation	No Mitigation
NR	-	-		
ESR	3.10E-05	5.00E-05	1.7E-09	-
SR	-	-		-
WCR	6.10E+01	1.00E+01	1.9E-10	1.9E-09
		Total Frequency	1.9E-09	1.9E-09

Table D-12, Initiating Event Logic for CH5 - Loss of Power to Hoist While Waste is being Transferred to the Underground Horizon (Sheet 1 of 2)

Variable Name	Description	Formula	Resulting Value	Comments
CH5_IE	Frequency of loss of Power to Hoist While Transferring Waste to the Underground	= f_Loss_pwr_hoist * T_hoist_yr/8760	1.4E-02 /yr	Constitutes dominant demand for brake system to function without backup. See DOE/WID-96-2178, Rev 0, Ref 39.
f_Loss_pwr_hoist	Frequency of loss power to the waste hoist(events/year)	= f_LOSP + f_Loss_onsite_pwr	4.3E-01 /yr	Power lost due to either the loss of the source or the loss of distribution. Onsite power sources will not come on line quickly enough to prevent a requirement for the hoist brake system to function upon loss of power.
f_Loss_onsite_pwr	Frequency of loss of distribution of power onsite to critical lifting equipment	= 3/T_pwr_exp	2.2E-01 /yr	Based on 3 offsite events in 13.8 years (See Sheet 2 of this table)
f_LOSP	Frequency of loss of offsite power from the STS	= 3/T_pwr_exp	2.2E-01 /yr	Based on 3 onsite events in 13.8 years (See Sheet 2 of this table)
T_hoist_yr	Time that hoist supports waste over a year of operation.	= N_hoist_ops * T_hoist_op	291 hr	Total exposure time of the hoist to events that could require the brakes to function to prevent a waste drop.
N_hoist_ops	Average number of CH Waste hoist transfers per year	=N_7pack_yr/4	1456 op/yr	Based on current estimated throughput.
T_hoist_op	Duration of time that the hoist supports waste during one transfer operation to the underground. (hours)	=T_hoist_op	0.20 hr	Based on current estimate by operations personnel

Table D-12, Initiating Event Logic for CH5 - Loss of Power to Hoist While Waste is being Transferred to the Underground Horizon (Sheet 2 of 2)

Loss of Power Events at the WIPP Site

Description	SPS (utility/offsite)	WIPP (onsite)	Comments
Event on12/8/1982	X		Probably preventable with additional transmission line (under construction)
Event on 10/23/1983		X	
Event on 5/16/1984		X	
Event on 1/31/1985		X	
Event during 1995	X		Post-'85 data per Lahey discussion
Event during 04/96	X		Post-'85 dats per Lahey discussion
Events through 05/96	3	3	

Sources: 1) Facilities Engineering letter to R.M. Coleman, HA:85:0549
2) Discussion with Dave Lahey, Electrical Engineering Department

Experience Baseline for Loss of Power Events

Description	Variable Name		Comments
Begin date for power loss experience	D_pwr_exp_begin	8/1/82	
End Date for power loss experience	D_pwr_exp_end	5/31/96	Date of Analysis
Elapsed time in years	T_pwr_exp	13.83 yr	

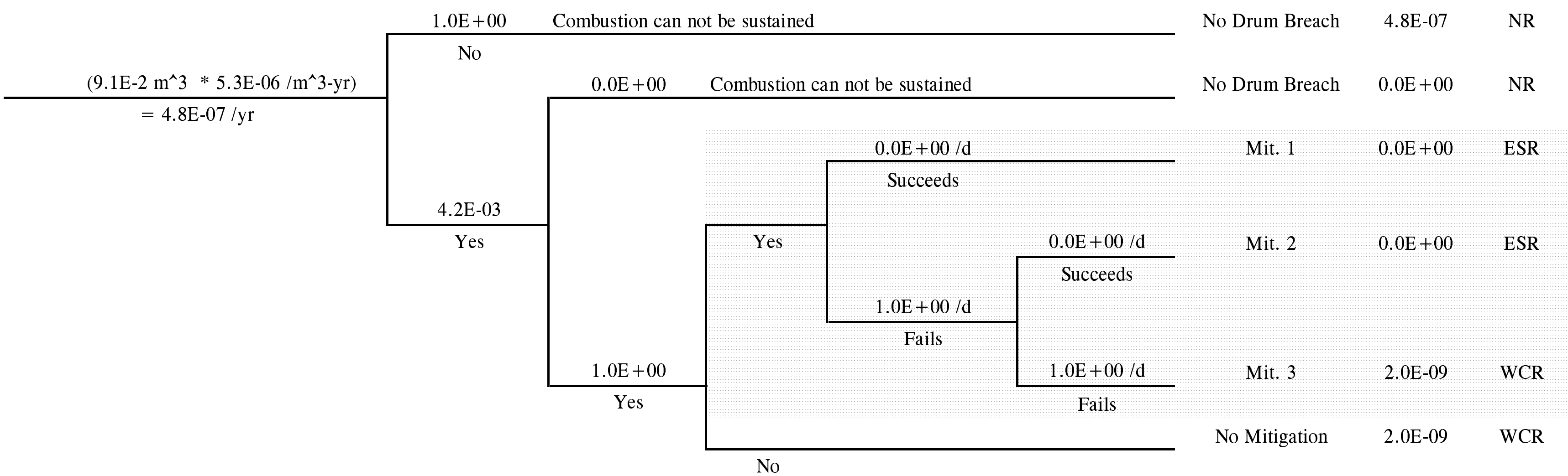
Table D-13, CH6 Seismicm Event

This section develops the scenario initiating event probability assuming that the preventative and mitigative measures function as designed during the accident scenario.

As discussed in (1) Chapters 2 and 3 of the existing WIPP FSAR WP 02-9 and the FY-95 Annual Update DOE/WIPP-Draft-2065, (2) the Draft Project Technical Baseline for Regulatory Compliance WP 02-RC1 and (3) Final Environmental Impact Statement DOE/EIS-0026, UC-70, the Design Basis Earthquake (DBE) is the most severe credible earthquake that could occur at the WIPP site. The DBE is based on a 1000-yr return interval established through a site specific study. The maximum ground acceleration for the DBE is 0.1 g in both the horizontal and vertical directions, with 10 maximum stress cycles.

Figure D-6 CH7 - Spontaneous Ignition (drum) in the Actively Ventilated Underground. (Example Event Tree showing frequency at which containers of combustible waste not to be processed with concentrations of >20 PE-Ci are involved. See Tables D-7 and D-15 for overall frequency calculation)

Time Av. Vol. of Not to be Processed Combustible >20PE-Ci in ventilated U/G	Spontaneous Ignition Rate for Not to be Processed Combustible	Sufficient Oxidant?	Sufficient Combustibles?	Mitigation Considered?	Manual U/G Shift to Filtration?	Auto-Shift to Filtration?	Scenario ID	Frequency/ Year	Offsite Release Category
Table D-14	Table D-14	L_oxidant	L_combust_gen		H_filter_UG2	L_filter_UG2	← Source of Event Quantification		



Release Category	Summary of Radiological Risk			
	Consequence (Rem)		Frequency (per year)	
	Maximum Exposed Onsite Individual	Maximum Exposed Offsite Individual	With Mitigation	No Mitigation
NR	-	-	4.8E-07	4.8E-07
ESR	1.70E-05	2.75E-06	0.0E+00	-
SR	-	-	-	-
WCR	3.30E+01	5.50E+00	2.0E-09	2.0E-09
		Total Frequency	4.8E-07	4.8E-07

LEGEND:

NR: No Release
ESR: Extremely Small Release
SR: Small Release
WCR: IE Worst Case Release

Table D-14, Initiating Event Logic for CH7 - Spontaneous Ignition (Drum) Within the Actively Ventilated Underground Horizon (Example for on specific Final Waste Form)

Variable Name	Description	Formula	Resulting Value	Comments
CH7_IE (Example)	Spontaneous ignition frequency of drums containing the "Combustible" final waste form with a TRU concentration > 20 PE-Ci/drum, not to be processed before certification.	= Vol_UG_vent_comb_not_p* f_ign_comb_not_p	4.8E-07 /yr	Illustrates the product of the two contributors to the initiating event frequency.
Vol_UG_vent_comb_not_p	Volume averaged Material at Risk for spontaneous ignition of the "Combustible" final waste form with a TRU concentration > 20 PE-Ci/drum, not to be processed before certification.	'= Vol_UG_vent* Vol%_comb_not_p	0.091 m^3	Product of the volume of non-WAC verified waste drums present and the spontaneous combustion rate for the final waste form category.
Vol_UG_vent	Time Averaged Stored Waste Volume in a ventilated panel room	=Vol_CH_UG_room/2	1503 m^3	It is assumed that a panel room is filled at a constant rate.
Vol%_comb_not_p	Percent of Total Stored Volume of TRU Waste that consists of the "Combustible" final waste form with a TRU concentration > 20 PE-Ci/drum, not to be processed before certification.	= 9.9%* 0.06% from Table D-4, BIR Matrix	0.006%	Product of %-Volume and % waste > 20 PE-Ci not to be processed
f_ign_comb_not_p	Spontaneous ignition rate for the "Combustible" final waste form with a TRU concentration > 20 PE-Ci/drum, not to be processed before certification.	= f_ign_est* WAC_comb_not_p	5.3E-06 /m^3-yr	
f_ign_est	Spontaneous ignition rate for non-WAC verified and non-process specific waste	=f_ign_est	5.3E-05 /m^3-yr	Refer to Sheet f(Spontaneous Ignition) for evidence used to estimate this frequency
WAC_comb_not_p	HEP for failure to verify that drum conforms to WAC for the "Combustible" final waste form with a TRU concentration > 20 PE-Ci/drum, not to be processed before certification.	Table D-7, Entry in subtable, Likelihood of Failure to Verify WAC	0.1	Only waste drums that may not conform to the WAC are susceptible to spontaneous ignition

Table D-15, Frequency of CH7, Sustained Combustion Event Within the Actively Ventilated Underground Horizon

	Frequency of Drum Breach Due to Sustained Combustion		Waste Volume in WHB		Distribution of Radionuclide Concentrations of Stored TRU Waste *PE-Ci concentrations are waste stream averaged						Frequency of Sustained Combustion of stored waste (Events/year)			
Waste Categories	Per m³-year of Storage		Apportioned to Each Final Waste Form		Not to be Processed/Repackaged Before WIPP Disposal			To be Processed/Repackaged Before WIPP Disposal			Combined Contribution of Processed and Non-Processed TRU Waste			
Final Waste Form Identification Code	Stored not to be Processed	Stored to be Processed	Vol. % of All Stored Waste	Material at Risk, m³	PE-Ci* < 8	8 < PE-Ci* < 20	20 < PE-Ci*	PE-Ci* < 8	8 < PE-Ci* < 20	20 < PE-Ci*	PE-Ci* < 8	8 < PE-Ci* < 20	20 < PE-Ci*	Overall Frequency
Combustible	2.2E-08	2.2E-09	9.9%	148.3	14.6%	0.5%	0.06%	83.0%	1.9%		7.50E-07	2.1E-08	2.0E-09	7.7E-07
Filter	2.2E-09	2.2E-10	0.4%	5.6	60.5%	31.4%	1.2%	6.6%		0.3%	7.6E-09	3.9E-09	1.5E-10	1.2E-08
Graphite	2.2E-09	2.2E-10	0.9%	13.1	22.3%	2.7%		75.0%			8.6E-09	7.9E-10		9.4E-09
Heterogeneous	2.2E-08	2.2E-09	39.3%	591.2	5.7%	0.03%	0.01%	82.8%	5.7%	5.8%	1.8E-06	7.8E-08	7.7E-08	2.0E-06
Inorganic non-metal	2.2E-09	2.2E-10	5.0%	75.2	7.9%	0.3%	0.04%	80.6%	8.8%	2.3%	2.7E-08	2.0E-09	4.4E-10	2.9E-08
Lead/cadmium meta	2.2E-09	2.2E-10	0.04%	0.61	72.7%			27.3%			1.0E-09			1.0E-09
Salt waste	2.2E-08	2.2E-09	0.04%	0.54	16.5%	8.4%	8.1%	23.6%	17.7%	25.6%	2.3E-09	1.2E-09	1.3E-09	4.8E-09
Soils	2.2E-09	2.2E-10	0.7%	10.5	4.9%			70.7%	24.5%		2.8E-09	5.6E-10		3.3E-09
Solidified Inorganics	2.2E-08	2.2E-09	16.5%	247.5	33.7%	0.1%	0.01%	64.1%	1.7%	0.4%	2.2E-06	1.6E-08	2.6E-09	2.2E-06
Solidified Organics	2.2E-08	2.2E-09	1.6%	23.4	24.4%	0.1%		75.5%			1.7E-07	7.4E-10		1.7E-07
Uncategorized meta	2.2E-09	2.2E-10	18.5%	278.3	6.2%	0.2%	0.1%	90.1%	2.7%	0.7%	9.3E-08	2.7E-09	1.1E-09	9.7E-08
Unknown	2.2E-08	2.2E-09	0.1%	1.7	38.3%		2.5%	34.9%		24.3%	1.6E-08		1.8E-09	1.7E-08
Various RF Residue	N/A	2.2E-11	7.1%	107.4					100.0%			2.4E-09		2.4E-09
Average Waste Volume in Ventilated Underground Room =				1,503	(=Vol_CH_UG_room/2)			Totals of All Final Waste Forms			5.1E-06	1.3E-07	8.6E-08	5.3E-06
								Percent of Overall Frequency			95.9%	2.4%	1.6%	100%

Table D-16, Frequency of CH8, Aircraft Crash (Sheet 1 of 2)

This section develops the scenario initiating event probability assuming that the preventative and mitigative measures discussed below function as designed during the accident scenario.

- Air space share facility not part of normal flight patterns
- Remote location

Using NUREG-800, the total aircraft hazard probability (combined airway, airport, and military designated airspace operations probability of an aircraft crash) is calculated as follows:

(1) Airport Operations

The Standard Review Plan (SRP) criteria state that if the number of annual operations is less than 1000d^2, where d is the distance from the facility to the airport (d > 10 mi) then the frequency of air crashes is assumed to be 1 x 10^7/yr (considered to be the general frequency of aircraft crashes from airports and federal airways). The closest commercial airport to the WIPP site is in Carlsbad, NM, at a distance of 28 miles. Therefore, applying the SRP criteria, the minimum frequency of operations yields:

1000d^2 = 1000 (28 mi)^2 = 784,000

This is well above the number of operations at the Carlsbad airport. Therefore, a frequency of 1 x 10^7/yr is assigned for aircraft crashes into the WIPP WHB as a result of airport operations.

(2) Airways

The SRP provides a method to estimate the frequency of aircraft crashes due to activity along airways as follows:

Pfa = C x N x A/w
C = in-flight crash rate
N = number of flights per year along airway
A = effective area of plant
w = width of airway (plus twice distance from airway edge to site)

Table D-16, Frequency of CH8, Aircraft Crash (Sheet 2 of 2)

Two airways, J15 and V102 pass within 5 miles of the WIPP:

J15 (4 mi NE of site)

C = in-flight crash rate = 4 x 10^10/flight-mile
N = number of flights per year along airway = (365d/yr)(23 flights/d) = 8,395 fights/yr
A = effective area of plant = (0.25 mi)^2 = 0.063 mi^2 (Property Protection area)
w = width of airway = 10 mi + 2 (4mi) = 18 mi

Pfa = C x N x A/w = (4 x 10^10/flight-mile)(8,395 fights/yr)[(0.063 mi^2)/18mi)] = 1.18 x 10-8/yr

V102 (3 mi NW of site)

C = in-flight crash rate = 4 x 10^10/flight-mile
N = number of flights per year along airway = (365d/yr)(5 flights/d) = 1,825 flights/yr
A = effective area of plant = (0.25 mi)^2 = 0.063 mi^2 (Property Protection area)
w = width of airway = 10 mi + 2 (3mi) = 16 mi

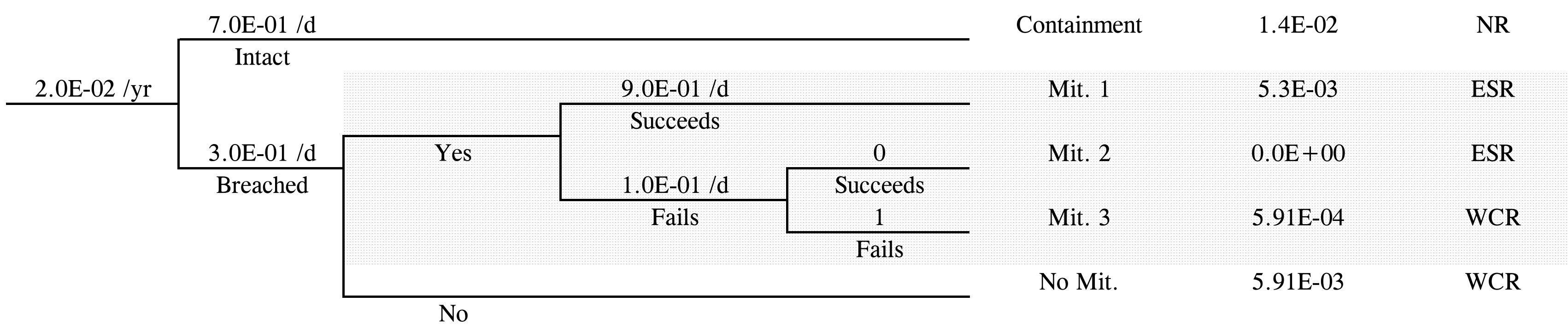
Pfa = C x N x A/w = (4 x 10^10/flight-mile)(1,825 flights/yr)[(0.063 mi^2)/16mi)] = 2.87 x 10^9/yr

Therefore, the total aircraft hazard probability (combined airway and airport probability of an aircraft crash) =

Pfa = (1 x 10^7/yr) + (1.18 x 10^8/yr) + (2.87 x 10^9/yr) = 1.03 x 10^7/yr

Figure D-7 Event Tree for CH9 - Drop of Waste Containers by Forklift in the Underground

Initiating Event - U/G Drop	Drums Breached?	Mitigation Considered?	Manual U/G Shift to Filtration?	Auto-Shift to Filtration?	Scenario ID	Frequency per Year	Offsite Release Category
Table D-17	L_drum_07		H_filter_UG1	L_filter_UG1	← Source of Event Quantification		



LEGEND:

NR: No Release
ESR: Extremely Small Release
SR Small Release
WCR: IE Worst Case Release

Summary of Radiological Risk

Release Category	Consequence (Rem)		Frequency (per year)	
	Maximum Exposed Onsite Individual	Maximum Exposed Offsite Individual	With Mitigation	No Mitigation
NR	-	-	1.4E-02	1.4E-02
ESR	1.30E-06	2.20E-07	5.3E-03	-
SR	-	-	-	-
WCR	2.70E+00	4.40E-01	5.9E-04	5.9E-03
		Total Frequency	2.0E-02	2.0E-02

Table D-17, Initiating Event Logic for CH9 - Drop of Waste Containers by Forklift in the Underground

Variable Name	Description	Formula	Resulting Value	Comments
CH9_IE	Drop of a drum seven-pack in the U/G	= N_forklift_UG * f_7pack_UG* f_top_level	2.0E-02 /yr	Frequency on an annual basis is the product of the number of operations in which a breach could occur and the accident rate per operation.
f_top_level	Fraction of operations that results in placing waste on third level of waste stack.	= 1/3	1/3	This is the only configuration in which the BRUDI clamp is released when the 7-pack is above 4 feet., thus putting the load in hazard for a drop that can produce consequences.
N_forklift_UG	Number of forklift operations in the U/G per year	= N_7pack_yr	5824 op/yr	Set equal to the throughput of 7-packs per year. One forklift operation per 7-pack.
f_7pack_UG	Frequency of seven pack drops from forklift during waste handling operations in the UG horizon	= H_forklift_drop + f_hardware	1.0E-05 /op	Drop may occur due to either human error or hardware failure.
H_forklift_drop	Drop due to human error	=H_forklift_drop	1.0E-05 /op	The forklift transfer in the underground is a standard operation done under excellent working conditions. Foor will be leveled prior to storage operations in a panel room. See Table D-1 for variable documentation.
f_hardware	Drop due to forklift hardware failure	= f_forklift_drop * T_forklift_op	8.6E-08 /op	Forklift hardware failures result from time-related mechanisms during operation, but only produce drops during the time period when the forklift is handling waste.

Table D-18, Frequency of CH10, Tornado Event

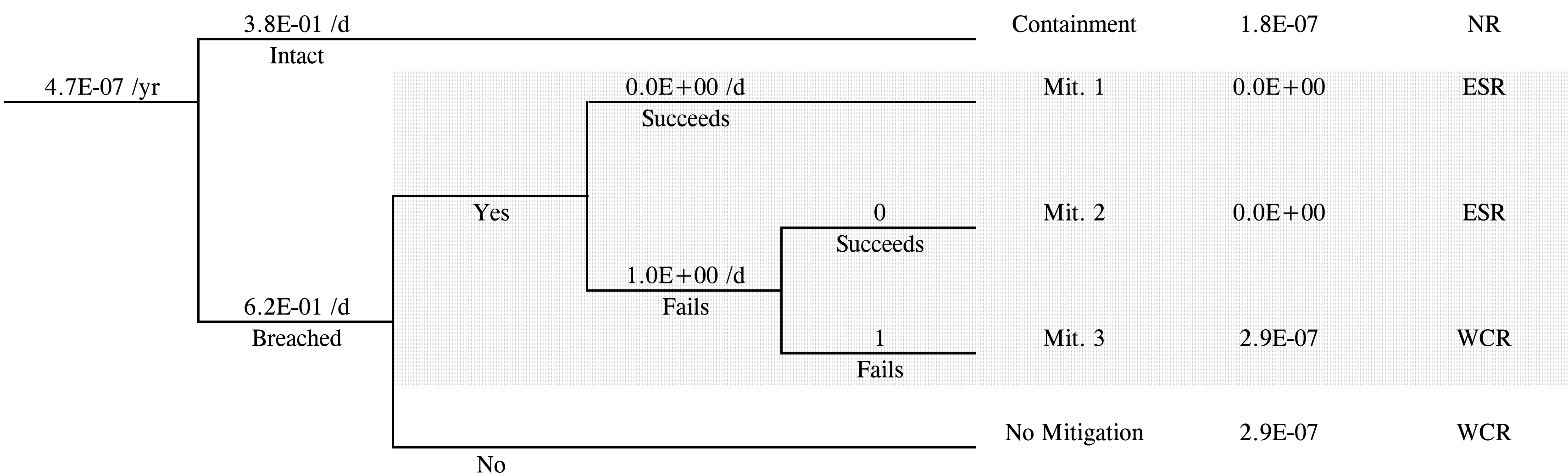
This section develops the scenario initiating event probability assuming that the preventative and mitigative measures discussed in Table 5.1-9 function as designed during the accident scenario.

