ANL/EAD/TM-106

Engineering Analysis for Disposal of Depleted Uranium Tetrafluoride (UF_4)

Environmental Assessment Division
Argonne National Laboratory

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under Contract W-31-109-Eng-38, for the

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Completed: June 2000
Published: June 2001

Work sponsored by U.S. Department of Energy, Office of Environmental Management, and Office of Site Closure–Oak Ridge Office

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NOTATION

The following is a list of the abbreviations, acronyms, and units of measure used in this report.

ABBREVIATIONS AND ACRONYMS

ALARA	as low as reasonably achievable
CFR	*Code of Federal Regulations*
CH_4	methane
CO	carbon monoxide
DF	damage fraction
DOE	U.S. Department of Energy
DOE-HDBK	U.S. Department of Energy Handbook
DOE-STD	U.S. Department of Energy Standard
DOT	U.S. Department of Transportation
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
FEMP	Fernald Environmental Management Project
FTE	full-time equivalent
HEPA	high-efficiency particulate air
HF	hydrogen fluoride
HVAC	heating, ventilation, and air-conditioning
LLMW	low-level mixed waste
LLNL	Lawrence Livermore National Laboratory
LLW	low-level radioactive waste
LLWPAA	Low-Level Radioactive Waste Policy Amendments Act of 1985
LPF	leak path factor
MAR	material at risk
MC&A	material control and accountability
MPFL	maximum possible fire loss
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NMHC	nonmethane hydrocarbons
NO_x	nitrogen oxides

NPH	natural phenomena hazard
NRC	U.S. Nuclear Regulatory Commission
NTS	Nevada Test Site
NTSWAC	Nevada Test Site Waste Acceptance Criteria
NV	Nevada Operations Office (DOE)
OSHA	Occupational Safety and Health Administration
PA	performance assessment
PM_{10}	particulate matter with a diameter of less than or equal to 10 micrometers
RARF	respirable airborne release fraction
ROD	Record of Decision
SO_2	sulfur dioxide
SSCs	structures, systems, and components
TEDE	total effective dose equivalent
U	uranium
UF_4	uranium tetrafluoride
UF_6	uranium hexafluoride
UO_2	uranium dioxide
U_3O_8	tiuranium octaoxide
USEC	United States Enrichment Corporation
WAC	waste acceptance criteria

UNITS OF MEASURE

Bq	becquerel(s)
Btu	British thermal unit(s)
°C	degree(s) Celsius
cfm	cubic foot (feet) per meter
Ci	curie(s)
cm	centimeter(s)
cm^3	cubic centimeter(s)
°F	degree(s) Fahrenheit
ft	foot (feet)
ft^2	square foot (feet)
g	gram(s)
h	hour(s)
ha	hectare(s)
in.	inch(es)
kg	kilogram(s)
kW-h	kilowatt-hour(s)
L	liter(s)
lb	pound(s)
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
ML	megaliter(s) (10^6 liters)
mrem	millirem(s)
mSv	millisievert(s)
MW-h	megawatt-hour(s)
pCi	picocurie(s)
ppm	part(s) per million
s	second(s)
te	metric ton(s) (1,000 kg)
wt%	weight percent (percent by weight)
yr	year(s)

ACKNOWLEDGMENTS

The assistance of John Sattler, Director of Waste Management at the U.S. Department of Energy Fernald Environmental Management Project (FEMP), and Rebecca Guertaf, HAZMAT Project Manager at the Nevada Test Site (NTS), in providing information about past disposal of depleted UF_4 from FEMP at NTS is gratefully acknowledged.

ENGINEERING ANALYSIS FOR DISPOSAL OF DEPLETED URANIUM TETRAFLUORIDE (UF_4)

by S.M. Folga and P.H. Kier

ABSTRACT

This report presents and evaluates options for disposing of depleted uranium in the chemical form of uranium tetrafluoride (UF_4). Two depleted uranium inventories are considered. One results from the original U.S. Department of Energy (DOE) inventory of 560,000 metric tons (te) of depleted uranium hexafluoride (UF_6); the other inventory is the original DOE inventory augmented by 145,000 te of depleted UF_6 from the United States Enrichment Corporation. Preconceptual designs are included for three disposal options: disposal in a vault, disposal in an engineered trench, and disposal in a deep mine cavity. The disposal container is taken to be either a 30-gallon drum or a 55-gallon drum. Descriptions of the facilities associated with the three disposal options are provided. Staffing estimates for the construction and operation of the facilities are also provided. Wastes and emissions from the facilities during construction, operation, and maintenance have been estimated. Parametric studies have also been performed on the basis of 25% and 50% of the original inventory.