As discussed in (1) Chapters 2 and 3 of the existing WIPP FSAR WP 02-9 and the FY-95 Annual Update DOE/WIPP-Draft-2065, (2) the Draft Project Technical Baseline for Regulatory Compliance WP 02-RC1, and (3) Final Environmental Impact Statement DOE/EIS-0026, UC-70, the Design Basis Tornado (DBT) is the most severe credible tornado (183 mi/hr) that could occur at the WIPP site, based on a 1,000,000-yr. recurrence period.

The DBT was developed by a site specific study SMRP No. 155, "A Site-Specific Study of Wind and Tornado Probabilities at the WIPP Site in Southeast New Mexico," Department of Geophysical Sciences, T. Fujita, University of Chicago, February 1978 and its Supplement of August 1978.

Figure D-8, Event Tree for CH11 - Unexpected Roof Fall on TRU Waste Stack in Actively Ventilated Underground

Initiating Event - Roof Fall	Waste drums Breached?	Mitigation Considered?	Manual Shift to Filtration?	Auto-Shift to Filtration?	Scenario ID	Frequency per Year	Offsite Release Category
Table D-19	L_drum_10		H_filter_UG2	L_filter_UG1	← Source of Event Quantification		



LEGEND:
NR: No Release
ESR: Extremely Small Release
SR: Small Release
WCR: IE Worst Case Release

Release Category	Summary of Radiological Risk			
	Consequence (Rem)		Frequency (per year)	
	Maximum Exposed Onsite Individual	Maximum Exposed Offsite Individual	With Mitigation	No Mitigation
NR	-	-	1.8E-07	1.8E-07
ESR	2.60E-06	4.30E-07	0.0E+00	-
SR	-	-	-	-
WCR	5.20E+00	8.60E-01	2.9E-07	2.9E-07
		Total Frequency	4.7E-07	4.7E-07

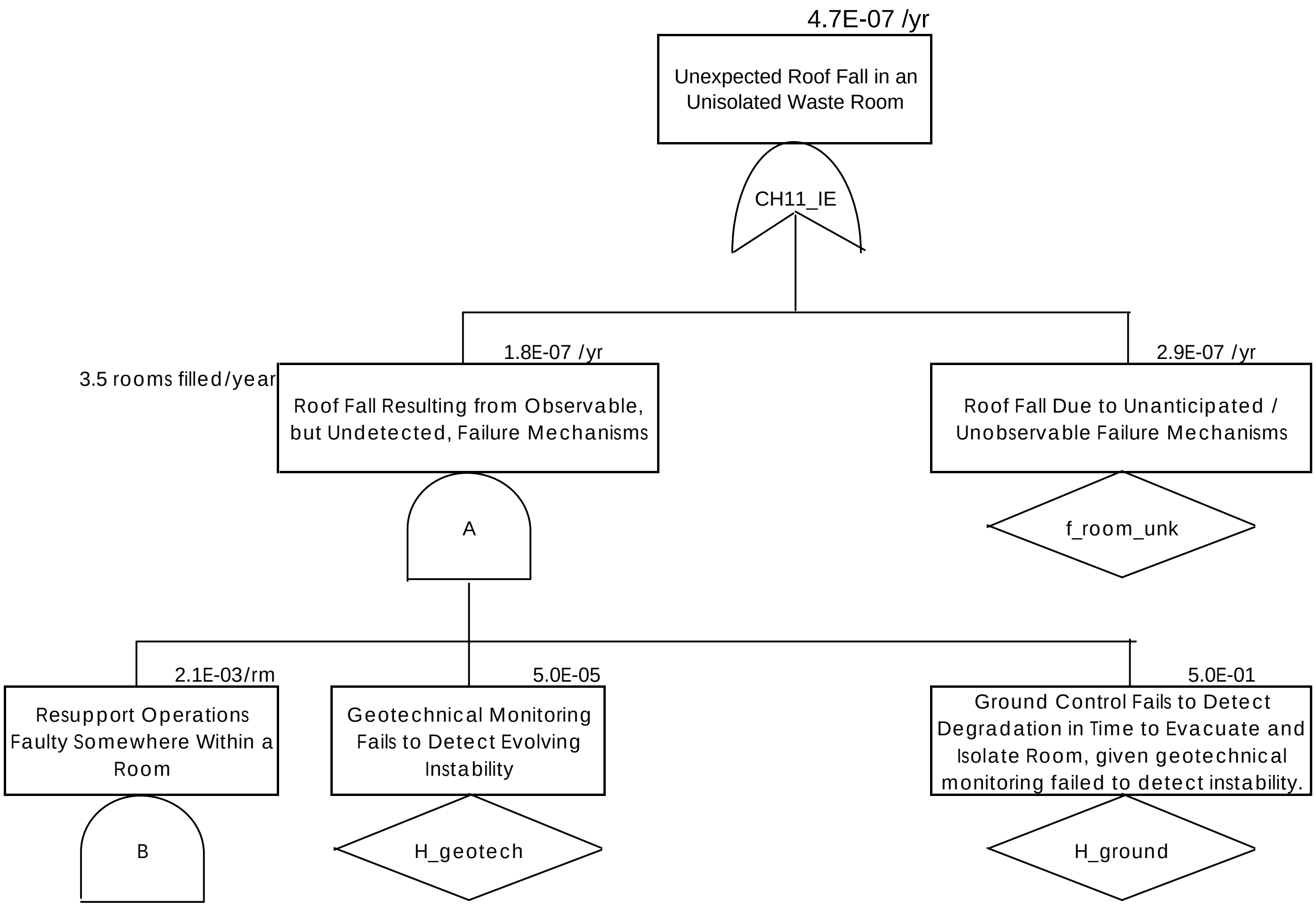
Table D-19, Initiating Event Logic for CH11 - Unexpected Roof Fall on TRU Waste Stack in Actively Ventilated Underground

Variable Name	Description	Formula	Resulting Value	Comments
CH11_IE	Unexpected Roof Fall in an Unisolated Waste Room	= f_room_unk + A	4.7E-07 /yr	
f_room_unk	Roof Fall Due to Unanticipated / Unobservable Failure Mechanisms	= f_roof_unk * (X_CH_active/2) /X_UG_active	2.9E-07 /yr	This event will be sudden and unannounced, but it can occur in any part of the active UG. Only a fall in the fraction of the UG having both CH and active ventilation will produce hazardous materials consequences. On average 1/2 of a room will be filled.
A	Roof Fall Resulting from Observable, but Undetected, Failure Mechanisms	= N_room_yr* H_geotech* H_ground* B	1.8E-07 /yr	Refer to the discussion of roof fall mechanisms in SAR Section 5.2.3.11.
N_room_yr	Average number rooms filled per year	=N_room_yr	3.5 /yr	Based on currently estimated throughput per year.
H_geotech	Geotechnical Monitoring Fails to Detect Evolving Instability	=H_com* H_check* H_High_dep	5.0E-05	At least three successive human errors required for this activity to fail. Refer to the discussion of geotechnical monitoring errors in SAR Section 5.2.3.11.
H_ground	Ground Control Fails to Detect Degradation in Time to Evacuate and Isolate Room, given geotechnical monitoring failed to detect instability.	=H_High_dep	5.0E-01	Ground control ability to detect is limited to that which can be observed in accessible areas. Therefore, there is a high dependence with failure of the geotechnical monitoring program.
B	Resupport Operations Faulty Somewhere Within a Room	= C*H_check	2.1E-03/rm	Estimate is for likelihood that observable unstable conditions could exist anywhere in the room. Instability is then assumed to propagate.
H_check	Torque Test Fails to Detect Bolt Installation Error	=H_check	1.0E-01	Torque testing is modeled as an immediate check of the installation, unless it can be shown as always being done by a crew that is completely independent of the installation crew..
C	Three or More Adjacent Supports Improperly Installed in a Room	= H_bolt_room + f_roof_hardware	2.1E-02/rm	Human error dominates the likelihood. Likelihood is represented for all the operations in the room.

Table D-19, Initiating Event Logic for CH11 - Unexpected Roof Fall on TRU Waste Stack in Actively Ventilated Underground

Variable Name	Description	Formula	Resulting Value	Comments
H_bolt_room	Human Error During Installation of Bolts	=H_com*20	2.0E-02/rm	Error of commission at 3 or more adjacent bolts. One independent opportunity to commit a multiple error of commission per shift. Estimate 20 shifts of teams to complete bolting.
f_roof_hardware	Mechanical failure of bolts or anchor resin	= f_roof_hardware	1.0E-03	Failure rate dominated by resin failure. One in one thousand batches assumed to be bad and not detected.

Figure D-9, Fault Tree for Initiating Event of CH11 - Unexpected Roof Fall on TRU Waste Stack in Actively Ventilated Underground



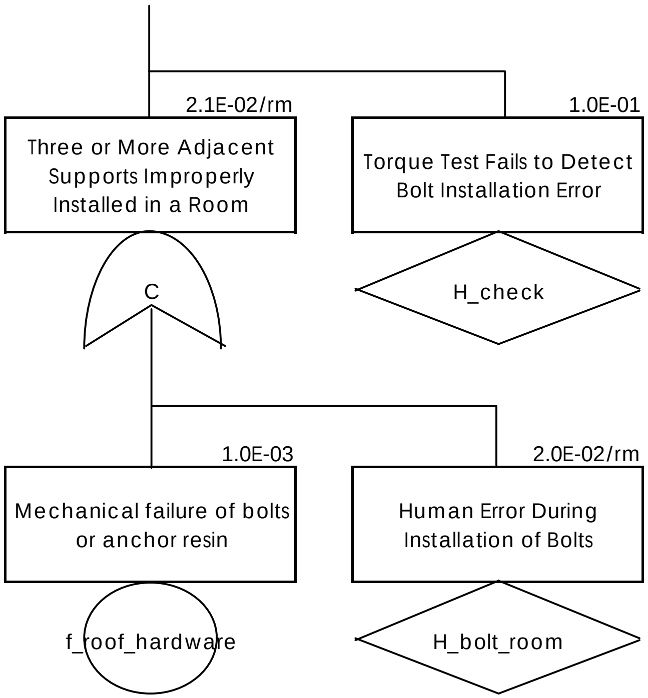

2.1E-02/rm
Three or More Adjacent Supports Improperly Installed in a Room
1.0E-01
Torque Test Fails to Detect Bolt Installation Error
C
H_check
1.0E-03
Mechanical failure of bolts or anchor resin
2.0E-02/rm
Human Error During Installation of Bolts
f_roof_hardware
H_bolt_room

Table D-20, Estimate of Life-Cycle for WHB 6-Ton cranes

Description	Value	Comments
Total scaled volume (m^3) of CH TRU waste authorized for dispersal at the WIPP	168,380	=Vol_CH_WIPP
Volume of one 55-gallon drum (m^3)	0.208 m^3	
Total number of drums that would be disposed at WIPP, if all waste is placed in drums.	809,519	
Total drums/TRUPACT-II	14	
Total TRUPACT-II deliveries	57,823	
Number of crane lifts per TRUPACT-II delivery	5	2 lifts ea for both the inner and outer containment vessel lids, plus the TRUPACT-II payload
Total number of crane lifts	289,114	
Total number of cranes	2	
Total lifts per crane during actual waste handling operations.	144,557	
Design lift cycles per crane	350,000	
Percentage of design lift cycles	41%	Plenty of room for training and partial loads
Number of TRUPACT II shipments to the WIPP per year (= N_7pack_yr/2)	2,912	
Number of years required to deliver TRUPACTS containing the total scaled volume of waste at SAR Section 4.3.1 throughput rate.	19.9	
Crane Design life in years	25	Design life can be extended with good maintenance.
Percentage of Design life to receive scaled volume of waste	79%	Time will be shorter if only stored and projected waste will be shipped to the WIPP, or the throughput is increased.

Table D-21, Comparison of Effective Dose Equivalent to 40CFR191, Subpart A, Paragraph 191.03(b) Standards for the Maximum Exposed Offsite Individual

Accident Scenario ID	Committed Effective Dose Equivalent (Rem)		Release Frequency (per year)		Annual Dose Equivalent (Rem/yr)	
	Unfiltered Release	Filtered Release	Mitigation Systems Fail to Function	Mitigation Systems Function Successfully	Mitigation Systems Fail to Function	Mitigation Systems Function Successfully
CH1	3.80	3.8E-06	5.4E-15	5.4E-11	2.1E-14	2.1E-16
CH2	0.31	3.1E-07	6.1E-07	6.1E-03	1.9E-07	1.9E-09
CH3	0.44	4.4E-07	4.0E-07	8.0E-03	1.8E-07	3.5E-09
CH4	0.10	1.0E-07	1.3E-07	1.3E-03	1.3E-08	1.3E-10
CH5	10.00	1.0E-05	1.9E-10	1.7E-09	1.9E-09	1.7E-14
CH7	5.50	5.5E-06	2.0E-09	Assumed Failed	1.1E-08	
CH9	0.44	4.4E-07	5.9E-04	5.3E-03	2.6E-04	2.3E-09
CH11	0.86	8.6E-07	2.9E-07	Assumed Failed	2.5E-07	
				Total	2.6E-04	7.9E-09

Comparison Requirement	Combined Annual Dose Equivalent	40 CFR 191.03 (b) Standard
Annual Dose Equivalent to the Whole Body	0.26 mrem/yr	< 25 mrem/yr
Annual Dose Equivalent To Most Critical Organ (Surface of Bone)*	4.7 mrem/yr	< 75 mrem/yr

*Ratio of most critical organ dose to whole body CEDE for Pu-239 = 2.11E-03/1.16E-04 = = 18.2

References for Appendix D

1. DOE/WIPP-96-2196, Waste Isolation Pilot Plant TRUDOCK Crane System Analysis, Westinghouse Waste Isolation Division, September, 1996.

2. INEL-94/0226, Safety Analysis Report for the Radioactive Waste Management Complex at the Idaho National Engineering Laboratory.

3. WIPP/WID-96-2178, WIPP Waste Hoist Brake System Analysis. July, 1996.

4. NUREG/CR-1274, Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications, Sandia National Laboratories, Albuquerque, N.M., June, 1983.

5. WSRC-TR-93-581, Savannah River Site Human Error Data Base Development for Nonreactor Nuclear Facilities.

6. PLG-1121, Damage Assessment of Waste Containers Involved in Accidents at the Waste Isolation Pilot Plant, PLG, Inc., August, 1996.

7. DOE/WIPP 87-005, Waste Drum Fire Propagation at the WIPP, April 1987.

8. DOE/WIPP 91-018, Position Paper on Flammability Concerns Associated with TRU Waste Destined for WIPP, Rev. 0, April 1991.

9. DOE/EIS-0026, Final Environmental Impact Statement, Waste Isolation Pilot Plant, 2 Vol., U.S. DOE, Carlsbad, New Mexico, 1980.

10. DOE/CAO-95-1121, U.S. Department of Energy Waste Isolation Pilot Plant Transuranic Waste Baseline Inventory Report (BIR), Revision 02, December 1995.

11. DOE\WIPP 87-005, Waste Drum Fire Propagation at the WIPP, April 1987.

12. EEG-45, Preliminary Investigation Into the Explosion Potential of Volatile Organic Compounds in WIPP CH-TRU Waste, Environmental Evaluation Group, New Mexico, June, 1990.

13. EEG-48, An Assessment of the Flammability Potential of Transuranic Waste, Environmental Evaluation Group, New Mexico, June, 1991.

14. DOE/WIPP-91-018, Position Paper on Flammability Concerns Associated with TRU Waste Destined for WIPP, April, 1991.

15. DOE/NS-0013, Fire, Explosion, and High-Pressure Hazards Associated with Waste Drums and Containers, DOE Office of Nuclear Safety, Safety Notice Issue No. 93-1, February, 1993.

16. CAO-94-1010, Revision 0, WIPP Quality Assurance Program Plan, U.S. Department of Energy, Carlsbad, N.M., 1995

17. WSTD-TME-063, Probability of a Catastrophic Waste Hoist Accident at the WIPP, July 1985.

18. SMRP No. 155, A Site Specific Study of Wind and Tornado Probabilities at the WIPP Site in Southeast New Mexico, Department of Geophysical Sciences, T. Fujita, February 1978 and Supplement of August 1978.

19. NUREG-800, U.S. Nuclear Regulatory Commission. Standard Review Plan, 3.5.1.6, Aircraft Hazards, Rev. 2, July 1981.

20. DOE/WIPP 93-033, The Current Basis for Roof Fall Prediction at WIPP and the Preliminary Prediction for SPDV Room II, August 1993.

21. DOE/WIPP-91-023, U.S. Department of Energy, Report of the Geotechnical Panel on the Effective Life of Rooms in Panel 1, DOE/WIPP 91-023, Waste Isolation Pilot Plant, Carlsbad, NM, 1991.

22. DOE/WIPP-94-2027, Westinghouse Electric Corporation, Waste Isolation Division, 1994 Panel 1 Utilization Plan, .WIPP/WID-94-2027.

23. DOE/WIPP-96-2180, Westinghouse Geotechnical Engineering, 1996 Long-Term Ground Control Plan for the Waste Isolation Pilot Plant, WIPP/WID-95-2180, June 1996.

24. WIPP-DOE-069, Rev. 4, TRU Waste Acceptance Criteria for the Waste Isolation Pilot Plant, December 1991.

This page intentionally left blank

APPENDIX E
Source Term/Dose Calculations

TABLE E-1 SOURCE TERM ANALYSIS FOR CH1 DRUM FIRE IN THE WHB											
CD	CI	DR	CF	CRF	CARF	NCF	NCRF	NCARF	Mit. LPF W/HEPA	Mit.Q (PE-Ci)	Unmit. Q (PE-Ci)
1	80	1	0.95	1	5.00E-04	0.05	1.00E-02	6.00E-03	1.0E-06	3.8E-08	3.8E-02

Q=MAR*DR*ARF*RF*LPF

Q=(CD*CI*DR*((CF*CRF*CARF)+(NCF*NCRF*NCARF)))*LPF (Ref. Eq. 5-1)

where:

Q = the source term (Ci)
CD = # of containers damaged
CI = the waste container (drum) inventory
MAR = CD * CI
ARF = Airborne Release Fraction=The fraction of radioactive material that is suspended in air.
RF = Respirable Fraction=Fraction of the airborne radioactive particles that are in the respirable size range, i.e. <10 um in aerodynamic equivalent diameter.
LPF = Leakpath Factor=The cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident (i.e. HEPA Filtration, plateout)
DR = Damage Ratio = 1 = The DR is that fraction of the MAR actually impacted by the accident condition.
CF = Combustible Fraction=Percentage of MAR that is combustible
CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range
CARF = Combustible airborne release fraction
NCF = Noncombustible Fraction=Percentage of the MAR that is noncombustible.
NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.
NCARF = Noncombustible airborne release fraction.