1 INTRODUCTION

A number of options for the long-term management of depleted uranium hexafluoride (UF_6) have been assessed by the U.S. Department of Energy (DOE) in the *Depleted Uranium Management Program;* the *Engineering Analysis Report for the Long-Term Management of Depleted Uranium Hexafluoride* (LLNL et al. 1997) and the *Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride* (DOE 1999a). These options included several choices for the chemical form of depleted uranium to be disposed of and three types of disposal facilities. The chemical forms specifically analyzed in the 1997 report were uranium dioxide (UO_2) and triuranium octaoxide (U_3O_8). The types of disposal facilities considered were engineered trenches, vaults, and deep mined cavities.

This report addresses disposal of an additional chemical form, namely, uranium tetrafluoride (UF_4). The 1997 LLNL et al. report documenting the engineering analyses for disposal of the other two chemical forms will be referred to here as the Engineering Analysis Report. Section 6.13 of the Engineering Analysis Report addresses the disposal options for the other chemical forms. To help ensure fair treatment of all options, the same assumptions were used in this report as in the Engineering Analysis Report to the extent possible. When different assumptions are made, they are discussed. Also, to assist in comparison of the options in

Section 6.13 with the option analyzed here for disposal of depleted UF_4, the table of contents, the figures, and the tables in this report are comparable to those in the Engineering Analysis Report, Section 6.13.

1.1 BACKGROUND ON THE DISPOSAL OF DEPLETED UF_4

For the purposes of this study, depleted uranium in the chemical form of uranium tetrafluoride (UF_4) is assumed to be produced at a site other than the disposal facility and is transported to the disposal facility by truck or rail. It is also assumed that the depleted UF_4 would be placed in disposal containers that are suitable for transportation.

1.1.1 Disposal Area Required

The area required for disposal depends on four factors: (1) the weight percent of uranium in the compound disposed of, (2) the bulk density of the compound disposed of, (3) the type of disposal container used, and (4) the type of disposal units used (engineered trenches, vaults, mined cavities). Depleted UF_4 is a solid composed of agglomerating particles with a texture similar to baking soda. It is nonvolatile, nonhydroscopic, but only slightly soluble in water (~40 ppm at room temperature) (Katz et al. 1986). It has a particle density of 6.5 g/cm^3; however, its bulk density, which depends on production process and the properties of the starting uranium compounds, ranges between 2.0 and 4.5 g/cm^3. To be consistent with the accident analysis in the Engineering Analysis Report in which a spill of a 55-gallon drum containing UF_4 is considered, the bulk density of UF_4 is taken as 3.2 g/cm^3.

The physical properties of UF_4 are given in Table 1.1.[1] Because of the difference between the particle density and the bulk density, UF_4 itself does not have structural stability.

It is assumed in this analysis that the potential evolution of fluoride ions due to chemisorbed hydrogen fluoride (HF) would be removed during the conversion process by heating the depleted UF_4 product before it is placed in drums.

Depleted UF_4 reacts very slowly with moisture at ambient temperature to form depleted UO_2 and HF, which would enhance the corrosion rate of the disposal packages. This analysis assumes that drum filling during the conversion process would be performed under inert conditions to exclude airborne moisture.

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[1] For reader convenience, tables and figures referred to in Section 1 are placed at the end of the section.

One potential issue is the reactivity of depleted UF_4 in bulk form. Croff et al. (2000) state that the low solubility of depleted UF_4 in water would result in a reaction rate low enough to consider the material to be not "reactive" as the term is generally interpreted in waste management.

Historically, approximately 1,870 te of depleted UF_4 in the form of salts, residues, and dust has been shipped from the U.S. DOE Fernald Environmental Management Project (FEMP) to the U.S. DOE Nevada Test Site (NTS) for disposal (Croff et al. 2000). The material was disposed of in white metal boxes ($1.2 \times 1.2 \times 2.1$ m [$4 \times 4 \times 7$ ft]) without any additional overpacking (Guertaf 2000a). The bulk depleted UF_4 from the FEMP was not treated before disposal at the NTS.