TABLE E-2 ON-SITE AND OFF-SITE CONSEQUENCE ANALYSIS FOR CH1 DRUM FIRE IN THE WHB									
	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (350 meters) X/Q (s/m3)	Site Boundary (2982 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area (350 meters) CEDE (rem)	Site Boundary (2982 meters) CEDE (rem)
Mitigated									
Drum	3.8E-08	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	3.3E-05	3.8E-06	2.6E-07
Unmitigated									
Drum	3.8E-02	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	3.3E+01	3.8E+00	2.6E-01

Committed Effective Dose Equivalent (CEDE) = D = Q * X/Q * BR * DCF (Ref. Eq. 5-5)

where:

Q = the source term (Ci)

X/Q = Site specific air dispersion factor (s/m3)

BR =Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)

DCF = Internal Dose Conversion Factor (Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.10E+08 rem/Ci)

TABLE E-3 CHEMICAL SOURCE TERM ANALYSIS FOR CH1 DRUM FIRE IN THE WHB												
Compound	**WF Per Drum**	**CI (mg)**	**CD**	**MAR**	**DR**	**CF**	**NCF**	**CARF**	**NCARF**	**CRF**	**NCRF**	**Q (mg)**
Chemical (Solids)												
Asbestos	2.74E-03	3.02E+05	1.00E+00	3.02E+05	1.00E+00	9.50E-01	5.00E-02	5.00E-04	6.00E-03	1.00E+00	1.00E-02	1.44E+02
Beryllium	2.10E-04	2.31E+04	1.00E+00	2.31E+04	1.00E+00	9.50E-01	5.00E-02	5.00E-04	6.00E-03	1.00E+00	1.00E-02	1.11E+01
Cadmium	3.00E-06	3.31E+02	1.00E+00	3.31E+02	1.00E+00	9.50E-01	5.00E-02	5.00E-04	6.00E-03	1.00E+00	1.00E-02	1.58E-01
Lead	8.26E-03	9.10E+05	1.00E+00	9.10E+05	1.00E+00	9.50E-01	5.00E-02	5.00E-04	6.00E-03	1.00E+00	1.00E-02	4.35E+02
Chemical (Liquids)												
Butyl Alcohol	3.00E-03	3.31E+05	1.00E+00	3.31E+05	1.00E+00	9.50E-01	5.00E-02	5.00E-04	6.00E-03	1.00E+00	1.00E-02	1.58E+02
Carbon Tetrachloride	6.27E-03	6.91E+05	1.00E+00	6.91E+05	1.00E+00	9.50E-01	5.00E-02	5.00E-04	6.00E-03	1.00E+00	1.00E-02	3.30E+02
Mercury	3.54E-03	3.90E+05	1.00E+00	3.90E+05	1.00E+00	9.50E-01	5.00E-02	5.00E-04	6.00E-03	1.00E+00	1.00E-02	1.87E+02
Methyl Alcohol	8.00E-06	8.82E+02	1.00E+00	8.82E+02	1.00E+00	9.50E-01	5.00E-02	5.00E-04	6.00E-03	1.00E+00	1.00E-02	4.21E-01
Methylene Chloride	4.00E-04	4.41E+04	1.00E+00	4.41E+04	1.00E+00	9.50E-01	5.00E-02	5.00E-04	6.00E-03	1.00E+00	1.00E-02	2.11E+01
Polychlorinated Biphenyl	8.54E-03	9.41E+05	1.00E+00	9.41E+05	1.00E+00	9.50E-01	5.00E-02	5.00E-04	6.00E-03	1.00E+00	1.00E-02	4.50E+02
Trichloroethylene	3.92E-03	4.32E+05	1.00E+00	4.32E+05	1.00E+00	9.50E-01	5.00E-02	5.00E-04	6.00E-03	1.00E+00	1.00E-02	2.07E+02

Q=MAR*DR*ARF*RF*LPF

Q=(CD*CI*((CF*CRF*CARF)+(NCF*NCRF*NCARF))) (Ref. Eq. 5.1)

where:

Q = The source term (mg)
CD = # of containers damaged
CI = The waste container (drum) inventory
MAR = CD * CI
DR '= Damage Ratio = 1 = The DR is that fraction of the MAR actually impacted by the accident condition.
CF = Combustible Fraction = Percentage of the MAR that is combustible.
CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range
CARF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range
ARF = Airborne Release Fraction=The fraction of radioactive material that is suspended in air.
RF = Respirable Fraction=Fraction of the airborne radioactive particles that are in the respirable size range, i.e. <10 um in aerodynamic equivalent diameter.
NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.
NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.
NCARF = Noncombustible airborne release fraction.
WF = Weight Fraction = Fraction of compound anticipated in a drum (INEL) =(WF) x (243 lb drum) x (453592.37 mg/lb)

TABLE E-4 CHEMICAL CONSEQUENCE ANALYSIS FOR CH1 DRUM FIRE IN THE WHB

Compound	Q (mg)	RR (sec.)	On-site (100 meters) X/Q (s/m3)	Exclusive Use Area (350 meters) X/Q (s/m3)	Site Boundary (2982 meters) X/Q (s/m3)	On-site (100 meters) C (mg/m3) or (f/cc)	Exclusive Use Area (350 meters) C (mg/m3) or (f/cc)	Site Boundary C (mg/m3) or (f/cc)	Most Restricted Criteria for Extremely Unlikely Case C (mg/m3)	Most Restrictive Onsite/Offsite Criteria (mg/m3)	TOX-2 Criteria (mg/m3)	Ratio (Conc./Limit) @ On-site (100 m) (mg/m3)	Ratio (Conc./Limit) @ Exclusive Use Area (mg/m3)	Ratio (Conc./Limit) @ Secured Site Boundary (mg/m3)
Chemical (Solids)														
Asbestos (f/cc)	1.44E+02	900	5.11E-03	5.96E-04	4.05E-05	6.31E-03	7.35E-04	5.00E-05	0.2	1	1	6.31E-03	7.35E-04	5.00E-05
Beryllium	1.11E+01	900	5.11E-03	5.96E-04	4.05E-05	6.28E-05	7.33E-06	4.98E-07	0.002	10/0.005	0.01	6.28E-06	1.47E-03	9.96E-05
Cadmium	1.58E-01	900	5.11E-03	5.96E-04	4.05E-05	8.97E-07	1.05E-07	7.11E-09	0.002	50/0.01	0.01	1.79E-08	1.05E-05	7.11E-07
Lead	4.35E+02	900	5.11E-03	5.96E-04	4.05E-05	2.47E-03	2.88E-04	1.96E-05	0.15	700/0.75	0.75	3.53E-06	3.84E-04	2.61E-05
Chemical (Liquids)														
Butyl Alcohol	1.58E+02	900	5.11E-03	5.96E-04	4.05E-05	8.97E-04	1.05E-04	7.11E-06	150	24,640/150	150	3.64E-08	6.98E-07	4.74E-08
Carbon Tetrachloride	3.30E+02	900	5.11E-03	5.96E-04	4.05E-05	1.88E-03	2.19E-04	1.49E-05	31	1,917/63	155	9.78E-07	3.47E-06	2.36E-07
Mercury	1.87E+02	900	5.11E-03	5.96E-04	4.05E-05	1.06E-03	1.24E-04	8.39E-06	0.1	28/0.1	0.1	3.78E-05	1.24E-03	8.39E-05
Methyl Alcohol	4.21E-01	900	5.11E-03	5.96E-04	4.05E-05	2.39E-06	2.79E-07	1.90E-08	266	33,250/266	266	7.20E-11	1.05E-09	7.13E-11
Methylene Chloride	2.11E+01	900	5.11E-03	5.96E-04	4.05E-05	1.20E-04	1.40E-05	9.48E-07	174	21,000/870	870	5.70E-09	1.60E-08	1.09E-09
Polychorinated Biphenyl	4.50E+02	900	5.11E-03	5.96E-04	4.05E-05	2.55E-03	2.98E-04	2.02E-05	0.5	10/2.5	2.5	2.55E-04	1.19E-04	8.10E-06
Trichloroethylene	2.07E+02	900	5.11E-03	5.96E-04	4.05E-05	1.17E-03	1.37E-04	9.29E-06	1092	1000/200	1092	1.17E-06	6.84E-07	4.65E-08

a. fibers/cc = (asbestos concentration mg/m3)(1 fiber/1.3E-7mg)(1 m3/1E6 cc)

$$C = (Q*X/Q)/RR$$

where:

C = Concentration (mg/m3)

Q = The source term (mg)

RR = Release Rate=The RR is the amount of material suspended in air as a function of time (Assumed 900 sec, 15 min.)

X/Q = Site specific air dispersion factor (s/m3)

TABLE E-5 SOURCE TERM ANALYSIS FOR CH 2 CRANE DROP IN THE WHB

CI (PE-Ci)	CD	MAR (PE-Ci)	DR	ARF	CF	CRF	NCF	NCRF	Q (PE-Ci)	Mit. LPF w/HEPA	Mit. Q (PE-Ci)	Unmit. Q (PE-Ci)
Drums												
80	1	80	0.025	0.001	0.050	0.100	0.950	1	1.9E-03	1.0E-06	1.9E-09	1.9E-03
8	6	48	0.025	0.001	0.050	0.100	0.950	1	1.1E-03	1.0E-06	1.1E-09	1.1E-03
										Total	**3.1E-09**	**3.1E-03**
SWBs												
130	1	130	0.010	0.001	0.050	0.100	0.950	1	1.2E-03	1.0E-06	1.2E-09	1.2E-03
										Total	**1.2E-09**	**1.2E-03**

Q = MAR*DR*ARF*RF*LPF

Q=(CD*CI*DR*ARF*((CF*CRF)+(NCF*NCRF)))*LPF

where:

Q = the source term (Ci)
CD = # of containers damaged
CI = the waste container inventory
MAR = CD * CI
DR = Damage Ratio =The DR is that fraction of the MAR actually impacted by the accident condition.
ARF = Airborne Release Fraction=The fraction of radioactive material that is suspended in air.
CF = Combustible Fraction Percentage of the MAR that is combustible
CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range
NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.
NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.
LPF = Leakpath Factor =the cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident (i.e. HEPA Filtration, plateout)

TABLE E-6 ON-SITE AND OFF-SITE CONSEQUENCE ANALYSIS FOR CH2 CRANE DROP IN THE WHB									
	Q (PE-Ci)	On-Site (100 m) X/Q (s/m3)	Exclusive Use Area (350 m) X/Q (s/m3)	Site Boundary (2982 m) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 m) CEDE (rem)	Exclusive Use Area (350 m) CEDE (rem)	Site Boundary CEDE (rem)
Mitigated									
Drums	3.1E-09	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	2.7E-06	3.1E-07	2.1E-08
SWBS	1.2E-09	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	1.1E-06	1.3E-07	8.5E-09
Unmitigated									
Drums	3.1E-03	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	2.7E+00	3.1E-01	2.1E-02
SWBs	1.2E-03	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	1.1E+00	1.3E-01	8.5E-03

Committed Effective Dose Equivalent (CEDE) = D = Q * X/Q * BR * DCF (Ref. Eq. 5-5)

where:

Q = the source term (Ci)

X/Q = Site specific air dispersion factor (s/m3)

BR = Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)

DCF = Internal Dose Conversion Factor (Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.10E+08 rem/Ci)

TABLE E-7 CH2 CHEMICAL SOURCE TERM/ CONSEQUENCE ANALYSIS FOR CRANE DROP IN THE WHB

Compound	MAR (mg/drum)	CD (drums)	Q (drums) (mg)	RR (1/1 sec)	On-site (100 meters) X/Q(s/m3)	Exclusive Use Area (350 meters) X/Q (s/m3)	Site Boundary (2982 meters) X/Q (s/m3)	On-site (100 meters) C (mg/m3)	Exclusive Use Area (350 meters) C (mg/m3)	Site Boundary (2982 meters) C (mg/m3)	Limiting On-site Criteria (mg/m3)	Limiting Off site Criteria (mg/m3)	Ratio (conc/limit) (100 meters)	Ratio (conc/limit) (350 meters)	Ratio (conc/limit) (2982 meters)
DRUMS															
methylene chloride*	205.23	7	1436.6	1	5.11E-03	5.96E-04	4.05E-05	7.34E+00	8.56E-01	5.8E-02	21000.00	870.0	0.03%	0.10%	0.007%
chloroform	19.80	7	138.6	1	5.11E-03	5.96E-04	4.05E-05	7.08E-01	8.26E-02	5.6E-03	5000.00	50.0	0.01%	0.17%	0.011%
carbon tetrachloride*	379.00	7	2653	1	5.11E-03	5.96E-04	4.05E-05	1.36E+01	1.58E+00	1.1E-01	1917.00	63.0	0.71%	2.51%	0.171%
1,1,2,2-Tetrachloroethane	10.40	7	72.8	1	5.11E-03	5.96E-04	4.05E-05	3.72E-01	4.34E-02	2.9E-03	1505.00	35.0	0.02%	0.12%	0.008%

$$C = (Q*X/Q)/RR$$

where:

C = Concentration (mg/m3)

Q = Source Term (mg)

RR = Release Rate- the RR is the amount of material suspended in air as a function of time (Assumed 900 sec, 15 min.)

X/Q = Site specific air dispersion factor (s/m3)

TABLE E-8 CH2 CHEMICAL SOURCE TERM/ CONSEQUENCE ANALYSIS FOR CRANE DROP IN THE WHB

Compound	MAR (mg/SWB)	CD (SWB)	RR (1/1 sec)	On-site (100 meters) X/Q(s/m3)	Use Area (350 meters) X/Q (s/m3)	Boundary (2982 meters) X/Q (s/m3)	On-site (100 meters) C (mg/m3)	Exclusive Use Area (350 meters)	Boundary (2982 meters) C (mg/m3)	Limiting On-site Criteria (mg/m3)	Limiting Off-site Criteria (mg/m3)	Ratio (conc/limit) (100 meters)	Ratio (conc/limit) (350 meters)	Ratio (conc/limit) (2982 meters)
SWBs														
methylene chloride	820.90	1	1	5.11E-03	5.96E-04	4.05E-05	4.19E+00	4.9E-01	3.3E-02	21000.00	870.0	0.02%	0.06%	0.004%
chloroform	79.30	1	1	5.11E-03	5.96E-04	4.05E-05	4.05E-01	4.7E-02	3.2E-03	5000.00	50.0	0.01%	0.09%	0.006%
carbon tetrachloride	1515.40	1	1	5.11E-03	5.96E-04	4.05E-05	7.74E+00	9.0E-01	6.1E-02	1917.00	63.0	0.40%	1.43%	0.097%
1,1,2,2-Tetrachloroethane	41.40	1	1	5.11E-03	5.96E-04	4.05E-05	2.12E-01	2.5E-02	1.7E-03	1505.00	35.0	0.01%	0.07%	0.005%

C = (Q*X/Q)/RR

where:

C = Concentration (mg/m3)
Q = Source Term (mg) = MAR *CD
RR = Release Rate- the RR is the amount of material suspended in air as a function of time (Assumed 900 sec, 15 min.)
X/Q = Site specific air dispersion factor (s/m3)

TABLE E-9 SOURCE TERM ANALYSIS FOR CH2 CRANE DROP IN THE WHB w/SOLIDIFIED 1800 PE-Ci DRUM

	CI (PE-Ci)	CD (damaged)	MAR (PE-Ci)	DR	ARF/RF	Source Term (PE-Ci)	Mit. LPF w/HEPA	Unmit. LPF w/o HEPA	Mit. Q w/HEPA (PE-Ci)	Unmit. Q w/o HEPA (PE-Ci)
Drum	1800	1	1800.0	1.00E-02	1.64E-05	3.0E-04	1.0E-06	1.0E+00	3.0E-10	3.0E-04

Q = MAR*DR*ARF*RF*LPF
Q=CD*CI*DR*ARF*((CF*CRF)+(NCF*NCRF))*LPF

where:

Q = the source term (Ci)
Mit.Q = the mitigated source term (*with* HEPA filtration)
Unmit. Q = the unmitigated source term (*without* HEPA filtration)
CD = # of containers damaged by drop or puncture
CI = the waste container inventory
MAR =(CD puncture + CD drop) * CI
DR = Damage Ratio = The DR is that fraction of the MAR actually impacted by the accident condition.
ARF = Airborne Release Fraction-The fraction of radioactive material that is suspended in air.
CF = Combustible Fraction = Percentage of MAR that is combustible.
CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range
NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.
NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.
LPF =Leakpath Factor = the cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident (i.e.,HEPA filtration; plateout)

TABLE E-10 SOURCE TERM ANALYSIS FOR CH2 CRANE DROP IN THE WHB w/OVERPACKED 1100 PE-Ci DRUM

CI (PE-Ci)	CD	MAR (PE-Ci)	DR	ARF	CF	CRF	NCF	NCRF	Q (PE-Ci)	Mit. LPF w/HEPA	Mit. Q (PE-Ci)	Unmit. Q (PE-Ci)
Drums												
1100	1	1100	2.50E-04	0.001	0.050	0.100	0.950	1	2.6E-04	1.0E-06	2.6E-10	2.6E-04

Q = MAR*DR*ARF*RF*LPF
Q=(CD*CI*DR*ARF*((CF*CRF)+(NCF*NCRF)))*LPF

where:

Q = the source term (Ci)
CD = # of containers damaged
CI = the waste container inventory
MAR = CD * CI
DR = Damage Ratio = The DR is that fraction of the MAR actually impacted by the accident condition.
ARF = Airborne Release Fraction=The fraction of radioactive material that is suspended in air.
CF = Combustible Fraction = Percentage of the MAR that is combustible
CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range
NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.
NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.
LPF = Leakpath Factor =the cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident (i.e. HEPA Filtration, plateout)

TABLE E-11 CONSEQUENCE ANALYSIS FOR CH2 CRANE DROP IN THE WHBw/SOLIDIFIED 1800 PE-Ci DRUM

	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (350 meters) X/Q (s/m3)	Site Boundary (2982 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area (350 meters) CEDE (rem)	Site Boundary CEDE (rem)
Mitigated									
Drum	3.0E-10	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	2.6E-07	3.0E-08	2.0E-09
Unmitigated									
Drum	3.0E-04	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	2.6E-01	3.0E-02	2.0E-03

Committed Effective Dose Equivalent (CEDE) = D = Q*X/Q*BR*DCF (Ref. Eq. 5-5)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = the source term (Ci)
X/Q = Site specific air dispersion factor (s/m3)
BR = C31Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)
DCF = Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public
(Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.1E+08 rem/Ci)

TABLE E-12 CONSEQUENCE ANALYSIS FOR CH2 CRANE DROP IN THE WHB w/OVERPACKED 1100 PE-Ci DRUM									
	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (350 meters) X/Q (s/m3)	Site Boundary (2982 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area (350 meters) CEDE (rem)	Site Boundary CEDE (rem)
Mitigated									
Drum	2.6E-10	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	2.3E-07	2.7E-08	1.8E-09
Unmitigated									
Drum	2.6E-04	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	2.3E-01	2.7E-02	1.8E-03

Committed Effective Dose Equivalent (CEDE) = D = Q*X/Q*BR*DCF (Ref. Eq. 5-5)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = the source term (Ci)
X/Q = Site specific air dispersion factor (s/m3)
BR = C31Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)
DCF = Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public
(Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.1E+08 rem/Ci)

TABLE E-13 SOURCE TERM ANALYSIS FOR BEYOND DESIGN BASIS CH2 CRANE DROP IN THE WHB

	CI (PE-Ci)	CD (damaged)	MAR (PE-Ci)	DR	ARF	CF	CRF	NCF	NCRF	Q (PE-Ci)	Mit. LPF w/HEPA	Unmit. LPF w/o HEPA	Mit. Q w/HEPA (PE-Ci)	Unmit. Q w/o HEPA (PE-Ci)
Drum	80	7	560.0	2.50E-02	0.001	0.050	0.100	0.950	1	1.3E-02	1.0E-06	1.0E+00	1.3E-08	1.3E-02

Q = MAR*DR*ARF*RF*LPF

Q=CD*CI*DR*ARF*((CF*CRF)+(NCF*NCRF))*LPF

where:

Q = the source term (Ci)
Mit.Q = the mitigated source term (*with* HEPA filtration)
Unmit. Q = the unmitigated source term (*without* HEPA filtration)
CD = # of containers damaged by drop or puncture
CI = the waste container inventory
MAR =(CD puncture + CD drop) * CI
DR = Damage Ratio = The DR is that fraction of the MAR actually impacted by the accident condition.
ARF = Airborne Release Fraction-The fraction of radioactive material that is suspended in air.
CF = Combustible Fraction = Percentage of MAR that is combustible.
CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range
NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.
NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.
LPF =Leakpath Factor = the cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident (i.e.,HEPA filtration; plateout)

TABLE E-14 CONSEQUENCE ANALYSIS FOR BEYOND DESIGN BASIS CH2 CRANE DROP IN THE WHB

	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (350 meters) X/Q (s/m3)	Site Boundary (2982 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area (350 meters) CEDE (rem)	Site Boundary CEDE (rem)
Mitigated									
Drums	1.3E-08	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	1.2E-05	1.4E-06	9.2E-08
Unmitigated									
Drums	1.3E-02	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	1.2E+01	1.4E+00	9.2E-02

Committed Effective Dose Equivalent (CEDE) = D = Q*X/Q*BR*DCF (Ref. Eq. 5-5)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = the source term (Ci)
X/Q = Site specific air dispersion factor (s/m3)
BR = C31Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)
DCF = Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public
(Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.1E+08 rem/Ci)

TABLE E-15 SOURCE TERM ANALYSIS FOR CH3 PUNCTURE AND DROP BY FORK LIFT IN THE WHB

CI (PE-Ci)	CD (punct.)	CD (drop)	MAR (PE-Ci)	DR	ARF	CF	CRF	NCF	NCRF	Source Term (PE-Ci)	LPF Mit.w/HEPA	Mit. Q (PE-Ci)	Unmit.Q (PE-Ci)
Drums													
80	1		80	0.050	0.001	0.050	0.100	0.950	1.000	3.8E-03	1.0E-06	3.8E-09	3.8E-03
8	1		8	0.050	0.001	0.050	0.100	0.950	1.000	3.8E-04	1.0E-06	3.8E-10	3.8E-04
8		2	16	0.010	0.001	0.050	0.100	0.950	1.000	1.5E-04	1.0E-06	1.5E-10	1.5E-04
											Total	**4.4E-09**	**4.4E-03**
SWBs													
130	1		130	0.010	0.001	0.050	0.100	0.950	1.000	1.2E-03	1.0E-06	1.2E-09	1.2E-03
32		1	32	0.010	0.001	0.050	0.100	0.950	1.000	3.1E-04	1.0E-06	3.1E-10	3.1E-04
											Total	**1.5E-09**	**1.5E-03**

Q = MAR*DR*ARF*RF*LPF

Q=(CD*CI*DR*ARF*((CF*CRF)+(NCF*NCRF))*LPF

where:

Q = the source term (Ci)

Mit.Q = the mitigated source term (*with* HEPA filtration)

Unmit. Q = the unmitigated source term (*without* HEPA filtration)

CD (puncture) = # of containers damaged by puncture

CD (drop) =# of containers damaged by drop

CI = the waste container inventory

MAR =(CD puncture + CD drop) * CI

DR = Damage Ratio = The DR is that fraction of the MAR actually impacted by the accident condition.

ARF = Airborne Release Fraction=The fraction of radioactive material that is suspended in air.

CF = Combustible Fraction = Percentage of the MAR that is combusible.

CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range

NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.

NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.

LPF =Leakpath Factor = the cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident (i.e.,HEPA filtration; plateout).