A review of the properties of the depleted UF_4 in bulk form by the FEMP and NTS prior to shipment to the NTS did not reveal any major issues associated with reactivity (Guertaf 2000a; Sattler 2000). It was demonstrated that the reaction rate was slow enough that the Nevada Test Site Waste Acceptance Criteria and U.S. Department of Transportation (DOT) requirements were met. A position paper was issued by the FEMP before these shipments began (Guertaf 2000b). However, it should still be demonstrated that depleted UF_4 produced in the future can be safely shipped; additional packaging costs or extended reviews of the waste program or waste stream profile may be required (Croff et al. 2000). Because of the speculative nature of the overpacking or review process, they were not considered further in this analysis.

Because UF_4 forms a corrosive product in the presence of water, it is not suitable for grouting. Furthermore, it cannot be vitrified and still be disposed of as UF_4 because vitrification would oxidize UF_4 to become an oxide containing UO_2 and U_3O_8. Macroencapsulation using molten polyethylene had been considered as a potential treatment option for depleted UF_4 shipped from the FEMP to the NTS for disposal; however, treatment of the FEMP's depleted UF_4 was considered unnecessary for disposal at the NTS. Therefore, it is assumed that UF_4 is not processed to achieve a stable waste form. However, it is not required that a disposal waste form be stable if it is Class A waste under NRC's classification scheme, and depleted UF_4 is Class A waste. All that is required is that waste must have structural stability (i.e., maintain its physical dimensions and its form) under expected disposal conditions (such as weight of the overburden and compaction equipment, the presence of moisture, and microbial activity) and expected internal factors (such as radiation effects and chemical changes). Structural stability can also be achieved by placing the waste in a disposal container and a structure that provide stability after disposal (Title 10, *Code of Federal Regulations,* Part 61.56(b) [10 CFR 61.56(b)]). It is assumed here that UF_4 is disposed of in strong 30-gallon or 55-gallon drums.[2] It is also assumed that the disposal container and the disposal facility provide structural stability.

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[2] The metric equivalents of 30 and 55 gallons are approximately 114 and 208 liters, respectively. Since these drums are more commonly referred to by their standard unit volumes, they will be called 30-gallon and 55-gallon drums in this report.

In the Engineering Analysis Report, 30-gallon drums with a wall thickness of 0.241 cm (0.095 in.) and weighing 45.4 kg (100 lb) were used for the disposal of UO_2, and 55-gallon drums with a wall thickness of 0.135 cm (0.053 in.) were used for the disposal of U_3O_8. It is assumed that drums with the same specifications would be used for the disposal of UF_4 (see Table 1.2). UF_4 is made directly from the conversion of UF_6. The DOE inventory of UF_6 considered in the Engineering Analysis Report was 560,000 te. This inventory converts to approximately 500,000 te of UF_4. Thus, with the assumed bulk density of 3.2g/cm^3, 1,373,000 30-gallon drums would be needed for its disposal. These drums would be shipped at the rate of 68,650 drums per year over a 20-year period. Alternatively, 749,000 55-gallon drums (or 37,450 drums per year) would be needed.

At the time the Engineering Analysis Report was written, the inventory of depleted UF_6 that fell under the responsibility of DOE was 560,000 te stored in 56,422 cylinders. Since then, two memoranda of agreement have been signed between DOE and the United States Enrichment Corporation (USEC) that have or will result in the transfer of 145,000 te of depleted UF_6 in approximately 11,200 cylinders from USEC to DOE (DOE 1999b). This transfer increases the inventory of the material that falls under DOE's management responsibility to approximately 705,000 te in about 57,700 cylinders. This report addresses the disposal of both the original inventory and the new inventory of depleted UF_6 after it has been converted to UF_4. The original inventory is included mainly to facilitate comparison with the Engineering Analysis Report. The new inventory converts to approximately 630,000 te of UF_4. Disposal of the new inventory would require 1,728,000 30-gallon drums or 943,000 55-gallon drums (Table 1.3).