TABLE E-16 ON-SITE AND OFF-SITE CONSEQUENCE ANALYSIS FOR CH3 PUNCTURE AND DROP BY FORK LIFT IN THE WHB									
	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (350 meters) X/Q (s/m3)	Site Boundary (2982 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area (350 meters) CEDE (rem)	Site Boundary (2982 meters) CEDE (rem)
Mitigated									
Drums	4.4E-09	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	3.8E-06	4.4E-07	3.0E-08
SWBS	1.5E-09	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	1.3E-06	1.6E-07	1.1E-08
Unmitigated									
Drums	4.4E-03	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	3.8E+00	4.4E-01	3.0E-02
SWBS	1.5E-03	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	1.3E+00	1.6E-01	1.1E-02

Committed Effective Dose Equivalent (CEDE) = D = Q * X/Q * BR * DCF (Ref. Eq. 5-5)

where:

Q	= the source term (Ci)
X/Q	= Site specific air dispersion factor (s/m3)
BR	=Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)
DCF	=Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public (Pu-239 Class W CEDE Inhalation '5.1E+02 rem/uCi or 5.10E+08 rem/Ci)

TABLE E-17 CHEMICAL SOURCE TERM AND CONSEQUENCE ANALYSIS FOR CH3 PUNCTURE AND DROP OF DRUMS BY FORK LIFT IN THE WHB

Compound	MAR (mg/drum)	CD (drums)	Q (drums) (mg)	RR (1/1 sec)	On-site (100 meters) X/Q(s/m3)	Exclusive Use Area (350 meters) X/Q (s/m3)	Site Boundary (2982 meters) X/Q (s/m3)	On-site (100 meters) C (mg/m3)	Exclusive Use Area (350 meters) C (mg/m3)	Site Boundary (2982 meters) C (mg/m3)	Limiting On-site Criteria (mg/m3)	Limiting Off-site Criteria (mg/m3)	Ratio (conc/limit) (100 meters)	Ratio (conc/limit) (350 meters)	Ratio (conc/limit) (2982 meters)
DRUMS															
methylene chloride*	205.23	4	820.9	1	5.11E-03	5.96E-04	4.05E-05	4.19E+00	4.89E-01	3.3E-02	21000.00	870.0	0.02%	0.06%	0.004%
chloroform	19.80	4	79.2	1	5.11E-03	5.96E-04	4.05E-05	4.05E-01	4.72E-02	3.2E-03	5000.00	50.0	0.01%	0.09%	0.006%
carbon tetrachloride*	379.00	4	1516	1	5.11E-03	5.96E-04	4.05E-05	7.75E+00	9.04E-01	6.1E-02	1917.00	63.0	0.40%	1.43%	0.097%
1,1,2,2-Tetrachloroethane	10.40	4	41.6	1	5.11E-03	5.96E-04	4.05E-05	2.13E-01	2.48E-02	1.7E-03	1505.00	35.0	0.01%	0.07%	0.005%

C = (Q*X/Q)/RR

where:

C = Concentration (mg/m3)

Q = Source Term (mg)

RR = Release Rate- the RR is the amount of material suspended in air as a function of time (Assumed 900 sec, 15 min.)

X/Q = Site specific air dispersion factor (s/m3)

TABLE E-18 CHEMICAL SOURCE TERM AND CONSEQUENCE ANALYSIS FOR CH3 PUNCTURE AND DROP OF SWB BY FORKLIFT IN THE WHB														
Compound	MAR (mg/SWB)	CD (SWBs)	RR (1/1 sec)	On-site (100 meters) X/Q(s/m3)	Exclusive UseArea (350 meters) X/Q (s/m3)	Site Boundary (2982 meters) X/Q (s/m3)	On-site (100 meters) C (mg/m3)	Exclusive Use Area (350 meters) C (mg/m3)	Site Boundary (2982 meters) C (mg/m3)	Limiting On-site Criteria (mg/m3)	Limiting Off-site Criteria (mg/m3)	Ratio (conc/limit) (100 meters)	Ratio (conc/limit) (350 meters)	Ratio (conc/limit) (2982 meters)
SWBs														
methylene chloride	820.90	2	1	5.11E-03	5.96E-04	4.05E-05	8.39E+00	9.8E-01	6.6E-02	21000.00	870.0	0.04%	0.11%	0.008%
chloroform	79.30	2	1	5.11E-03	5.96E-04	4.05E-05	8.10E-01	9.5E-02	6.4E-03	5000.00	50.0	0.02%	0.19%	0.013%
carbon tetrachloride	1515.40	2	1	5.11E-03	5.96E-04	4.05E-05	1.55E+01	1.8E+00	1.2E-01	1917.00	63.0	0.81%	2.87%	0.195%
1,1,2,2-Tetrachloroethane	41.40	2	1	5.11E-03	5.96E-04	4.05E-05	4.23E-01	4.9E-02	3.4E-03	1505.00	35.0	0.03%	0.14%	0.010%

C = (Q*X/Q)/RR

where:

C = Concentration (mg/m3)

Q = Source Term (mg) = MAR *CD

RR = Release Rate- the RR is the amount of material suspended in air as a function of time (Assumed 900 sec, 15 min.)

X/Q = Site specific air dispersion factor (s/m3)

TABLE E-19 SOURCE TERM ANALYSIS FOR CH3 WASTE CONTAINER PUNCTURE IN THE WHB w/SOLIDIFIED 1800 PE-Ci DRUM

	CI (PE-Ci)	CD (damaged)	MAR (PE-Ci)	DR	ARF/RF	Source Term (PE-Ci)	Mit. LPF w/HEPA	Unmit. LPF w/o HEPA	Mit. Q w/HEPA (PE-Ci)	Unmit. Q w/o HEPA (PE-Ci)
Drum	1800	1	1800.0	1.00E-02	1.60E-05	2.9E-04	1.0E-06	1.0E+00	2.9E-10	2.9E-04

Q = MAR*DR*ARF*RF*LPF
Q=CD*CI*DR*ARF*((CF*CRF)+(NCF*NCRF))*LPF

where:

Q = the source term (Ci)
Mit.Q = the mitigated source term (*with* HEPA filtration)
Unmit. Q = the unmitigated source term (*without* HEPA filtration)
CD = # of containers damaged by drop or puncture
CI = the waste container inventory
MAR = Damage Ratio = The DR is that fraction of the MAR actually impacted by the accident condition.
DR = Material Release Fraction = Fraction of contents of each waste container released during event
ARF = Airborne Release Fraction-The fraction of radioactive material that is suspended in air.
CF = Combustible Fraction = Percentage of MAR that is combustible.
CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range
NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.
NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.
LPF =Leakpath Factor = the cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident (i.e.,HEPA filtration; plateout)

TABLE E-20 SOURCE TERM ANALYSIS FOR CH3 PUNCTURE IN THE WHB w/1100 PE-Ci DRUM OVERPACKED IN SWB

CI (PE-Ci)	CD (punct.)	CD (drop)	MAR (PE-Ci)	DR	ARF	CF	CRF	NCF	NCRF	Source Term (PE-Ci)	LPF Mit.w/HEPA	Mit. Q (PE-Ci)	Unmit.Q (PE-Ci)
Drums													
1100	1		1100	0.010	0.001	0.050	0.100	0.950	1.000	1.1E-02	1.0E-06	1.1E-08	1.1E-02

Q = MAR*DR*ARF*RF*LPF
Q=(CD*CI*DR*ARF*((CF*CRF)+(NCF*NCRF))*LPF

where:

Q = the source term (Ci)
Mit.Q = the mitigated source term (*with* HEPA filtration)
Unmit. Q = the unmitigated source term (*without* HEPA filtration)
CD (puncture) = # of containers damaged by puncture
CD (drop) =# of containers damaged by drop
CI = the waste container inventory
MAR =(CD puncture + CD drop) * CI
DR = Damage Ratio = The DR is that fraction of the MAR actually impacted by the accident condition.
ARF = Airborne Release Fraction=The fraction of radioactive material that is suspended in air.
CF = Combustible Fraction = Percentage of the MAR that is combusible.
CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range
NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.
NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.
LPF =Leakpath Factor = the cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident (i.e.,HEPA filtration; plateout).

TABLE E-21 CONSEQUENCE ANALYSIS FOR CH3 PUNCTURE IN THE WHB w/SOLIDIFIED 1800 PE-Ci DRUM

	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (350 meters) X/Q (s/m3)	Site Boundary (2982 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area CEDE (rem)	Site Boundary CEDE (rem)
Mitigated									
Drums	2.9E-10	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	2.5E-07	2.9E-08	2.0E-09
Unmitigated									
Drums	2.9E-04	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	2.5E-01	2.9E-02	2.0E-03

Committed Effective Dose Equivalent (CEDE) = D = Q*X/Q*BR*DCF (Ref. Eq. 5-5)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = the source term (Ci)
X/Q = Site specific air dispersion factor (s/m3)
BR = C31Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)
DCF = Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public
(Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.1E+08 rem/Ci)

TABLE E-22 CONSEQUENCE ANALYSIS FOR CH3 PUNCTURE IN THE WHB w/1100 PE-Ci DRUM OVERPACKED IN SWB

	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (350 meters) X/Q (s/m3)	Site Boundary (2982 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area CEDE (rem)	Site Boundary CEDE (rem)
Mitigated									
Drums	1.1E-08	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	9.1E-06	1.1E-06	7.2E-08
Unmitigated									
Drums	1.1E-02	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	9.1E+00	1.1E+00	7.2E-02

Committed Effective Dose Equivalent (CEDE) = D = Q*X/Q*BR*DCF (Ref. Eq. 5-5)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)

Q = the source term (Ci)

X/Q = Site specific air dispersion factor (s/m3)

BR = C31Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)

DCF = Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public (Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.1E+08 rem/Ci)

TABLE E-23 SOURCE TERM ANALYSIS FOR BEYOND DESIGN BASIS CH3 PUNCTURE AND DROP

CI (PE-Ci)	CD (punct.)	CD (drop)	MAR (PE-Ci)	DR	ARF	CF	CRF	NCF	Source Term (PE-Ci)	LPF Mit.w/HEPA	Mit. Q (PE-Ci)	Unmit.Q (PE-Ci)
Drums												
80	1		80	0.050	0.001	0.050	0.100	0.950	3.8E-03	1.0E-06	3.8E-09	3.8E-03
80	1		80	0.050	0.001	0.050	0.100	0.950	3.8E-03	1.0E-06	3.8E-09	3.8E-03
80		2	160	0.010	0.001	0.050	0.100	0.950	1.5E-03	1.0E-06	1.5E-09	1.5E-03
										Total	**9.2E-09**	**9.2E-03**

Q = MAR*DR*ARF*RF*LPF

Q=(CD*CI*DR*ARF*((CF*CRF)+NCF))*LPF

where:

Q = the source term (Ci)
Mit.Q = the mitigated source term (*with* HEPA filtration)
Unmit. Q = the unmitigated source term (*without* HEPA filtration)
CD (puncture) = # of containers damaged by puncture
CD (drop) =# of containers damaged by drop
CI = the waste container inventory
MAR =(CD puncture + CD drop) * CI
DR = Damage Ratio = The DR is that fraction of the MAR actually impacted by the accident condition.
ARF = Airborne Release Fraction=The fraction of radioactive material that is suspended in air.
CF = Combustible Fraction = Percentage of the MAR that is combusible.
CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range
NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.

TABLE E-24 ON-SITE AND OFF-SITE CONSEQUENCE ANALYSIS FOR BEYOND DESIGN BASIS CH3 PUNCTURE AND DROP									
	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (350 meters) X/Q (s/m3)	Site Boundary (2982 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area (350 meters) CEDE (rem)	Site Boundary (2982 meters) CEDE (rem)
Mitigated									
Drums	9.2E-09	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	8.0E-06	9.3E-07	6.3E-08
Unmitigated									
Drums	9.2E-03	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	8.0E+00	9.3E-01	6.3E-02

Committed Effective Dose Equivalent (CEDE) = D = Q * X/Q * BR * DCF (Ref. Eq. 5-5)

where:

Q = the source term (Ci)

X/Q = Site specific air dispersion factor (s/m3)

BR =Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)

DCF =Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public (Pu-239 Class W CEDE Inhalation '5.1E+02 rem/uCi or 5.10E+08 rem/Ci)

TABLE E-25 SOURCE TERM ANALYSIS FOR CH4 DROP OF WASTE CONTAINER FROM FORK LIFT IN THE WHB

CD (PE-Ci)	CI (dropped)	MAR (PE-Ci)	DR	ARF	CF	CRF	NCF	NCRF	Source Term (PE-Ci)	Mit. LPF w/HEPA	Mit. Q (PE-Ci)	Unmit. Q w/o HEPA (PE-Ci)
Drums												
80	1	80	0.010	0.001	0.050	0.100	0.950	1.000	7.6E-04	1.0E-06	7.6E-10	7.6E-04
8	3	24	0.010	0.001	0.050	0.100	0.950	1.000	2.3E-04	1.0E-06	2.3E-10	2.3E-04
										Total	**9.93E-10**	**9.9E-04**
SWBs												
130	1	130	0.001	0.001	0.050	0.100	0.950	1.000	1.2E-04	1.0E-06	1.2E-10	1.2E-04
32	1	32	0.001	0.001	0.050	0.100	0.950	1.000	3.1E-05	1.0E-06	3.1E-11	3.1E-05
										Total	**1.5E-10**	**1.5E-04**

Q = MAR*DR*ARF*RF*LPF

Q=(CD*CI*DR*ARF((CF*CRF)+(NCF*NCRF))*LPF

where:

Q = the source term (Ci)

Mit.Q = the mitigated source term (*with* HEPA filtration)

Unmit. Q = the unmitigated source term (*without* HEPA filtration)

CD (drop) =# of containers damaged by drop

CI = the waste container inventory

MAR =(CD puncture + CD drop) * CI

DR = Damage Ratio = The DR is that fraction of the MAR actually impacted by the accident condition.

ARF = Airborne Release Fraction-The fraction of radioactive material that is suspended in air.

CF = Combustible Fraction = Percentage of the MAR that is combustible.

CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range

NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.

NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.

LPF =Leakpath Factor = the cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident (i.e.,HEPA filtration; plateout)

TABLE E-26 ON-SITE AND OFF-SITE CONSEQUENCE ANALYSIS FOR CH4 DROP OF WASTE CONTAINER IN WHB

	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (350 meters) X/Q (s/m3)	Site Boundary (2982 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area (350 meters) CEDE (rem)	Site Boundary CEDE (rem)
Mitigated									
Drums	9.9E-10	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	8.6E-07	1.0E-07	6.8E-09
SWBS	1.5E-10	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	1.3E-07	1.6E-08	1.1E-09
Unmitigated									
Drums	9.9E-04	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	8.6E-01	1.0E-01	6.8E-03
SWBS	1.5E-04	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	1.3E-01	1.6E-02	1.1E-03

Committed Effective Dose Equivalent (CEDE) = D = Q * X/Q * BR * DCF

where:

Q = the source term (Ci)

X/Q = Site specific air dispersion factor (s/m3)

BR =Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)

DCF = Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public
(Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.1E+08 rem/Ci)

TABLE E-27 SOURCE TERM ANALYSIS FOR CH4 DROP IN THE WHB w/1100 PE-Ci DRUM OVERPACKED IN SWB														
	CI (PE-Ci)	CD (damaged)	MAR (PE-Ci)	DR	ARF	CF	CRF	NCF	NCRF	Source Term (PE-Ci)	Mit. LPF w/HEPA	Unmit. LPF w/o HEPA	Mit. Q w/HEPA (PE-Ci)	Unmit. Q w/o HEPA (PE-Ci)
Drum	1100	1	1100.0	1.00E-05	0.001	0.050	0.100	0.950	1	1.1E-05	1.0E-06	1.0E+00	1.1E-11	1.1E-05

Q = MAR*DR*ARF*RF*LPF

Q=CD*CI*DR*ARF*((CF*CRF)+(NCF*NCRF))*LPF

where:

Q = the source term (Ci)

Mit.Q = the mitigated source term (*with* HEPA filtration)

Unmit. Q = the unmitigated source term (*without* HEPA filtration)

CD = # of containers damaged by drop or puncture

CI = the waste container inventory

MAR =(CD puncture + CD drop) * CI

DR = Damage Ratio = The DR is that fraction of the MAR actually impacted by the accident condition.

ARF = Airborne Release Fraction-The fraction of radioactive material that is suspended in air.

CF = Combustible Fraction = Percentage of MAR that is combustible.

CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range

NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.

NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.

LPF =Leakpath Factor = the cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident (i.e.,HEPA filtrations; plateout)

TABLE E-28 CONSEQUENCE ANALYSIS FOR CH4 DROP IN THE WHB w/1100 PE-Ci DRUM OVERPACKED IN SWB

	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (350 meters) X/Q (s/m3)	Site Boundary (2982 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area (350 meters) CEDE (rem)	Site Boundary CEDE (rem)
Mitigated									
Drums	1.1E-11	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	9.1E-09	1.1E-09	7.2E-11
Unmitigated									
Drums	1.1E-05	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	9.1E-03	1.1E-03	7.2E-05

Committed Effective Dose Equivalent (CEDE) = D = Q*X/Q*BR*DCF (Ref. Eq. 5-5)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = the source term (Ci)
X/Q = Site specific air dispersion factor (s/m3)
BR = C31Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)
DCF = Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public
(Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.1E+08 rem/Ci)

TABLE E-29 SOURCE TERM ANALYSIS FOR BEYOND DESIGN BASIS CH4 DROP IN THE WHB

	CI (PE-Ci)	CD (damaged)	MAR (PE-Ci)	DR	ARF	CF	CRF	NCF	NCRF	Q (PE-Ci)	Mit. LPF w/HEPA	Unmit. LPF w/o HEPA	Mit. Q w/HEPA (PE-Ci)	Unmit. Q w/o HEPA (PE-Ci)
Drum	80	4	320.0	1.00E-02	0.001	0.050	0.100	0.950	1	3.1E-03	1.0E-06	1.0E+00	3.1E-09	3.1E-03

Q = MAR*DR*ARF*RF*LPF

Q=CD*CI*DR*ARF*((CF*CRF)+(NCF*NCRF))*LPF

where:

Q = the source term (Ci)

Mit.Q = the mitigated source term (*with* HEPA filtration)

Unmit. Q = the unmitigated source term (*without* HEPA filtration)

CD = # of containers damaged by drop or puncture

CI = the waste container inventory

MAR =(CD puncture + CD drop) * CI

DR = Damage Ratio = The DR is that fraction of the MAR actually impacted by the accident condition.

ARF = Airborne Release Fraction-The fraction of radioactive material that is suspended in air.

CF = Combustible Fraction = Percentage of MAR that is combustible.

CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range

NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.

NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.

LPF =Leakpath Factor = the cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident (i.e.,HEPA filtration; plateout)

TABLE E-30 CONSEQUENCE ANALYSIS FOR BEYOND DESIGN BASIS CH4 DROP IN THE WHB									
	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (350 meters) X/Q (s/m3)	Site Boundary (2982 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area (350 meters) CEDE (rem)	Site Boundary CEDE (rem)
Mitigated									
Drums	3.1E-09	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	2.7E-06	3.1E-07	2.1E-08
Unmitigated									
Drums	3.1E-03	5.11E-03	5.96E-04	4.05E-05	3.33E-04	5.1E+08	2.7E+00	3.1E-01	2.1E-02

Committed Effective Dose Equivalent (CEDE) = D = Q*X/Q*BR*DCF (Ref. Eq. 5-5)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = the source term (Ci)
X/Q = Site specific air dispersion factor (s/m3)
BR = C31Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)
DCF = Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public
(Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.1E+08 rem/Ci)

TABLE E-31 SOURCE TERM ANALYSIS FOR CH5 WASTE HOIST DROP

Q (PE-Ci)	CD (dropped)	MAR (PE-Ci)	DR	ARF	CF	CRF	NCF	MR (PE-Ci)	Mit. LPF w/HEPA	Mit. Q (PE-Ci)	Unmit. Q (PE-Ci)
Drums											
80	1	80	0.250	0.001	0.050	0.100	0.950	1.9E-02	1.0E-06	1.9E-08	1.9E-02
8	27	216	0.250	0.001	0.050	0.100	0.950	5.2E-02	1.0E-06	5.2E-08	5.2E-02
									Total	7.1E-08	**7.1E-02**
SWBs											
130	1	130	0.250	0.001	0.050	0.100	0.950	3.1E-02	1.0E-06	3.1E-08	3.1E-02
32	3	96	0.250	0.001	0.050	0.100	0.950	2.3E-02	1.0E-06	2.3E-08	2.3E-02
									Total	**5.4E-08**	**5.4E-02**

Q = MAR*DR*ARF*RF*LPF

Q=(CD*CI*DR*ARF*((CF*CRF)+NCF))*LPF

where:

Q = the source term (Ci)

Mit.Q = the mitigated source term (*with* HEPA filtration)

Unmit. Q = the unmitigated source term (*without* HEPA filtration)

CD (drop) =# of containers damaged by drop

CI = the waste container inventory

MAR = CD * CI

DR = Damage Ratio = The DR is that fraction of the MAR actually impacted by the accident condition.

ARF = Airborne Release Fraction=The fraction of radioactive material that is suspended in air.

CF = Combustible Fraction = Percentage of the MAR that is combustible.

CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range

NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.

NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.