An arid climate provides the most favorable conditions for disposal of depleted uranium. A specific arid location for the disposal facility, which could be a DOE facility or a commercial facility operating under a radioactive materials license issued by the U.S. Nuclear Regulatory Commission (NRC) or an Agreement State, will be determined at a later date. To identify whether there might be issues associated with the disposal of depleted UF_4, questions of conformity to the waste acceptance criteria (WAC) of a DOE disposal facility and to the conditions of the radioactive material license of a commercial facility are considered. For the purposes of this report, the waste acceptance criteria for the NTS (DOE 1999c) and the radioactive materials license conditions for the Envirocare facility in Clive, Utah (Utah Department of Environmental Quality 2000), are considered to be typical of disposal requirements in an arid climate.

The current waste acceptance criteria at NTS limit the weight of a drum to 544 kg. As discussed in Section 9, a 30-gallon drum fully loaded with UF_4 would comply with this limitation, while a fully loaded 55-gallon drum (665 kg, or 1,466 lb) would not. This limitation in the WAC is apparently based on an Occupational Safety and Health Administration regulation regarding the loading of hoists as applied to forklifts currently in use at NTS. The Engineering Analysis Report, which considered an earlier set of waste acceptance criteria at NTS, allowed disposal of 625 kg (1,378 lb) of U_3O_8 in 55-gallon drums. The radioactive material license for the Envirocare disposal facility does not limit the weight of disposal containers. Disposal of UF_4

in 55-gallon drums may be cost-effective for some disposal options. Also, the weight limit on drums at NTS does not have a radiological basis. Use of stronger forklifts at a depleted UF_4 disposal facility at NTS might remove this limitation. Therefore, the option of disposal in 55-gallon drums is presented in this report.

1.1.2 Other Considerations

The primary concerns for disposal of UF_4, as for other radioactive wastes, are to isolate the waste from the environment for as long as possible, to ensure that if or when engineered barriers have lost effectiveness that standards for the protection of the general public are met, and that after institutional control over the disposal facility has ended, inadvertent intruders will not be harmed. To ensure that these performance objectives are met, both DOE and NRC or Agreement States require detailed analyses, called performance assessments, of the potential radiological dose to the public following closure of the disposal facility. DOE in DOE M 435.1-1, *Radioactive Waste Management Manual*, requires a performance assessment that covers a 1,000-year period after closure. It is beyond the scope of an engineering analysis to estimate radiological dose to the general public or an inadvertent intruder following closure of a disposal facility. However, such analyses would be conducted under the National Environmental Policy Act (NEPA).

1.1.3 Safety and Safeguards

DOE M 435.1-1, *Radioactive Waste Management Manual*, requires that appropriate features be incorporated into the design and operation of radioactive waste management facilities, operations, and activities to prevent unauthorized access and operations, and for purposes of nuclear material control and accountability, where applicable. These features are to be consistent with DOE O 470.1, *Safety and Security Program*.

DOE O 470.1 requires that certain facilities have a safeguards and security program. Such facilities include “Those that have a radiological/toxicological sabotage threat that would cause a unacceptable impact on the national security, the health and safety of employees, the public or the environment.” Persons entering the disposal facility with sabotage or another malevolent intent could cause drums to be damaged or cause explosions that could damage engineered trenches, vaults, or access to mined cavities. Hence, the health and safety of employees and the public, or the environment, could be threatened; therefore, a safeguards and security program would be needed. Because the disposal facility will not contain special nuclear material nor classified matter, DOE intends that a graded approach be used so that the “magnitude of the resources expended are commensurate with the security interest’s importance and the impact of the loss, destruction, misuse.”

It is beyond the scope of an engineering analysis to address details of a safeguards and security plan except how it would affect the equipment required (Appendix A) and the data used to estimate radiation exposure and staffing (Appendix B). It was assumed that security personnel would be assigned to the product receiving and shipping warehouse, the administration building, a disposal unit, and key areas of the site (e.g., entry point); that all persons when on-site would be issued security badges that would have location indicators that would be monitored by security personnel; and that the receiving warehouse and repackaging building would have an automated security station to control access. Security surveillance and alarm systems (e.g., closed circuit television, remote operated locked barriers) would be included, as appropriate. Site security fencing could consist of galvanized steel fabric fencing with barbed wire or barbed wire coil topping. The fence would limit access into the site to a single road where a guard station would be located at the boundary of the site. Perimeter fence lighting particulars will be determined by security and safeguards requirements. Full-time security and emergency staff could provide immediate aid in the event of any security breach or environmental incident.