LPF = Leakpath Factor = the cumulative fraction of airborne material that escapes to the atmosphere (i.e.,HEPA filtration; plateout)

TABLE E-32 ON-SITE AND OFF-SITE CONSEQUENCE ANALYSIS FOR CH5 WASTE HOIST DROP

	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (285 meters) X/Q (s/m3)	Site Boundary (3029 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area (285 meters) CEDE (rem)	Site Boundary (3029 meters) CEDE (rem)
Mitigated									
Drums	7.1E-08	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	6.1E-05	1.0E-05	4.8E-07
SWBS	5.4E-02	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	4.7E+01	7.7E+00	3.7E-01
Unmitigated									
Drums	7.1E-02	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	6.1E+01	1.0E+01	4.8E-01
SWBS	5.4E-02	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	4.7E+01	7.7E+00	3.7E-01

Committed Effective Dose Equivalent (CEDE) = D = Q * X/Q * BR * DCF (Ref. Eq. 5-5)

where:

Q = the source term (Ci)

X/Q = Site specific air dispersion factor (s/m3)

BR = Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)

DCF = Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public (Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.1E+08 rem/Ci)

TABLE E-33 CHEMICAL SOURCE TERM/CONSEQUENCE ANALYSIS FOR CH5 WASTE HOIST DROP

Compound	MAR (mg/drum)	CD (drums)	Q (drums) (mg)	RR (1/1 sec)	On-site (100 meters) X/Q(s/m3)	Exclusive Use Area (285 meters) X/Q (s/m3)	Site Boundary (3029 meters) X/Q (s/m3)	On-site (100 meters) C (mg/m3)	Exclusive Use Area (285 meters) C (mg/m3)	Site Boundary (3029 meters) C (mg/m3)	Limiting On-site Criteria (mg/m3)	Limiting Off-site Criteria (mg/m3)	Ratio (conc/limit) (100 meters)	Ratio (conc/limit) (285 meters)	Ratio (conc/limit) (3029 meters)
Drums															
methylene chloride	205.2	28.0	5746.4	1.0	5.11E-03	8.43E-04	4.05E-05	2.94E+01	4.84E+00	2.33E-01	2.10E+04	8.70E+02	0.140%	0.557%	0.027%
chloroform	19.8	28.0	554.4	1.0	5.11E-03	8.43E-04	4.05E-05	2.83E+00	4.67E-01	2.25E-02	5.00E+03	5.00E+01	0.057%	0.935%	0.045%
carbon tetrachloride	379.0	28.0	10612.0	1.0	5.11E-03	8.43E-04	4.05E-05	5.42E+01	8.95E+00	0.4298	1.92E+03	6.30E+01	2.829%	14.200%	0.682%
1,1,2,2-Tetrachloroethane	10.4	28.0	291.2	1.0	5.11E-03	8.43E-04	4.05E-05	1.49E+00	2.45E-01	1.18E-02	1.51E+03	3.50E+01	0.099%	0.701%	0.034%
SWBs															
methylene chloride	820.9	4.0	3283.6	1.0	5.11E-03	8.43E-04	4.05E-05	1.68E+01	1.11E+01	5.32E-01	2.10E+04	8.70E+02	0.080%	1.273%	0.061%
chloroform	79.3	4.0	317.2	1.0	5.11E-03	8.43E-04	4.05E-05	6.48E+00	1.07E+00	5.14E-02	5.00E+03	5.00E+01	0.130%	2.139%	0.103%
carbon tetrachloride	1515.4	4.0	6061.6	1.0	5.11E-03	8.43E-04	4.05E-05	1.24E+02	2.04E+01	9.82E-01	1.92E+03	6.30E+01	6.463%	32.444%	1.559%
1,1,2,2-Tetrachloroethane	41.4	4.0	165.6	1.0	5.11E-03	8.43E-04	4.05E-05	3.38E+00	5.58E-01	2.68E-02	1.51E+03	3.50E+01	0.225%	1.595%	0.077%

CONCENTRATION (C)=(MAR*X/Q)/RR (Ref. Eq. 5-6)

where:

MAR = Material At Risk- the amount of material present that may be acted upon with the potentially dispersive energy source
RR = release rate- the RR is the amount of material suspended in air as a function of time.
X/Q = Site specific air dispersion factor (s/m3)

TABLE E-34 SOURCE TERM ANALYSIS FOR CH7 INTERNAL DRUM FIRE IN THE UNDERGROUND

CI (PE-Ci)	CD (drums)	MAR (PE-Ci)	CF	CRF	CARF	NCF	NCARF	NCRF	Q (PE-Ci)	Mit. LPF w/HEPA	Unmit. LPF w/o HEPA	Mit. Q w/HEPA (PE-Ci)	Unmit. Q w/o HEPA (PE-Ci)
80	1	80	0.95	1.00	0.0005	0.050	0.006	0.010	3.82E-02	1.0E-06	1.0E+00	3.8E-08	3.8E-02

Q = MAR*DR*ARF*RF*LPF

Q=(CD*CI*DR*((CF*CRF*CARF)+(NCF*NCRF*NCARF)))*LPF (Ref. Eq. 5-1)

where:

Q = the source term (Ci)
Mit.Q = the mitigated source term (*with* HEPA filtration)
Unmit. Q = the unmitigated source term (*without* HEPA filtration)
CD = # of containers involved
CI = the waste container inventory (PE-Ci)
MAR = Material at Risk = CD * CI
DR = Damage Ratio = The DR is that fraction of the MAR actually impacted by the accident condition.
CF = Combustible Fraction = Fraction of the waste that is combustible=1 for this analysis.
CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range
CARF = Combustible airborne release fraction
NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.
NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.
NCARF =Noncombustible Airborne Release Fraction = The percentage of noncombustible material that is suspended in air.
LPF = Leakpath Factor = The cumulative fraction of airborne material that escapes to the atmosphere (i.e.,HEPA filtration; plateout)

TABLE E-35 ON-SITE AND OFF-SITE CONSEQUENCE ANALYSIS FOR CH7 DRUM FIRE IN THE UNDERGROUND

	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (285 meters) X/Q (s/m3)	Site Boundary (3029 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area (285 meters) CEDE (rem)	Site Boundary CEDE (rem)
Mitigated									
Drum	3.8E-08	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	3.3E-05	5.5E-06	2.6E-07
Unmitigated									
Drum	3.8E-02	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	3.3E+01	5.5E+00	2.6E-01

Committed Effective Dose Equivalent (CEDE) = D = Q*X/Q*BR*DCF (Ref. Eq. 5-5)

where:

CEDE = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)

Q = the source term (Ci)

X/Q = Site specific air dispersion factor (s/m3)

BR = C31Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)

DCF = Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public
(Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.1E+08 rem/Ci)

TABLE E-36 CHEMICAL SOURCE TERM/CONSEQUENCE ANALYSIS FOR CH7 DRUM FIRE/SPONTANEOUS IGNITION IN THE WHB

Compound	WF	CI (mg) 243 (lbs drum)	CD	MAR	CF	NCF	CARF	NCARF	C RF	NC RF	Combustible Source Term (Q)	Noncombust Source Term (Q)	Total (Q) (mg)
Chemical (Solids)													
Asbestos	2.74E-03	3.02E+05	1	3.02E+05	0.95	0.05	5.00E-04	6.00E-03	1.00E+00	1.00E-02	1.43E+02	9.06E-01	1.44E+02
Beryllium	2.10E-04	2.31E+04	1	2.31E+04	0.95	0.05	5.00E-04	6.00E-03	1.00E+00	1.00E-02	1.10E+01	6.94E-02	1.11E+01
Cadmium	3.00E-06	3.31E+02	1	3.31E+02	0.95	0.05	5.00E-04	6.00E-03	1.00E+00	1.00E-02	1.57E-01	9.92E-04	1.58E-01
Lead	8.26E-03	9.10E+05	1	9.10E+05	0.95	0.05	5.00E-04	6.00E-03	1.00E+00	1.00E-02	4.32E+02	2.73E+00	4.35E+02
Chemical (Liquids)													
Butyl Alcohol	3.00E-03	3.31E+05	1	3.31E+05	0.95	0.05	5.00E-04	6.00E-03	1.00E+00	1.00E-02	1.57E+02	9.92E-01	1.58E+02
Carbon Tetrachloride	6.27E-03	6.91E+05	1	6.91E+05	0.95	0.05	5.00E-04	6.00E-03	1.00E+00	1.00E-02	3.28E+02	2.07E+00	3.30E+02
Mercury	3.54E-03	3.90E+05	1	3.90E+05	0.95	0.05	5.00E-04	6.00E-03	1.00E+00	1.00E-02	1.85E+02	1.17E+00	1.87E+02
Methyl Alcohol	8.00E-06	8.82E+02	1	8.82E+02	0.95	0.05	5.00E-04	6.00E-03	1.00E+00	1.00E-02	4.19E-01	2.65E-03	4.21E-01
Methylene Chloride	4.00E-04	4.41E+04	1	4.41E+04	0.95	0.05	5.00E-04	6.00E-03	1.00E+00	1.00E-02	2.09E+01	1.32E-01	2.11E+01
Nitric Acid	1.90E-03	2.09E+05	1	2.09E+05	0.95	0.05	5.00E-04	6.00E-03	1.00E+00	1.00E-02	9.95E+01	6.28E-01	1.00E+02
Polychlorinated Biphenyl	8.54E-03	9.41E+05	1	9.41E+05	0.95	0.05	5.00E-04	6.00E-03	1.00E+00	1.00E-02	4.47E+02	2.82E+00	4.50E+02
Trichloroethylene	3.92E-03	4.32E+05	1	4.32E+05	0.95	0.05	5.00E-04	6.00E-03	1.00E+00	1.00E-02	2.05E+02	1.30E+00	2.07E+02

where:

Weight Fraction = Fraction of compound anticipated in a drum (INEL)

243 lb drum = Weight of the average drum anticipated (INEL)

Q = the source term (Ci)

MAR = Material At Risk is the maximum amount and type of material present that may be acted upon with the potentially dispersive energy source

DR '= Damage Ratio = 1 = The DR is that fraction of the MAR actually impacted by the accident condition.

ARF =Airborne Release Fraction is the fraction of radioactive material that is suspended in air.

RF =Respirable Fraction-fraction less than 10um in aerodynamic equivalent diameter.

LPF =Leakpath Factor is the cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident. (i.e. HEPA Filtration, Plateout)

TABLE E-37 CHEMICAL SOURCE TERM/CONSEQUENCE ANALYSIS FOR CH 7 DRUM FIRE IN THE UNDERGROUND

Compound	Q (mg)	RR (sec.)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (285 meters) X/Q (s/m3)	Site Boundary (3029 meters) X/Q (s/m3)	Concentration @ Off Limits Area Boundary	On-site (100 m) (mg/m3) or (f/cc)	Exclusive Use Area (285 meters) (mg/m3) or (f/cc)	Concentration Site Boundary	Site Boundary (3029 meters) (mg/m3) or (f/cc)	Most Restricted Criteria for Extremely Unlikely Case	Most Restrictive Criteria for Extremely Unlikely Case(mg/m3)	TOX-2 Criteria	Ratio (Conc./Limit) @ On-site (100 m) (mg/m3)	Ratio (Conc./Limit) @ Exclusive Use Area Boundary (mg/m3)	Ratio (Conc./Limit) @ Site Boundary (mg/m3)
Chemical (Solids)																
Asbestos (f/cc)	1.44E+02	900	5.11E-03	8.43E-04	3.99E-05	1.04E-03	6.31E-03	1.04E-03	4.92E-05	4.92E-05	0.2	*0.2*	1	3.15E-02	5.20E-03	2.46E-04
Beryllium	1.11E+01	900	5.11E-03	8.43E-04	3.99E-05	1.04E-05	6.28E-05	1.04E-05	4.91E-07	4.91E-07	0.002	0.002	0.01	3.14E-02	5.18E-03	2.45E-04
Cadmium	1.58E-01	900	5.11E-03	8.43E-04	3.99E-05	1.48E-07	8.97E-07	1.48E-07	7.01E-09	7.01E-09	0.002	0.002	0.01	4.49E-04	7.40E-05	3.50E-06
Lead	4.35E+02	900	5.11E-03	8.43E-04	3.99E-05	4.08E-04	2.47E-03	4.08E-04	1.93E-05	1.93E-05	0.15	0.15	0.75	1.65E-02	2.72E-03	1.29E-04
Chemical (Liquids)																
Butyl Alcohol	1.58E+02	900	5.11E-03	8.43E-04	3.99E-05	1.48E-04	8.97E-04	1.48E-04	7.01E-06	7.01E-06	150	150	150	5.98E-06	9.87E-07	4.67E-08
Carbon Tetrachloride	3.30E+02	900	5.11E-03	8.43E-04	3.99E-05	3.09E-04	1.88E-03	3.09E-04	1.46E-05	1.46E-05	31	31	155	6.05E-05	9.98E-06	4.72E-07
Mercury	1.87E+02	900	5.11E-03	8.43E-04	3.99E-05	1.75E-04	1.06E-03	1.75E-04	8.27E-06	8.27E-06	0.1	0.1	0.1	1.06E-02	1.75E-03	8.27E-05
Methyl Alcohol	4.21E-01	900	5.11E-03	8.43E-04	3.99E-05	3.95E-07	2.39E-06	3.95E-07	1.87E-08	1.87E-08	266	266	266	9.00E-09	1.48E-09	7.02E-11
Methylene Chloride	2.11E+01	900	5.11E-03	8.43E-04	3.99E-05	1.97E-05	1.20E-04	1.97E-05	9.34E-07	9.34E-07	174	174	870	6.88E-07	1.13E-07	5.37E-09
Polychorinated Biphenyl	4.50E+02	900	5.11E-03	8.43E-04	3.99E-05	4.21E-04	2.55E-03	4.21E-04	1.99E-05	1.99E-05	0.5	0.5	2.5	5.11E-03	8.43E-04	3.99E-05
Trichloroethylene	2.07E+02	900	5.11E-03	8.43E-04	3.99E-05	1.93E-04	1.17E-03	1.93E-04	9.16E-06	9.16E-06	1092	1092	1092	1.07E-06	1.77E-07	8.38E-09

a. fibers/cc = (asbestos concentration mg/m3)(1 fiber/1.3E-7mg)(1 m3/1E6 cc)

$$C = (Q*X/Q)/RR$$

where:

C = Concentration (mg/m3)

Q = Source Term (mg)

RR = Release Rate- the RR is the amount of material suspended in air as a function of time (Assumed 900 sec, 15 min.)

X/Q =Dispersion Coefficient (mg)

TABLE E-38 SOURCE TERM ANALYSIS FOR CH9 DROP OF WASTE CONTAINERS IN THE UNDERGROUND

CI (PE-Ci)	CD (containers)	MAR (PE-Ci)	DR	ARF	CF	CRF	NCF	MR (PE-Ci)	Mit. LPF w/HEPA	Mit. Q w/HEPA (PE-Ci)	Unmit. Q w/o HEPA (PE-Ci)
Drums											
80	1	80	0.025	0.001	0.050	0.100	0.950	1.9E-03	1.0E-06	1.9E-09	1.9E-03
8	6	48	0.025	0.001	0.050	0.100	0.950	1.1E-03	1.0E-06	1.1E-09	1.1E-03
									Total	**3.1E-09**	**3.1E-03**
SWBs											
130	1	130	0.010	0.001	0.050	0.100	0.950	1.2E-03	1.0E-06	1.2E-09	1.2E-03
									Total	**1.2E-09**	**1.2E-03**

Q = MAR*DR*ARF*RF*LPF

Q = (CI*CD)*DR*ARF*((CF*CRF) + (NCF*NCRF)*LPF

where:

Mit.Q = the mitigated source term (*with* HEPA filtration)
Unmit. Q = the unmitigated source term (*without* HEPA filtration)
CD = # of containers involved
CI = the waste container inventory (PE-Ci)
MAR = Material at Risk = CD * CI
DR = Damage Ratio = The DR is that fraction of the MAR actually impacted by the accident condition.
ARF = Airborne Release Fraction-The fraction of radioactive material that is suspended in air.
CF = Combustible Fraction = Fraction of the waste that is combustible=1 for this analysis.
CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range
NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.
NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.
Mit.LPF = Leakpath Factor = The cumulative fraction of airborne material that escapes to the atmosphere (i.e.,HEPA filtration; plateout)
Unmit. LPF = Unmitigated Leakpath Factor =(1 for this scenario and, therefore, not represented in the table)=The cumulative fraction of airborne material that that escapes to the atmosphere.

TABLE E-39 ON-SITE AND OFF-SITE CONSEQUENCE ANALYSIS FOR CH9 DROP OF WASTE CONTAINERS IN THE UNDERGROUND									
	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (285 meters) X/Q (s/m3)	Site Boundary (3029 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area (285 meters) CEDE (rem)	Site Boundary CEDE (rem)
Mitigated									
Drums	3.1E-09	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	2.7E-06	4.4E-07	2.1E-08
SWBS	1.2E-09	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	1.1E-06	1.8E-07	8.4E-09
Unmitigated									
Drums	3.1E-03	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	2.7E+00	4.4E-01	2.1E-02
SWBS	1.2E-03	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	1.1E+00	1.8E-01	8.4E-03

Committed Effective Dose Equivalent (CEDE) = D = Q*X/Q*BR*DCF

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = the source term (Ci)
X/Q = Site specific air dispersion factor (s/m3)
BR = C31Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)
DCF = Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public
(Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.10E+08 rem/Ci)

TABLE E-40 CHEMICAL SOURCE TERM/CONSEQUENCE ANALYSIS FOR CH9 DROP OF WASTE CONTAINERS FROM FORKLIFT IN THE UNDERGROUND

Compound	MAR (mg/drum)	CD (drums)	Q (drums) (mg)	RR (1/1 sec)	On-site (100 meters) X/Q(s/m3)	Exclusive Use Area (285 meters) X/Q (s/m3)	Site Boundary (3029 meters) X/Q (s/m3)	On-site (100 meters) C (mg/m3)	Exclusive Use Area (285 meters) C (mg/m3)	Site Boundary (3029 meters) C (mg/m3)	Limiting On-site Criteria (mg/m3)	Limiting Off-site Criteria (mg/m3)	Ratio (conc/limit) (100 meters)	Ratio (conc/limit) (285 meters)	Ratio (conc/limit) (3029 meters)
Drums															
methylene chloride*	205.23	7	1436.61	1	5.11E-03	8.43E-04	3.99E-05	7.34E+00	1.21E+00	5.7E-02	21000.0	870.0	0.03%	0.14%	0.007%
chloroform	19.80	7	138.6	1	5.11E-03	8.43E-04	3.99E-05	7.08E-01	1.17E-01	5.5E-03	5000.0	50.0	0.01%	0.23%	0.011%
carbon tetrachloride*	379.00	7	2653	1	5.11E-03	8.43E-04	3.99E-05	1.36E+01	2.24E+00	1.1E-01	1917.0	63.0	0.71%	3.55%	0.168%
1,1,2,2-Tetrachloroethane	10.40	7	72.8	1	5.11E-03	8.43E-04	3.99E-05	3.72E-01	6.14E-02	2.9E-03	1505.0	35.0	0.02%	0.18%	0.008%
SWBs															
methylene chloride*	820.90	1	820.90	1	5.11E-03	8.43E-04	3.99E-05	4.19E+00	6.9E-01	3.3E-02	21000.0	870.0	0.02%	0.08%	0.004%
chloroform	79.30	1	79.30	1	5.11E-03	8.43E-04	3.99E-05	4.05E-01	6.7E-02	3.2E-03	5000.0	50.0	0.01%	0.13%	0.006%
carbon tetrachloride*	1515.40	1	1515.40	1	5.11E-03	8.43E-04	3.99E-05	7.74E+00	1.3E+00	6.0E-02	1917.0	63.0	0.40%	2.03%	0.096%
1,1,2,2-Tetrachloroethane	41.40	1	41.40	1	5.11E-03	8.43E-04	3.99E-05	2.12E-01	3.5E-02	1.7E-03	1505.0	35.0	0.01%	0.10%	0.005%

C = (Q*X/Q)/RR

where:

C = Concentration (mg/m3)

Q = Source Term (mg)

RR = Release Rate=The RR is the amount of material suspended in air as a function of time = 1/1 sec.G24:G25

X/Q = Dispersion Coefficient (mg)

TABLE E-41 SOURCE TERM ANALYSIS FOR CH9 DROP IN THE U/G w/1100 PE-Ci DRUM OVERPACKED IN SWB														
	CI (PE-Ci)	CD (damaged)	MAR (PE-Ci)	DR	ARF	CF	CRF	NCF	NCRF	Source Term (PE-Ci)	Mit. LPF w/HEPA	Unmit. LPF w/o HEPA	Mit. Q w/HEPA (PE-Ci)	Unmit. Q w/o HEPA (PE-Ci)
Drum	1100	1	1100.0	2.50E-04	0.001	0.050	0.100	0.950	1	2.6E-04	1.0E-06	1.0E+00	2.6E-10	2.6E-04

Q = MAR*DR*ARF*RF*LPF

Q=CD*CI*DR*ARF*((CF*CRF)+(NCF*NCRF))*LPF

where:

Q = the source term (Ci)

Mit.Q = the mitigated source term (*with* HEPA filtration)

Unmit. Q = the unmitigated source term (*without* HEPA filtration)

CD = # of containers damaged by drop or puncture

CI = the waste container inventory

MAR =(CD puncture + CD drop) * CI

DR = Damage Ratio = The DR is that fraction of the MAR actually impacted by the accident condition.

ARF = Airborne Release Fraction-The fraction of radioactive material that is suspended in air.

CF = Combustible Fraction = Percentage of MAR that is combustible.

CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range

NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.

NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.

LPF =Leakpath Factor = the cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident (i.e.,HEPA filtration; plateout)

TABLE E-42 CONSEQUENCE ANALYSIS FOR CH9 DROP IN THE U/G w/1100 PE-Ci DRUM OVERPACKED IN SWB

	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (285 meters) X/Q (s/m3)	Site Boundary (3029 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area (285 meters) CEDE (rem)	Site Boundary CEDE (rem)
Mitigated									
Drums	2.6E-10	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	2.3E-07	3.8E-08	1.8E-09
Unmitigated									
Drums	2.6E-04	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	2.3E-01	3.8E-02	1.8E-03

Committed Effective Dose Equivalent (CEDE) = D = Q*X/Q*BR*DCF (Ref. Eq. 5-5)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)

Q = the source term (Ci)

X/Q = Site specific air dispersion factor (s/m3)

BR = C31Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)

DCF = Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public (Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.1E+08 rem/Ci)

TABLE E-43 SOURCE TERM ANALYSIS FOR BEYOND DESIGN BASIS CH9 DROP IN THE U/G

	CI (PE-Ci)	CD (damaged)	MAR (PE-Ci)	DR	ARF	CF	CRF	NCF	NCRF	Q (PE-Ci)	Mit. LPF w/HEPA	Unmit. LPF w/o HEPA	Mit. Q w/HEPA (PE-Ci)	Unmit. Q w/o HEPA (PE-Ci)
Drum	80	7	560.0	2.50E-02	0.001	0.050	0.100	0.950	1	1.3E-02	1.0E-06	1.0E+00	1.3E-08	1.3E-02

Q = MAR*DR*ARF*RF*LPF

Q=CD*CI*DR*ARF*((CF*CRF)+(NCF*NCRF))*LPF

where:

Q = the source term (Ci)
Mit.Q = the mitigated source term (*with* HEPA filtration)
Unmit. Q = the unmitigated source term (*without* HEPA filtration)
CD = # of containers damaged by drop or puncture
CI = the waste container inventory
MAR =(CD puncture + CD drop) * CI
DR = Damage Ratio = The DR is that fraction of the MAR actually impacted by the accident condition.
ARF = Airborne Release Fraction-The fraction of radioactive material that is suspended in air.
CF = Combustible Fraction = Percentage of MAR that is combustible.
CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range
NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.
NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.
LPF =Leakpath Factor = the cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident (i.e.,HEPA filtration; plateout)

TABLE E-44 CONSEQUENCE ANALYSIS FOR BEYOND DESIGN BASIS CH9 DROP IN THE U/G

	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (285 meters) X/Q (s/m3)	Site Boundary (3029 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area (285 meters) CEDE (rem)	Site Boundary CEDE (rem)
Mitigated									
Drums	1.3E-08	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	1.2E-05	1.9E-06	9.1E-08
Unmitigated									
Drums	1.3E-02	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	1.2E+01	1.9E+00	9.1E-02

Committed Effective Dose Equivalent (CEDE) = D = Q*X/Q*BR*DCF (Ref. Eq. 5-5)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)

Q = the source term (Ci)

X/Q = Site specific air dispersion factor (s/m3)

BR = C31Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)

DCF = Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public
(Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.1E+08 rem/Ci)

TABLE E-45 SOURCE TERM ANALYSIS FOR CH11 ROOF FALL IN THE UNDERGROUND

CI (PE-Ci)	CD	MAR (PE-Ci)	DR	ARF	CF	CRF	NCF	NCRF	MR (PE-Ci)	Mit. LPF w/HEPA	Unmit. LPF w/o HEPA	Mit. Q w/HEPA (PE-Ci)	Unmit. Q w/o HEPA (PE-Ci)
Drums													
80	1	80	0.025	0.001	0.500	0.100	0.950	1	2.0E-03	1.0E-06	1	2.0E-09	2.0E-03
8	20	160	0.025	0.001	0.500	0.100	0.950	1	4.0E-03	1.0E-06	1	4.0E-09	4.0E-03
											Total	**6.0E-09**	**6.0E-03**
SWBs													
130	1	130	0.010	0.001	0.500	0.100	0.950	1	1.3E-03	1.0E-06	1	1.3E-09	1.3E-03
32	4	128	0.010	0.001	0.500	0.100	0.950	1	1.3E-03	1.0E-06	1	1.3E-09	1.3E-03
											Total	**2.6E-09**	**2.6E-03**

Q = MAR*DR*ARF*RF*LPF

Q = (CI*CD)*DR*ARF*((CF*CRF) + (NCF*NCRF))*LPF

where:

Mit.Q = the mitigated source term (*with* HEPA filtration)
Unmit. Q = the unmitigated source term (*without* HEPA filtration)
CD = # of containers involved
CI = the waste container inventory (PE-Ci less than 10um in aerodynamic equivalent diameter.
MAR = Material at Risk = CD * CI
DR = Damage Ratio = The DR is that fraction of the MAR actually impacted by the accident condition.
ARF = Airborne Release Fraction-The fraction of radioactive material that is suspended in air.
CF = Combustible Fraction = Fraction of the waste that is combustible=1 for this analysis.
CRF = Combustible Respirable Fraction = The percentage of combustible material that is in the respirable size range
NCF = Noncombustible Fraction = Percentage of the MAR that is noncombustible.
NCRF = Noncombustible Respirable Fraction = The percentage of noncombustible material that is in the respirable size range.
Mit.LPF = Leakpath Factor = The cumulative fraction of airborne material that escapes to the atmosphere (i.e.,HEPA filtration; plateout)
Unmit. LPF =Leakpath Factor = the cumulative fraction of airborne material that escapes to the atmosphere from the postulated accident (i.e.,HEPA filtration; plateout)

TABLE E-46 ON-SITE AND OFF-SITE CONSEQUENCE ANALYSIS FOR CH11 ROOF FALL IN THE UNDERGROUND

	Q (PE-Ci)	On-Site (100 meters) X/Q (s/m3)	Exclusive Use Area (285 meters) X/Q (s/m3)	Site Boundary (3029 meters) X/Q (s/m3)	BR (m3/s)	DCF (rem/Ci)	On-Site (100 meters) CEDE (rem)	Exclusive Use Area (285 meters) CEDE (rem)	Site Boundary CEDE (rem)
Mitigated									
Drums	6.0E-09	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	5.2E-06	8.6E-07	4.1E-08
SWBS	2.6E-09	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	2.2E-06	3.7E-07	1.7E-08
Unmitigated									
Drums	6.0E-03	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	5.2E+00	8.6E-01	4.1E-02
SWBS	2.6E-03	5.11E-03	8.43E-04	3.99E-05	3.33E-04	5.1E+08	2.2E+00	3.7E-01	1.7E-02

Committed Effective Dose Equivalent (CEDE) = D = Q*X/Q*BR*DCF

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = the source term (Ci)
X/Q = Site specific air dispersion factor (s/m3)
BR = C31Breathing rate (standard man) (m3/s) International Commission on Radiological Protection (ICRP) No. 23 (Light activity 20.0 liters/min or 3.33 E-04 m3/s)
DCF = Dose Conversion Factor (rem/Ci) Internal Dose Conversion Factors for Calculation of Dose to the Public
(Pu-239 Class W CEDE Inhalation 5.1E+02 rem/uCi or 5.10E+08 rem/Ci)

TABLE E-47 CHEMICAL SOURCE TERM/CONSEQUENCE ANALYSIS FOR CH11 ROOF FALL IN THE UNDERGROUND

Compound	MAR (mg/drum)	CD (drums)	Q (drums) (mg)	RR (1/1 sec)	On-site (100 meters) X/Q(s/m3)	Exclusive Use Area (285 meters) X/Q (s/m3)	Site Boundary (3029 meters) X/Q (s/m3)	On-site (100 meters) C (mg/m3)	Exclusive Use Area (285 meters) C (mg/m3)	Site Boundary (3029 meters) C (mg/m3)	Limiting On-site Criteria (mg/m3)	Limiting Off-site Criteria (mg/m3)	Ratio (conc/limit) (100 meters)	Ratio (conc/limit) (285 meters)	Ratio (conc/limit) (3029 meters)
Drums															
methylene chl	205.23	21	4309.83	1	5.11E-03	8.43E-04	3.99E-05	2.20E+01	3.63E+00	1.7E-01	21000.0	870.0	0.10%	0.42%	0.020%
chloroform	19.80	21	415.8	1	5.11E-03	8.43E-04	3.99E-05	2.12E+00	3.51E-01	1.7E-02	5000.0	50.0	0.04%	0.70%	0.033%
carbon tetrach	379.00	21	7959	1	5.11E-03	8.43E-04	3.99E-05	4.07E+01	6.71E+00	3.2E-01	1917.0	63.0	2.12%	10.65%	0.504%
1,1,2,2-Tetra	10.40	21	218.4	1	5.11E-03	8.43E-04	3.99E-05	1.12E+00	1.84E-01	8.7E-03	1505.0	35.0	0.07%	0.53%	0.025%
SWBs															
methylene chl	820.90	5	4104.50	1	5.11E-03	8.43E-04	3.99E-05	2.10E+01	3.5E+00	1.6E-01	21000.0	870.0	0.10%	0.40%	0.019%
chloroform	79.30	5	396.50	1	5.11E-03	8.43E-04	3.99E-05	2.03E+00	3.3E-01	1.6E-02	5000.0	50.0	0.04%	0.67%	0.032%
carbon tetrach	1515.40	5	7577.00	1	5.11E-03	8.43E-04	3.99E-05	3.87E+01	6.4E+00	3.0E-01	1917.0	63.0	2.02%	10.14%	0.480%
1,1,2,2-Tetra	41.40	5	207.00	1	5.11E-03	8.43E-04	3.99E-05	1.06E+00	1.7E-01	8.3E-03	1505.0	35.0	0.07%	0.50%	0.024%

C = (Q*X/Q)/RR

where:

C = Concentration (mg/m3)

Q = Source Term (mg)

RR = Release Rate = The RR is the amount of material suspended in air as a function of time = 1/1 sec.G24:G25

X/Q = Dispersion Coefficient (mg)

TABLE E-48 EXPANDING CLOUD NUMERICAL ANALYSIS CALCULATIONS

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D	= Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q	= Radiological source term (Ci)
T	= Exposure time in seconds (depends on the scenario)
BR	= Breathing rate (standard man) (m^3/s)
DCF	= Dose conversion factor (rem/Ci)
V	= Volume of expanding cloud at time to reach receptor (m3) = 2/3 (Pi)(radius cubed)
r	= cloud radius at time t = (cloud speed)(time) + initial cloud radius
V	$=2/3\ (Pi)\ [(0.25\ m/s)(t) + (2m)]^3$ (SAR Section 5.2.1.2)

t (sec)	Radius (m)	Vol (m3)		[(BR)(DCF)(T)/V] (rem/ci)
12.00	5.00	261.67		6.49E+02
13.00	5.25	302.91		5.61E+02
14.00	5.50	348.28		4.88E+02
15.00	5.75	397.96		4.27E+02
16.00	6.00	452.16		3.76E+02
17.00	6.25	511.07		3.32E+02
18.00	6.50	574.88		2.95E+02
19.00	6.75	643.80		2.64E+02
20.00	7.00	718.01		2.37E+02
21.00	7.25	797.72		2.13E+02
			Total	3.84E+03

TABLE E-49 IMMEDIATE WORKER CONSEQUENCE ANALYSIS FOR CH1 SPONTANEOUS IGNITION IN			
	Q (PE-Ci)	[(BR)(DCF)(T)/V] (rem/ci) Table E-48 and SAR Section 5.2.1.2	CEDE (rem)
Waste Container			
Drums	4.2E-04	3.6E+03	1.5E+00

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological source term (Ci) * (10 Sec exposure / 900 sec release)
T = Exposure time in seconds (depends on the scenario)
BR = Breathing rate (standard man) (m3/s)
DCF = Dose conversion factor (rem/Ci)
V = Volume of expanding cloud at time to reach receptor (m3)

TABLE E-50 IMMEDIATE WORKER CONSEQUENCE ANALYSIS FOR CH2 CRANE DROP IN THE WHB			
	Q (PE-Ci)	[(BR)(DCF)(T)/V] (rem/ci) Table E-48 and SAR Section 5.2.1.2	CEDE (rem)
Waste Container			
Drums	3.1E-03	3.6E+03	1.1E+01
SWBs	1.2E-03	3.6E+03	4.5E+00

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological source term (Ci)
T = Exposure time in seconds (depends on the scenario)
BR = Breathing rate (standard man) (m3/s)
DCF = Dose conversion factor (rem/Ci)
V = Volume of expanding cloud at time to reach receptor (m3)

TABLE E-51 IMMEDIATE WORKER CONSEQUENCE ANALYSIS FOR CH3 PUNCTURE IN THE WHB			
	Q (PE-Ci)	[(BR)(DCF)(T)/V] (rem/ci) Table E-48 and SAR Section 5.2.1.2	CEDE (rem)
Waste Container			
Drums	4.4E-03	7.3E+03	3.2E+01
SWBs	1.5E-03	7.3E+03	1.1E+01

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological source term (Ci)
T = Exposure time in seconds (depends on the scenario)
BR = Breathing rate (standard man) (m3/s)
DCF = Dose conversion factor (rem/Ci)
V = Volume of expanding cloud at time to reach receptor (m3)

TABLE E-52 IMMEDIATE WORKER CONSEQUENCE ANALYSIS FOR CH4 DROP IN THE WHB			
	Q (PE-Ci)	[(BR)(DCF)(T)/V] (rem/ci) Table E-48 and SAR Section 5.2.1.2	CEDE (rem)
Waste Container			
Drums	9.9E-04	3.6E+03	3.6E+00
SWBs	1.5E-04	3.6E+03	5.6E-01

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological source term (Ci)
T = Exposure time in seconds (depends on the scenario)
BR = Breathing rate (standard man) (m3/s)
DCF = Dose conversion factor (rem/Ci)
V = Volume of expanding cloud at time to reach receptor (m3)

TABLE E-53 IMMEDIATE WORKER CONSEQUENCE ANALYSIS FOR CH5 WASTE HOIST DROP

	Q (PE-Ci)	V (m3)	T (sec)	BR (m3/s)	DCF (rem/Ci)	CEDE (rem)
Waste Container						
Drums	7.1E-02	2.40E+01	1.00E+00	3.33E-04	5.1E+08	5.0E+02

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological source term (Ci)
T = Exposure time in seconds (depends on the scenario)
BR = Breathing rate (standard man) (m3/s)
DCF = Dose conversion factor (rem/Ci)
V = Volume of expanding cloud at time to reach receptor (m3)

TABLE E-54 IMMEDIATE WORKER CONSEQUENCE ANALYSIS FOR CH7 SPONTANEOUS IGNITION IN THE U/G						
	Q (PE-Ci)	V (m3)	T (sec)	BR (m3/s)	DCF (rem/Ci)	CEDE (rem)
Waste Container						
Drums	4.2E-04	2.40E+01	1.00E+00	3.33E-04	5.1E+08	3.0E+00

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological source term (Ci) * (10 Sec exposure / 900 sec release)
T = Exposure time in seconds (depends on the scenario)
BR = Breathing rate (standard man) (m3/s)
DCF = Dose conversion factor (rem/Ci)
V = Volume of expanding cloud at time to reach receptor (m3)

TABLE E-55 IMMEDIATE WORKER CONSEQUENCE ANALYSIS FOR CH9 DROP IN THE U/G

	Q (PE-Ci)	V (m3)	T (sec)	BR (m3/s)	DCF (rem/Ci)	CEDE (rem)
Waste Container						
Drums	3.1E-03	2.40E+01	1.00E+00	3.33E-04	5.1E+08	2.2E+01
SWBs	1.2E-03	2.40E+01	1.00E+00	3.33E-04	5.1E+08	8.8E+00

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological source term (Ci)
T = Exposure time in seconds (depends on the scenario)
BR = Breathing rate (standard man) (m3/s)
DCF = Dose conversion factor (rem/Ci)
V = Volume of expanding cloud at time to reach receptor (m3)

TABLE E-56 IMMEDIATE WORKER CONSEQUENCE ANALYSIS FOR CH11 ROOF FALL IN THE U/G						
	Q (PE-Ci)	V (m3)	T (sec)	BR (m3/s)	DCF (rem/Ci)	CEDE (rem)
Waste Container						
SWBs	6.0E-03	2.40E+01	1.00E+00	3.33E-04	5.1E+08	4.2E+01

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological source term (Ci)
T = Exposure time in seconds (depends on the scenario)
BR = Breathing rate (standard man) (m3/s)
DCF = Dose conversion factor (rem/Ci)
V = Volume of expanding cloud at time to reach receptor (m3)

TABLE E-57 IMMEDIATE WORKER CONSEQUENCE ANALYSIS FOR CH2 CRANE DROP IN THE WHB W/1800 PE CI SOLIDIFIED DRUM

	Q (PE-Ci)	[(BR)(DCF)(T)/V] (rem/ci) Table E-48 and SAR Section 5.2.1.2	CEDE (rem)
Waste Container			
Drums	3.0E-04	3.6E+03	1.1E+00

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological source term (Ci)
T = Exposure time in seconds (depends on the scenario)
BR = Breathing rate (standard man) (m3/s)
DCF = Dose conversion factor (rem/Ci)
V = Volume of expanding cloud at time to reach receptor (m3)

TABLE E-58 IMMEDIATE WORKER CONSEQUENCE ANALYSIS FOR CH2 CRANE DROP IN THE WHB W/1100 PE CI OVERPACKED DRUM			
	Q (PE-Ci)	[(BR)(DCF)(T)/V] (rem/ci) Table E-48 and SAR Section 5.2.1.2	CEDE (rem)
Waste Container			
Drums	2.6E-04	3.6E+03	9.5E-01

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological source term (Ci)
T = Exposure time in seconds (depends on the scenario)
BR = Breathing rate (standard man) (m3/s)
DCF = Dose conversion factor (rem/Ci)
V = Volume of expanding cloud at time to reach receptor (m3)

TABLE E-59 IMMEDIATE WORKER CONSEQUENCE ANALYSIS FOR CH3 PUNCTURE IN THE WHB w/SOLIDIFIED 1800 PE-Ci DRUMS			
	Q (PE-Ci)	[(BR)(DCF)(T)/V] (rem/ci) Table E-48 and SAR Section 5.2.1.2	CEDE (rem)
Waste Container			
Drums	2.9E-04	7.3E+03	2.1E+00

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological source term (Ci)
T = Exposure time in seconds (depends on the scenario)
BR = Breathing rate (standard man) (m3/s)
DCF = Dose conversion factor (rem/Ci)
V = Volume of expanding cloud at time to reach receptor (m3)

TABLE E-60 IMMEDIATE WORKER CONSEQUENCE ANALYSIS FOR CH3 PUNCTURE IN THE WHB w/OVERPACKED 1100 PE-Ci DRUM			
	Q (PE-Ci)	[(BR)(DCF)(T)/V] (rem/ci) Table E-48 and SAR Section 5.2.1.2	CEDE (rem)
Waste Container			
Drums	1.1E-02	7.3E+03	7.7E+01

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological source term (Ci)
T = Exposure time in seconds (depends on the scenario)
BR = Breathing rate (standard man) (m3/s)
DCF = Dose conversion factor (rem/Ci)
V = Volume of expanding cloud at time to reach receptor (m3)

TABLE E-61 IMMEDIATE WORKER CONSEQUENCE ANALYSIS FOR BEYOND DESIGN BASIS CH2 CRANE DROP IN THE WHB			
	Q (PE-Ci)	[(BR)(DCF)(T)/V] (rem/ci) Table E-48 and SAR Section 5.2.1.2	CEDE (rem)
Waste Container			
Drums	1.3E-02	3.6E+03	4.8E+01

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological source term (Ci)
T = Exposure time in seconds (depends on the scenario)
BR = Breathing rate (standard man) (m3/s)
DCF = Dose conversion factor (rem/Ci)
V = Volume of expanding cloud at time to reach receptor (m3)

TABLE E-62 IMMEDIATE WORKER CONSEQUENCE ANALYSIS FOR BEYOND DESIGN BASIS CH3 PUNCTURE IN THE WHB			
	Q (PE-Ci)	[(BR)(DCF)(T)/V] (rem/ci) Table E-48 and SAR Section 5.2.1.2	CEDE (rem)
Waste Container			
Drums	9.2E-03	7.3E+03	6.6E+01

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological source term (Ci)
T = Exposure time in seconds (depends on the scenario)
BR = Breathing rate (standard man) (m3/s)
DCF = Dose conversion factor (rem/Ci)
V = Volume of expanding cloud at time to reach receptor (m3)

TABLE E-63 IMMEDIATE WORKER CONSEQUENCE ANALYSIS FOR BEYOND DESIGN BASIS CH4 DROP IN THE WHB			
	Q (PE-Ci)	[(BR)(DCF)(T)/V] (rem/ci) Table E-48 and SAR Section 5.2.1.2	CEDE (rem)
Waste Container			
Drums	3.1E-03	3.6E+03	1.1E+01

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological source term (Ci)
T = Exposure time in seconds (depends on the scenario)
BR = Breathing rate (standard man) (m3/s)
DCF = Dose conversion factor (rem/Ci)
V = Volume of expanding cloud at time to reach receptor (m3)

TABLE E-64 IMMEDIATE WORKER CONSEQUENCE ANALYSIS FOR BEYOND DESIGN BASIS CH9 DROP IN THE U/G

	Q (PE-Ci)	V (m3)	T (sec)	BR (m3/s)	DCF (rem/Ci)	CEDE (rem)
Waste Container						
Drums	1.3E-02	2.40E+01	1.00E+00	3.33E-04	5.1E+08	9.5E+01

D = (Q*T*BR*DCF)/V (Ref. Eq. 5-7)

where:

D = Radiological dose (Committed Effective Dose Equivalent (CEDE)) (rem)
Q = Radiological source term (Ci)
T = Exposure time in seconds (depends on the scenario)
BR = Breathing rate (standard man) (m3/s)
DCF = Dose conversion factor (rem/Ci)
V = Volume of expanding cloud at time to reach receptor (m3)

TABLE E-65 IMMEDIATE WORKER CHEMICAL CONSEQUENCE ANALYSIS FOR CH2 CRANE DROP IN THE WHB

	MAR drum (mg)	MAR SWB (mg)	CD (drums)	CD (SWBs)	RR (1/1 sec)	Q (drums) (mg)	Q (SWBs) (mg)	V (m3)	Drum C (mg/m3)	SWB C (mg/m3)	Limit (mg/m3)	Drum Ratio (Conc /limit)	SWB Ratio (Conc /limit)
methylene chloride	205.2	820.9	7.0	1.0	1.0	1436.6	820.9	261.7	5.49E+00	3.14E+00	2.10E+04	0.026%	0.015%
chloroform	19.8	79.3	7.0	1.0	1.0	138.6	79.3	261.7	5.30E-01	3.03E-01	5.00E+03	0.011%	0.006%
carbon tetrachloride	379.0	1515.4	7.0	1.0	1.0	2653.0	1515.4	261.7	1.01E+01	5.79E+00	1.92E+03	0.529%	0.302%
1,1,2,2-Tetrachloroethane	10.4	41.4	7.0	1.0	1.0	72.8	41.4	261.7	2.78E-01	1.58E-01	1.51E+03	0.018%	0.011%

C=(Q*T)/(RR*V) (Ref. Eq. 5-8)

where:

C = Concentration (mg/m3)
Q = Source Term (mg)
RR = Release Rate = The amount of material suspended in air as a function of time.
T = Time of exposure = 1 second for this scenario.
V = Volume (m3)

TABLE E-66 IMMEDIATE WORKER CHEMICAL CONSEQUENCE ANALYSIS FOR CH3 PUNCTURE IN THE WHB

	MAR drum (mg)	MAR SWB (mg)	CD (drums)	CD (SWBs)	RR (1/1 sec)	Q (drums) (mg)	Q (SWBs) (mg)	V (m3)	Drum C (mg/m3)	SWB C (mg/m3)	Limit (mg/m3)	Drum Ratio (Conc /limit)	SWB Ratio (Conc /limit)
methylene chloride	205.2	820.9	4.0	2.0	1.0	820.9	1641.8	261.7	3.14E+00	6.27E+00	2.10E+04	0.015%	0.030%
chloroform	19.8	79.3	4.0	2.0	1.0	79.2	158.6	261.7	3.03E-01	6.06E-01	5.00E+03	0.006%	0.012%
carbon tetrachloride	379.0	1515.4	4.0	2.0	1.0	1516.0	3030.8	261.7	5.79E+00	1.16E+01	1.92E+03	0.302%	0.604%
1,1,2,2-Tetrachloroethane	10.4	41.4	4.0	2.0	1.0	41.6	82.8	261.7	1.59E-01	3.16E-01	1.51E+03	0.011%	0.021%

$C=(Q*T)/(RR*V)$ (Ref. Eq. 5-8)

where:

C = Concentration (mg/m3)
Q = Source Term (mg)
RR = Release Rate = The amount of material suspended in air as a function of time.
T = Time of exposure = 1 second for this scenario.
V = Volume (m3)

TABLE E-67 IMMEDIATE WORKER CHEMICAL CONSEQUENCE ANALYSIS FOR CH4 DROP OF WASTE CONTAINER FROM FORKLIFT

	MAR drum (mg)	MAR SWB (mg)	CD (drums)	CD (SWBs)	RR (1/1 sec)	Q (drums) (mg)	Q (SWBs) (mg)	V (m3)	Drum C (mg/m3)	SWB C (mg/m3)	Limit (mg/m3)	Drum Ratio (Conc /limit)	SWB Ratio (Conc /limit)
methylene chloride	205.2	820.9	4.0	2.0	1.0	820.9	1641.8	261.7	3.14E+00	6.27E+00	2.10E+04	0.015%	0.030%
chloroform	19.8	79.3	4.0	2.0	1.0	79.2	158.6	261.7	3.03E-01	6.06E-01	5.00E+03	0.006%	0.012%
carbon tetrachloride	379.0	1515.4	4.0	2.0	1.0	1516.0	3030.8	261.7	5.79E+00	1.16E+01	1.92E+03	0.302%	0.604%
1,1,2,2-Tetrachloroethane	10.4	41.4	4.0	2.0	1.0	41.6	82.8	261.7	1.59E-01	3.16E-01	1.51E+03	0.011%	0.021%

C=(Q*T)/(RR*V) (Ref. Eq. 5-8)

where:

C = Concentration (mg/m3)
Q = Source Term (mg)
RR = Release Rate = The amount of material suspended in air as a function of time.
T = Time of exposure = 1 second for this scenario.
V = Volume (m3)

TABLE E-68 IMMEDIATE WORKER CHEMICAL CONSEQUENCE ANALYSIS FOR CH9 DROP IN THE U/G

	MAR drum (mg)	MAR SWB (mg)	CD (drums)	CD (SWBs)	RR (1/1 sec)	Q (drums) (mg)	Q (SWBs) (mg)	V (m3)	Drum C (mg/m3)	SWB C (mg/m3)	Limit (mg/m3)	Drum Ratio (Conc /limit)	SWB Ratio (Conc /limit)
methylene chloride	205.2	820.9	7.0	1.0	1.0	1436.6	820.9	24.0	5.99E+01	3.42E+01	2.10E+04	0.285%	0.163%
chloroform	19.8	79.3	7.0	1.0	1.0	138.6	79.3	24.0	5.78E+00	3.30E+00	5.00E+03	0.116%	0.066%
carbon tetrachloride	379.0	1515.4	7.0	1.0	1.0	2653.0	1515.4	24.0	1.11E+02	6.31E+01	1.92E+03	5.766%	3.294%
1,1,2,2-Tetrachloroethane	10.4	41.4	7.0	1.0	1.0	72.8	41.4	24.0	3.03E+00	1.73E+00	1.51E+03	0.202%	0.115%

C=(Q*T)/(RR*V) (Ref. Eq. 5-8)

where:

C = Concentration (mg/m3)
Q = Source Term (mg)
RR = Release Rate = The amount of material suspended in air as a function of time.
T = Time of exposure = 1 second for this scenario.
V = Volume (m3)

This page intentionally left blank

DOE/WIPP-95-2125 REV. 4

WASTE ISOLATION PILOT PLANT TECHNICAL SAFETY REQUIREMENTS

December 1999

Prepared for

United States Department of Energy

Westinghouse Electric Corporation
Waste Isolation Division

This page intentionally blank

TECHNICAL SAFETY REQUIREMENTS
TABLE OF CONTENTS

TECHNICAL SAFETY REQUIREMENTS
TABLE OF CONTENTS

TECHNICAL SAFETY REQUIREMENTS
LIST OF TABLE

This page intentionally blank

TECHNICAL SAFETY REQUIREMENTS

1 Use and Application

This document provides the WIPP Technical Safety Requirements (TSR), in accordance with the requirements of DOE Order 5480.22, *Technical Safety Requirements*.[1] DOE Order 5480.22[1] provides detailed criteria for the selection of TSR Safety Limits (SLs), Limiting Control Settings (LCSs), Limiting Conditions for Operations (LCOs), Surveillance Requirements (SRs), and Administrative Controls (ACs).

Based on the WIPP Safety Analysis Report (SAR)[2] Chapter 5, Hazards and Accident Analyses, SLs, LCSs, LCOs, and SRs are not required for the WIPP facility as discussed below. As discussed in SAR[2] Chapter 5, Design Class I Systems, Structures or Components (SSCs) are not required for the WIPP to mitigate any accidental radiological and non-radiological Maximally Exposed Individual (MEI) and noninvolved worker consequences to acceptable levels. WIPP TSR in the form of ACs are derived in SAR[2] Chapter 6. These ACs provide TSR covering the WIPP defense-in-depth approach developed in SAR[2] Chapter 5.

1.1 Definitions

---NOTE--

The definitions provided in this section are specifically applicable to the TSR, and they are displayed in all capital letters throughout this TSR Document. Also, some definitions refer the reader to a specific section of this document to help provide a more complete description than can be provided in a summarized definition read out of context.

Term	Definition
MODE	A MODE of operation defines the operating condition of the WIPP facility at a given time. See Section 1.2, MODES.
OPERATIONAL LIMITS	Those limits that are required to ensure the safe operation of a nuclear facility. Specifically, these limits include LCSs and LCOs.
TECHNICAL SAFETY REQUIREMENTS	TSR are those requirements that define the conditions, safe boundaries, and the management or administrative controls necessary to ensure the safe operation of a nuclear facility and that reduce the potential risk to the public and facility workers from uncontrolled releases of radioactive materials or from radiation exposures due to inadvertent criticality. TSR consist of safety limits, OPERATIONAL LIMITS, surveillance requirements, administrative controls, use and application instructions, and the basis thereof.
VIOLATION	See Section 5.7, TSR VIOLATIONS.
WASTE	Contact-Handled (CH) Transuranic (TRU) WASTE materials being received, handled and disposed in WIPP-approved CH containers. Site derived mixed waste is also considered in this definition when it is handled in containers or cleaned up following a breach in a container.

WASTE HANDLING	Activities occurring when actual WASTE is being unloaded (including opening or closing a loaded TRUPACT-II), transported (outside of TRUPACT-IIs), and emplaced. The following similar activities are not considered WASTE HANDLING activities, and do not present the level of hazard requiring the protections afforded the handling of WASTE; storing or inspecting WASTE in the WHB or the Underground, moving closed TRUPACT-IIs, TRUPACT-II maintenance, or the preparation of empty TRUPACT-IIs for shipment to generator sites.
WASTE STORAGE/ DISPOSAL	For the purposes of these TECHNICAL SAFETY REQUIREMENTS, with regard to transuranic waste: the term "STORAGE" refers to the temporary storage of that waste above ground; and, the term "DISPOSAL" refers to that waste which has been emplaced in the underground horizon.

1.2 Facility MODES

Operations at the WIPP consist of WASTE HANDLING, storage, and disposal operations. The following is a definition of the MODES of operations. The MODE is defined such that the Waste Handling Building and the Underground may be in different MODES. Defense-In-Depth SSCs are operated as required in each MODE as specified in Section 5. The facility will always be in the WASTE STORAGE/DISPOSAL MODE or WASTE HANDLING MODE as described below.

1.2.1 WASTE HANDLING MODE

The Waste Handling Building (WHB) and/or the Underground is configured for WASTE HANDLING, and all required Defense-In Depth SSCs are operated as required in Table 5-1. Maintenance, repair activities, and inspections are allowed as long as they do not prevent the functions of the Defense-In Depth SSCs required for the WASTE HANDLING MODE.

1.2.2 WASTE STORAGE/DISPOSAL MODE

WASTE HANDLING operations are not being conducted in the WHB and/or in the Underground. WHB and/or the Underground is configured for WASTE STORAGE/DISPOSAL MODE, and required Defense-In-Depth SSCs are operated as required in Table 5-1. No WASTE HANDLING operations are allowed during WASTE STORAGE/DISPOSAL MODE, except as required to provide orderly transition, according to procedure, from WASTE HANDLING MODE. Maintenance, repair activities, and inspections are allowed, provided the Defense-In-Depth SSCs required for the MODE are restored in a timely manner, and Defense-In-Depth SSCs are not intentionally removed from service during the WASTE HANDLING completion allowed above.

1.3 Safety Limits (SLs)

As defined in DOE Order 5480.22,[1] SLs are limits on process variables associated with those physical barriers, generally passive, that are necessary for the intended facility function, and that are found to be required to guard against the uncontrolled release of radioactivity and other hazardous material. "Process Variables" refers to observable, measurable parameters such as temperature and pressure. "Passive physical barriers" refers to those barriers that constitute the primary process material boundary.

Based on the analysis presented in SAR[2] Chapter 5, no SLs are identified for the WIPP facility.

1.4 Limiting Control Settings (LCSs)

As defined in DOE Order 5480.22,[1] LCSs are settings on safety systems that control process variables to prevent exceeding SLs. More precisely, an LCS is the set point for an instrument or device monitoring a process variable that, if exceeded, initiates actions to prevent exceeding an SL.

The WIPP facility has no SLs identified, therefore, no LCSs are required.

1.5 Limiting Conditions for Operations (LCOs)

DOE Order 5480.22,[1] Attachment 1, Section II.2.3.h, provides that "LCOs should be written only for systems and equipment which meet one (or more) of the following descriptions," and prescribes five selection criteria, h.(1) through h.(5). The order also emphasizes that "Maintaining the LCOs at the minimum number necessary will emphasize the importance of the LCOs and better ensure the compliance with them." All five criteria clearly tie the LCOs to the facility accident or transient analyses.

The LCO selection criteria interpretations define TSR content based on key nuclear safety analysis requirements. Specifically, three of the five TSR LCO selection criteria are understood to restrict TSR LCOs to only those requirements that are under the direct control of the facility's operators and are of primary importance for: **prevention** (Criterion h.(1)), **mitigation** (Criterion h.(2)), and **initial conditions** (Criterion h.(3)) of credible, unmitigated accident scenarios. Additionally, Criterion h.(4) involves the application of criteria h.(1), h.(2), and h.(3) to experiments and experimental facilities, and Criterion h.(5) to systems and equipment that are used for handling fissile material.

The specifics of each criterion as applied to the WIPP facility are as follows:

Criterion h.(1) - Prevention:

A basic concept in the protection of the public is the prevention of accidents that have the potential for an uncontrolled release of radioactive material. Criterion h.(1) is intended to ensure that TSR be selected to identify instrumentation that is used to detect, and to indicate in the control room or other control location, a significant degradation of the physical barriers which prevent the uncontrolled release of radioactive or other hazardous materials. For example, instrumentation installed to detect significant degradation of a reactor coolant pressure boundary enables the operator to correct the degraded condition prior to accident initiation or to place the facility in a condition that reduces the likelihood of the accident.

WIPP instrumentation, such as the Continuous Air Monitors (CAMs), Effluent Monitors, Area Radiation Monitors (ARMs), and installed instrumentation to control differential pressure, are not required to prevent accidents as analyzed in the SAR[2] from occurring, or to facilitate the Central Monitoring Room (CMR) operator placing the facility in a condition reducing the likelihood of an accident from occurring. Therefore, Criterion h.(1) has no application to the WIPP.

Criterion h.(2) - Mitigation:

Criterion h.(2) provides that "Structures, systems, and components that are relied upon in the Safety Analyses to function or actuate to prevent or mitigate accidents, or transients that either involve the assumed failure of, or present a challenge to, the integrity of a physical barrier that prevents the uncontrolled release of radioactive materials ... intended to include only those structures, systems, and components that are part of the primary success path of a safety sequence analysis and those support and actuation systems necessary for them to function successfully."

The "primary success path of a safety sequence analysis" is defined as "the sequence of events assumed by the Safety Analyses, which leads to the conclusion of a transient or accident with consequences that are acceptable. Hence, any structure, system, or component in that assumed sequence should be included in the LCO."

Consistent with the primary intent of DOE Order 5480.22[1] establishing requirements for the protection of the public, the existing practice is: 1) to evaluate the unmitigated radiological and non-radiological consequences to members of the MEI and noninvolved worker as the result of an accident, 2) to compare the radiological and non-radiological consequences to established accident risk evaluation guidelines, and 3) if the consequences of the accident exceed the established accident consequence risk evaluation guidelines, to define SSCs and associated TSR LCOs mitigating or reducing those consequences to acceptable levels below the established criteria.

The unmitigated MEI and noninvolved worker radiological and non-radiological consequences and risk evaluation guidelines, as documented in Chapter 5, Tables 5.2-3, and 5.2-4., are used as the basis for applying this criterion.

Application of DOE Order 5480.22[1] TSR LCO Selection Criterion h.(2) to the WIPP:

The WIPP SSCs that are assumed to function in the SAR accident analysis mitigating an accident's radiological and non-radiological consequences to acceptable levels (to within the accident risk evaluation guidelines) satisfy Criterion h.(2).

The unmitigated radiological and non-radiological accident consequences were estimated and compared to the risk evaluation guidelines in Chapter 5. The unmitigated radiological and non-radiological accident consequences are below the consequence risk evaluation guidelines therefore; 1) mitigating SSCs are not required, and 2) TSR LCOs are not required. Tables 5.2-3 and 5.2-4 of Chapter 5 of the SAR list the analyzed accidents and the mitigated and unmitigated MEI and noninvolved worker radiological consequences. All of the radiological and non-radiological accident consequences are well below the applicable risk evaluation guidelines.

Criterion h.(3) - Initial Condition:

Process variables as initial conditions of accidents, or transients that are monitored and controlled during operations so the parameter remains within the analysis bounds, satisfy this selection criterion. The WIPP is not a process facility, therefore process variables are not considered in the SAR[2] accident analysis as initial conditions for accidents. Thus, Criterion h.(3) is not applicable to the WIPP.

Criterion h.(4)

Criterion h.(4) involves applying criteria h.(1), h.(2), and h.(3) to experimental activities involving radioactive or other hazardous materials. There are currently no planned experimental or test activities at the WIPP. Therefore, Criterion h.(4) is not applicable to the WIPP.

Criterion h.(5)

Criterion h.(5) applies to fissile material handling facilities, and is only related to inadvertent criticality protection. Inadvertent criticality is not a credible hazard at the WIPP. Inadvertent criticality is controlled through the ACs Criticality Program in conjunction with the WASTE Characteristics program which conforms to the WIPP Waste Acceptance Criteria (WAC).[3] Therefore, Criterion h.(5) is not applicable to the WIPP.

1.6 Surveillance Requirements (SRs)

As defined in DOE Order 5480.22,[1] SRs relate to testing, channel calibration, channel operational testing, or inspection to maintain the operability, quality, and safety of SSCs, and their support systems. SRs are defined as the requirements necessary to maintain facility operation within the SLs, LCSs, and LCOs. Selection criteria for SRs are defined in DOE Order 5480.22.[1] Without SLs, LCSs, and LCOs for the WIPP facility, SRs are not required.

1.7 Administrative Controls (ACs)

As discussed in Section 2.4 of Attachment 1 of DOE Order 5480.22,[1] ACs impose necessary requirements controlling operation of the facility to meet all TSR requirements. Without SLs, LCSs, LCOs, and SRs, WIPP specific ACs impose administrative and operational requirements supporting the WIPP defense-in-depth concept.

Supporting the first layer of defense-in-depth (the prevention of accidents) as defined in SAR[2] Section 5.1.6, WIPP TSR ACs are established as follows:

- To maintain the design, quality, testability, inspectability, operational capability, maintainability, and accessibility of the facility, TSR ACs are required relating to: (1) configuration and document control, (2) maintenance, (3) quality assurance, and (4) geotechnical monitoring. These ACs are important to ensure the frequency of events and the availability of the operational and design conditions remain as analyzed in SAR Section 5.2.3.

- To ensure that the facility operations are conducted by trained and certified/qualified personnel in a controlled and planned manner, TSR ACs are required relating to: (1) facility operations chain of command and responsibilities, (2) facility staffing requirements, (3) procedures, (4) staff qualifications, (5) conduct of operations, and (6) training. These ACs are important to ensure the low frequency of the accidents analyzed in SAR Section 5.2.3, in particular to those WASTE handling accidents where human error is the major contributor to the likelihood of the accident initiating event (CH3, CH4, and CH9).

- To ensure that hazards are limited within the bounds assumed in Chapter 5.2, or that the occurrence of a deviation from the assumed hazard bounds are at an acceptably low frequency, TSR ACs are required relating to: (1) WASTE characteristics (Waste Acceptance Criteria), (2) WASTE container integrity, and (3) criticality safety. The TSR AC for WASTE characteristics limits the radionuclide content of each WASTE container, restricts the fissile content of the containers, and restricts the presence of WASTE characteristics unacceptable for management at the WIPP facility. Container integrity ensures the robustness reflected in the WASTE release analyses, while criticality safety is a designed in-storage and handling configuration that ensures (in conjunction with WASTE characteristics) that active criticality control is not required.

Supporting the second and third layers of defense-in-depth, WIPP TSR ACs are identified which establish programs for radiation protection (including radiation monitoring equipment and airborne radioactivity monitoring), and mitigation of off-normal events through emergency management.

Consistent with the discussion in SAR Section 5.1.8, specific SSCs that fulfill a defense-in-depth safety function important to accident scenarios, or considered essential for WASTE HANDLING, storage and/or disposal operations are as follows: (1) Waste Handling Building (WHB) Heating, Ventilation and Air Conditioning (HVAC) and Underground Ventilation and Filtration Systems (UVFS) (including underground shift to filtration and excluding RH area ventilation; unless the RH area is used for CH storage or handling); (2) Waste Hoist Equipment (including Brake System); (3) WASTE Handling Equipment (including the TRUDOCK Bridge Crane, forklifts, transporters, etc.); (4) WHB structure including tornado doors; (5) Central Monitoring System (to support underground shift to filtration only); and (6) Radiation Monitoring System, active waste disposal room exit alpha CAM (for underground shift to filtration). The applicability of the important defense-in-depth SSCs to each accident, analyzed in SAR Section 5.2.3, is listed in SAR Table 6-1. The above SSCs are classified as "Defense-In-Depth SSCs."

As shown in Section 1.5, based on the criteria for assigning Technical Safety Requirement (TSR) Limiting Conditions for Operation (LCOs), defense-in-depth SSCs are not assigned TSR LCOs. The facility has no complex system requirements to maintain an acceptable level of risk. The WIPP Waste Acceptance Criteria for transuranic WASTE and the design of the WASTE handling process and its supporting facilities provide assurance that the immediate consequences of an accident will be limited and allow the WIPP facility to isolate and contain releases while maintaining a high assurance that no additional releases will occur. The facility is designed to minimize the presence and impact of other energy sources that could provide the heat or driving force to disperse hazardous materials. The magnitude of hazardous materials that can be involved in an accident leading to a release is very limited. The radioactive material is delivered to the site in sealed containers, and the WASTE HANDLING operations are designed to maintain that integrity throughout the entire process required to safely emplace those containers in the site's underground WASTE disposal rooms. Inventory limits on individual containers ensure that heat generated by radioactive decay can be easily dissipated by passive mechanisms. Finally, only a limited number of WASTE containers have the possibility of being breached as a result of any one accident initiating event. As a result, the consequences of unmitigated releases from all accidents hypothesized in Chapter 5, including those initiated by human error, do not produce significant offsite health consequences.

When something unusual happens during normal operations (such as defense-in-depth SSCs becoming unavailable), **WASTE HANDLING can be simply stopped** until an acceptable condition is reestablished. The facility is designed to minimize the presence and impact of other energy sources that could provide the heat or driving force to disperse hazardous materials. Should an accident involving the breach of a container occur, **the plant design permits the immediate cessation of activity and isolation of the area where the breach occurs**. Once isolation is achieved, there is no driving force within the WASTE or WASTE HANDLING area that could result in a further release of the WASTE material. The absence of energy sources that can disperse the radioactive WASTE allows the immediate termination of all activities, evacuation of personnel, and isolation of the area without the threat of additional consequences. This will enable WIPP personnel to then proceed with detailed planning to meet the unique circumstances of any accidental release prior to initiating decontamination and the execution of recovery actions, while assuring that the health and safety of both workers and the public is protected. The controls necessary to maintain safety during the recovery and cleanup can be documented in the recovery plans, its associated Radiological Work Permit, and the USQ process. In order to ensure protection by the identified SSCs during recovery from an event that breaches a WASTE container, the Defense-In-Depth SSCs for the WASTE HANDLING MODE will be required during the period of time that WASTE may be exposed.

Based on the above discussion, specific functional requirements are not assigned here for the Defense-In-Depth SSCs, rather, the SSCs shall be operated, as required during the applicable WIPP MODE of operation defined in the next sections. Detailed design descriptions for the Defense-In-Depth Equipment may be found in Chapter 4 and the applicable Systems Design Descriptions.

Due to the importance of the Defense-In-Depth SSCs in the WIPP defense-in-depth strategy and worker protection from accidents, TSR ACs are assigned in SAR Chapter 6 and required in this WIPP TSR Document, requiring the Defense-In-Depth SSCs to be operated as required when WASTE HANDLING operations are being conducted (to enter the WASTE HANDLING MODE in the WHB or the Underground).

The Defense-In-Depth SSCs operational requirements ensure that important defense-in-depth SSCs are operated as required during WASTE HANDLING operations in the Surface or Underground WASTE HANDLING MODES, to provide protection for the “most likely” WASTE HANDLING accidents identified in SAR Section 5.2.3: (1) CH2, Crane Failure in the Waste Handling Building (WHB), (2) CH3, Puncture of Waste Containers in the Waste Handling Building, (3) CH4, Drum Drop in WHB, and (4) CH9, Drum Drop in the Underground); for natural phenomenon events: (1) CH6, Design Basis Earthquake, and CH10, Design Basis Tornado; and for less likely operational accidents identified in SAR Section 5.2.3: (1) CH1, Spontaneous Ignition in a Drum in the WHB, (2) CH5, Waste Hoist Failure, (3) CH7, Spontaneous Ignition in a Drum in the Underground, and (4) CH11, Roof Fall.

As discussed above, if any of the Defense-In-Depth SSCs fail to operate (when required), or becomes unavailable during WASTE HANDLING operations, WASTE HANDLING operations shall be stopped, and the facility shall be placed in the WASTE STORAGE/DISPOSAL MODE. WASTE HANDLING operations shall not resume until the above Defense-In-Depth SSCs are capable of being operated, as required.

During WASTE STORAGE/DISPOSAL MODE in the WHB, the above Defense-In-Depth SSCs operational requirements ensure that important defense-in-depth SSCs are operated as required during temporary storage operations (for WASTE temporarily stored in the WHB prior to transfer to the underground) to provide protection for less likely operational accidents evaluated in SAR Section 5.2.3: (1)CH1, Spontaneous Ignition in a Drum in the WHB; and for natural phenomenon events: (1) CH6, Design Basis Earthquake, and CH10, Design Basis Tornado.

During WASTE STORAGE/DISPOSAL MODE in the Underground, the above Defense-In-Depth SSCs operational requirements ensure that important defense-in-depth SSCs are operated as required (for WASTE disposed in the underground), to provide protection for less likely operational accidents evaluated in SAR Section 5.2.3: (1) CH7, Spontaneous Ignition in a Drum in the Underground, and (2) CH11, Roof Fall.

For the WASTE STORAGE/DISPOSAL MODE, if any of the required Defense-In-Depth SSCs fail to operate (when required) or become unavailable, no specific actions are identified, other than to perform corrective maintenance on the affected equipment in a timely manner.

A summary of the applicability of defense-in-depth SSCs in relation to the MODE definitions is presented in Table 5-1.

2 Safety Limits

No SLs are defined for the WIPP facility.

3/4 OPERATIONAL LIMITS and Surveillance Requirements

No LCSs or LCOs are defined for the WIPP facility.

Because no OPERATIONAL LIMITS have been defined for the WIPP facility, no SRs are needed.

5 Administrative Controls

5.1 Defense-In-Depth SSC Operation

Defense-in-depth SSCs are listed in WIPP Safety Analysis Report,[2] Chapter 6, Table 6-1. The applicable System Design Descriptions define defense-in-depth SSCs, describe their intended safety functions, and specify the requirements for design, operation, maintenance, testing, and calibration. WP 04-AD3001, Facility Mode Compliance, shall be implemented, and maintained to ensure that defense-in-depth SSCs are operated as required during each facility mode as described in Table 5-1.

5.2 Facility Operations Chain of Command and Responsibilities

Facility Manager (FM)

The FM shall be responsible for overall WIPP facility operation. The FM shall delegate in writing the succession to this responsibility during his/her absence. The Manager of the Operations Department of the Management and Operations Contractor (MOC) is the FM for the WIPP facility operation.

The Operations Department section managers are responsible for reporting plant status to the FM, and resolving issues as they arise.

Facility Shift Manager (FSM)

The FSM shall be responsible for operation of facility equipment and systems during normal and emergency situations. The FSM directs shift personnel through approved plans, procedures, and instructions. The FSM is the senior manager on shift during periods other than normal working hours, and reports to the FM through the organizational structure.

5.3 Facility Staffing Requirements

The MOC organizational structure, responsibilities, and staffing qualifications are described in Chapter 8 of the SAR.[2] The minimum required operating staff to maintain the facility in a safe condition is specified below. The minimums are based on conducting WASTE HANDLING operations in series (e.g., completing surface WASTE HANDLING activities before beginning underground WASTE HANDLING activities) from a single TRUDOCK position. The personnel performing surface WASTE HANDLING activities may perform underground WASTE HANDLING activities providing surface WASTE HANDLING activities are completed. When parallel WASTE HANDLING activities are occurring at two or more TRUDOCK positions, additional staff is required to provide the minimum concurrent coverage for surface and underground WASTE HANDLING activities. In addition to the minimum operating staff, adequate staffing will be available to implement and maintain the TSR ACs.

5.3.1 WASTE STORAGE/DISPOSAL MODE Staffing Requirements

Facility Shift Manager (FSM)

Central Monitoring Room Operator (CMRO)

Surface Roving Watch

One of the following personnel;

Emergency Services Technician (EST), or

Fire Protection Technician (FPT)

The EST/FPT may be temporarily absent from the facility as part of required emergency response actions or as part of normal duties (e.g. taking the ambulance for required drive on a daily basis) without a TSR VIOLATION.

5.3.2 WASTE HANDLING MODE Staffing Requirements

After initiation of the WASTE HANDLING MODE, required personnel (over and above those required for WASTE STORAGE/DISPOSAL MODE) will only be necessary during actual WASTE HANDLING. These are facility staffing requirements and only need to be present in the WHB as required for the WASTE HANDLING MODE. Planned breaks do not constitute a TSR VIOLATION.

5.3.2.1 Staffing Requirements for WASTE HANDLING MODE in the WHB

Staffing requirements from WASTE STORAGE/DISPOSAL MODE plus:

WASTE HANDLING Engineer

Radiological Control Technician (one per TRUDOCK position in operation)

Radiological Control Air Monitoring Technician (rover)

WASTE HANDLING Technician (one per TRUDOCK position in operation)

WASTE HANDLING Technician (one per TRUDOCK crane in operation)

During WASTE HANDLING not involving the TRUDOCK, there shall be at least one WASTE HANDLING Technician, one WASTE HANDLING Engineer, and one Radiological Control Technician present.

During WASTE HANDLING involving the TRUDOCK, the WASTE HANDLING Engineer can simultaneously serve in the capacity of a WASTE HANDLING Technician.

5.3.2.2 Staffing Requirements for WASTE HANDLING MODE in the Underground

Staffing requirements from WASTE STORAGE/DISPOSAL MODE plus:

WASTE HANDLING Engineer

Radiological Control Technician (one for each WASTE HANDLING area)

WASTE HANDLING Technician (two for each underground transporter in operation). When handling WASTE in the underground without the involvement of the Transporter, there shall be at least one WASTE HANDLING Technician.

During WASTE HANDLING involving the Transporter, the WASTE HANDLING Engineer can simultaneously serve in the capacity of a WASTE HANDLING Technician.

Underground Facility Operations Engineer

Underground Roving Watch

Radiological Control Air Monitoring Technician Rover (performed at surface, only one required for WASTE HANDLING in either area).

5.4 Facility Staff Qualifications

Each member of the WIPP facility operation staff and technical support personnel shall meet or exceed the minimum qualifications as prescribed in job descriptions established and maintained under the direction of the manager of Human Resources.

5.5 Nuclear Review Board (NRB)

The NRB shall have a documented Charter and Scope as follows:

- Provide policy guidance in areas involving nuclear and/or occupational safety, and surety of TRU WASTE HANDLING/disposal operations,
- Conduct formal reviews of activities or issues having nuclear/occupational safety or environmental significance.

5.6 Reportable Occurrence Action

Procedures shall be established, implemented, and maintained for the administration of reportable occurrence actions.

5.7 TSR VIOLATIONS

Any of the following constitutes a TSR VIOLATION: (1) failure to establish, implement, or maintain a TSR AC required program; (2) failure to establish, implement, or maintain a TSR AC required procedure; and (3) systematic failure to comply with TSR AC programs or procedures. A procedure containing the following components shall be established, implemented, and maintained for the reportingof TSR AC VIOLATIONS:

1. Placing the facility in the WASTE STORAGE/DISPOSAL MODE.
2. Reporting the VIOLATION in accordance with the above required reporting procedure.
3. Preparing a recovery plan describing steps that will reinstate compliance with the TSR AC.
4. Performing and documenting a technical evaluation, if appropriate, of the TSR AC VIOLATION to determine if an Unreviewed Safety Question exists.

5.8 Revisions to the TSR

All proposed changes to the TSR shall be submitted to the DOE for approval prior to implementation of the revision.

5.9 Programs

5.9.1 Configuration Control

A Configuration Control Program and associated procedures shall be established, implemented, and maintained to control designs, modifications, and procurement to ensure that the WIPP facility remains consistent with the design features assumed in the SAR.[2]

5.9.2 Document Control

A Document Control Program and associated procedures shall be established, implemented, and maintained to control WIPP documents. The program shall establish minimum review and approval requirements, change control, and minimum record retention requirements for the WIPP.

5.9.3 Maintenance

A Maintenance Program and associated procedures shall be established, implemented, and maintained to ensure that routine, corrective, and preventative maintenance, inspection, testing, and calibration activities are controlled.

5.9.4 Quality Assurance Program

A Quality Assurance Program and associated procedures shall be established, implemented, and maintained.

The basic elements of the Quality Assurance program should encompass, as applicable, work such as planning; training and personnel development; preparing, reviewing, approving, and verifying designs; qualifying suppliers; preparing, reviewing, approving, and issuing instructions, procedures, schedules, and procurement documents; purchasing; verifying supplier work; identifying and controlling hardware and software; manufacturing; managing and operating facilities; calibrating and controlling measuring and test equipment; conducting investigations and acquiring data; performing maintenance, repair, and improvements; performing assessments; and controlling records.

5.9.5 Procedures

Procedures shall be established, implemented, and maintained for WIPP TRU WASTE HANDLING and disposal related activities.

5.9.6 Training

A Training Program for the WIPP facility operation staff and technical support personnel shall be established and maintained.

5.9.7 Conduct of Operations

The Conduct of Operations program shall contain elements of organization and administration of facility operations to ensure that a high level of operations is achieved through effective implementation and control of operations activities.

Effective implementation and control of operating activities are primarily achieved through established written standards for operations, periodic monitoring and performance assessment, and holding personnel accountable for their performance.

The basic elements of the Conduct of Operations program should include, as applicable, guidance for: operations organization and administration; shift routines and operating practices; control area activities; communications; control of on-shift training; control of equipment and system status; lockouts and tagouts; independent verification; log keeping; operations turnover; timely orders to operators; operations procedures; operator aid postings; and equipment and piping labeling.

Preoperational checks shall be performed to ensure that WASTE HANDLING equipment (including waste hoist, and WHB 6-ton bridge crane) operate as required prior to WASTE HANDLING activities

5.9.8 Emergency Management

An Emergency Management Program and associated procedures shall be established, implemented, and maintained that provides preparedness, training, and operational response capabilities to minimize consequences to workers and the public from accidents involving WIPP operations.

5.9.9 Radiation Protection

A Radiation Protection program and associated procedures shall be established, implemented, and maintained to ensure personnel radiation protection for all operations involving personnel radiation exposure.

The basic elements of the Radiation Protection program, as specified in the WIPP Radiological Protection Plan should encompass, as applicable, the specifications of: policy considerations and general facility design features employed to maintain radiation exposures ALARA; radiological control zoning and access control; radiation shielding; ventilation systems; differential pressure; radiation monitoring equipment, and effluent monitoring and sampling systems.

5.9.10 WASTE Container Integrity

Procedures shall be established, implemented, and maintained to ensure WASTE container integrity from the time a WASTE container is no longer sealed inside an authorized transport package (DOT Type B) until it has been emplaced in the underground disposal area. Procedures shall also be established, implemented, and maintained to manage WASTE container integrity of site-derived mixed WASTE.

The basic elements of this program should include the following requirements:

- Transport packaging (TRUPACT-IIs) loaded with materials intended for disposal at the WIPP facility shall not be opened outside the designated WIPP Controlled Area (CA).

- WASTE containers loaded with materials intended for disposal at the WIPP shall not leave the boundaries of the CA unless they are inside a sealed TRUPACT-II.

- CH WASTE containers {drums, boxes, or ten drum overpacks (TDOPs)} received at the WIPP for disposal shall be isolated from the normal disposal processing if they are found to exceed any of the following criteria:

  1) The removable surface contamination limits of the WIPP WAC[3]

  2) The surface contact dose rate limits of the WIPP WAC[3]

  3) A known or suspected breach of container integrity

  All containers failing these criteria will be dealt with in accordance with the following requirements.

- Decontamination in accordance with the Radiological Control Plan, shielding to below 200 mrem/hr contact dose rate, or sealing inside another container to meet the listed criteria (overpacking), as appropriate, shall be performed prior to returning the containers to the WASTE HANDLING process.

5.9.11 Criticality Safety

The Criticality Safety program is established by implementing the following criticality safety configuration requirements which apply at all times:

CH WASTE package configuration (including site-derived mixed WASTE):

- Fissile loading shall not exceed 200 grams per 55- or 85-gallon drum (WWIS).

- Fissile loading shall not exceed 325 grams per ten-drum overpack (TDOP) direct loaded with CH TRU waste.

- Fissile loading in WASTE boxes approximately equal to or greater in size than the TRUPACT-II SWB design shall not exceed 325 grams per box (WWIS).

- Drum arrays shall not exceed three drums high. Drum arrays may be infinite in the horizontal directions.

- Box arrays shall not exceed three boxes high. Box arrays may be infinite in the horizontal directions.

- WASTE drums shall be stacked only in the vertical position (longest dimension vertical).

- WASTE boxes shall be stacked only in the normal horizontal position (longest dimension horizontal).

Associated procedures shall be established, implemented, and maintained to ensure the prevention of accidental criticality at the WIPP facility.

5.9.12 WASTE Characteristics

A WASTE Characterization Program shall ensure that only WASTE that is compatible with the design, operation, and long-term performance of the WIPP facility are shipped to WIPP, and that any exceptions are weighed against all applicable baseline documents prior to their authorization for shipment.

Procedures shall be established, implemented, and maintained to ensure that the following WIPP WAC[3] requirements apply to all WASTE that is to be shipped to and/or emplaced at the WIPP are implemented:

- The WASTE accepted for placement in the WIPP facility must conform with the WIPP WAC[3] unless an exception to the WAC has been approved as a result of examination in relation to the SAR.[2] Site-derived mixed WASTE containers must also meet these requirements as they are packaged for disposal. Specific criteria used in the development of the safety analysis are as follows:

  - WASTE Containers
    1. Containers shall be noncombustible, and meet DOT Type A packaging requirements.
    2. Limit acceptable containers to 55-gallon drums, ten-drum overpacks, pipe containers in 55-gallon drums (pipe overpack containers), 85-gallon drum overpack, and standard WASTE boxes (SWBs).
    3. Removable surface contamination criteria shall be consistent with the requirements of the DOE Radiological Control Manual.

  - Liquids
    1. Liquid waste will not be accepted at the WIPP. Only residual liquids in well-drained internal containers are allowed. The aggregate amount of residual liquid is limited to less than 1 volume percent of the external container.

  - Pyrophoric Materials
    1. No non-radionuclide pyrophorics permitted. Radionuclides in pyrophoric form are limited to $<1\%$ by weight in each WASTE package.

  - Explosives and Compressed Gases
    1. No explosives or compressed gases are permitted.

  - TRU Mixed WASTE
    1. TRU WASTE shall contain no hazardous WASTE unless they exist as co-contaminants with transuranics.
    2. Characteristic ignitable (D001), corrosive (D002), and reactive (D003) WASTE are not acceptable at WIPP.

  - Specific Activity of WASTE
    1. WASTE shall be greater than 100 nanocuries of TRU per gram of WASTE, exclusive of added shielding, rigid liners, and the WASTE containers, including alpha contaminated WASTE handled.

- Nuclear Criticality (Pu-239 FGE)
    1. Accepted package limits, including two times the error, are:
        a. <200g/55- or 85-gallon drum
        b. <325g/SWB
        c. <325g/TDOP direct loaded with CH TRU waste

- Pu-239 Equivalent Activity

    Untreated WASTE
    1. ≤ 80 PE-Ci/55- or 85-gallon drum
    2. ≤ 130 PE-Ci/SWB
    3. ≤ 130 PE-Ci/TDOP direct loaded with CH TRU waste
    4. ≤ 1,100 PE-Ci/55-gallon drum overpacked in SWB, 85-gallon drum, or TDOP; or SWB overpacked in TDOP

    Solidified/Vitrified WASTE
    1. ≤ 1,800 PE-Ci/55-gallon Drum

    Pipe Overpack Container
    1. ≤ 1,800 PE-Ci/pipe overpack container

- Surface Dose Rate
    1. WASTE containers shall not exceed 200 mrem/hr surface reading.

- Gas Generation
    1. All WASTE containers shipped shall be vented with one or more filters.

- Data Package/Certification
    1. A data package with certification shall be transmitted prior to shipment.

- In addition to the SAR, all exceptions shall be evaluated against the WIPP facility Operational, Health, and Safety Requirements; the Final and Supplemental Environmental Impact Statements; agreements with the state of New Mexico; the Performance Assessment; RCRA requirements; and any applicable regulations before approval to ship is granted.

- Radioactive mixed WASTE to be emplaced at WIPP shall be managed in accordance with the applicable requirements of the RCRA Part B Permit issued by the state of New Mexico.

5.9.13 Unreviewed Safety Questions

An Unreviewed Safety Question program and associated procedures shall be established, implemented, and maintained that maintains the facility consistent with the SAR and design features.

5.9.14 Geotechnical Monitoring

A geotechnical monitoring program shall be established, implemented, and maintained to characterize, monitor, and trend salt behavior that might result in a roof fall in open WASTE disposal panels or rooms in the underground, so that remedial actions may be formulated as deemed necessary.

6 References

1 DOE Order 5480.22, Technical Safety Requirements, September 15, 1992.

2 WIPP Safety Analysis Report, DOE/WIPP 2065.

3 WIPP-DOE-069, Waste Acceptance Criteria for the Waste Isolation Pilot Plant, Rev. 5, February, 1996.

Table 5-1, Summary of Applicability of Defense-In-Depth SSCs to WIPP MODEs **Page 1 of 1**

Defense-In-Depth SSCs	WASTE HANDLING MODE		WASTE STORAGE/DISPOSAL MODE	
	WHB	Underground	WHB	Underground
WHB HVAC System	X		X*	
WASTE Hoist (when required to transport WASTE)	X	X		
WASTE HANDLING equipment (including the WHB TRUDOCK Bridge Crane, forklifts, facility pallets, underground transporters, etc.) as required during WASTE HANDLING operations only)	X	X		
WHB structure including tornado doors	X		X*	
Underground Ventilation and Filtration System		X		X
Radiation Monitoring System (active waste disposal room exit alpha CAM for underground shift to filtration)		X		X
Central Monitoring System to support underground shift to filtration		X		X

*Note that no defense-in-depth operational requirements apply to the WHB when no WASTE is present.

Following failure of a required SSC, the facility will be placed in the WASTE STORAGE/DISPOSAL MODE. During the time required to effect the required repairs, the facility is not in violation of the TSR.

APPENDIX A BASES

This appendix is utilized to provide summary statements of the reasons for the OPERATIONAL LIMITS and the associated SRs. No OPERATIONAL LIMITS or associated SRs have been identified for the WIPP. Accordingly, no BASES statements are presented in this appendix.

APPENDIX B DESIGN FEATURES

The provisions of the DESIGN FEATURES are present in the DOE-approved WIPP SAR[2] , Chapter 4. As stated in DOE Order 5480.22, Attachment 1, paragraph 2.6, this DESIGN FEATURES appendix is not needed.