1.1.4 Fire Protection

DOE O 420.1, *Facility Safety*, Section 4.2, establishes requirements for a comprehensive protection program to minimize the likelihood of the occurrence of a fire or related event and to minimize adverse impacts should a fire or related event occur. Acceptance methods for facility fire protection are contained in DOE Standard DOE-STD-1066-97, *Fire Protection Design Criteria* (DOE 1997), and the *DOE Fire Protection Handbook*, DOE-HDBK-1062-96 (DOE 1996). These requirements replace certain mandatory fire protection requirements that were formerly stipulated in DOE Order 5480.7A, *Fire Protection*, and DOE Order 6430.1A, *General Design Criteria*. Supplemental fire protection guidance applicable to the design and construction of DOE facilities and site features (such as water distribution systems) is provided. This guidance is intended to be used in conjunction with the application building code, National Fire Protection Association (NFPA) Codes and Standards, and any other applicable construction criteria.

DOE Standard DOE-STD-1066-97 states in Section 5.2 that new permanent structures in excess of 5,000 ft^2 (465 m^2) in floor area should be of noncombustible or fire resistive construction if no local building code is enforced. The three long-term storage options for depleted uranium metal (i.e., building, vault, mined cavity) would meet this structural requirement.

In addition, DOE Standard DOE-STD-1066-97 states in Section 5.3 that all facilities of significance, including facilities where a fire could cause unacceptable off-site consequences to health and safety, should be protected by an automatic fire suppression system (usually a wet pipe sprinkler system). DOE has historically considered a facility with a maximum possible fire loss (MPFL) in excess of $1 million as being significant from a property protection standpoint.

In accordance with these requirements, the following fire protection systems and features are provided:

- Fire detection and alarm systems are provided in all buildings.

- Automatic fire sprinkler systems are used throughout the facilities, including the product receiving and shipping warehouse.

- The administration building and the product receiving and shipping warehouse (where the majority of the workers are located) are subdivided by fire-rated barriers to limit the maximum possible fire loss and to protect life by providing fire-rated escape routes for operating personnel.

It is assumed during building design that water for fire fighting would be obtained from the domestic system. Necessary equipment would include water pumps and area distribution loops.

1.1.5 Overview of Disposal Facilities

For purposes of this report, a disposal facility would be a single-purpose facility intended for permanent disposal of drums containing depleted uranium. It would be designed for receiving, inspecting, and repackaging (when necessary) drums of depleted UF_4 and disposing of them in disposal units. A disposal facility for this purpose would have the following support facilities: an administration building, a receiving warehouse, a repackaging area, and a workshop. The repackaging area would share a building (product receiving and shipping warehouse) with the receiving warehouse.

The process flow within a disposal facility would be as follows. Drums of depleted uranium would be received at the facility by rail or road and be unloaded by davit crane at an unloading dock attached to the product receiving and shipping warehouse. Drums would be inspected for damage and external smearable contamination in the product receiving and shipping warehouse. Undamaged drums without smearable contamination would be transported to a temporary storage area by a bridge crane. Damaged drums and contaminated drums would be transported to a repackaging area, where the contents of damaged and contaminated drums would be transferred to new drums, reinspected, and then transferred back to the area where undamaged drums are placed in temporary storage.

Drums containing UF_4 would be transported on pallets by truck from the temporary storage area in the product receiving and shipping warehouse to a disposal unit. For disposal in engineered trenches and vaults, mobile cranes on track vehicles would be used for emplacement. For disposal in mined cavities, forklifts would be used for emplacement.

Operations at a disposal facility would require little energy and few materials. The major consumable item would be the diesel fuel used in the on-site movement of the drums. Minor amounts of wastes would be generated, the most notable being the air emissions from on-site diesel transport and from minimal space heating, and the waste resulting from damaged drums, which would be assumed to be low-level (radioactive) waste (LLW). Material and energy flows for a disposal facility would be dominated by the material and energy used in its construction.

The depleted uranium waste material flows, from depleted UF_6 through drum storage as depleted UF_4, are shown on Figures 1.1a and 1.1b. These figures reflect the original and new inventories, respectively.

Process flow diagrams for construction and operation of the wasteform facility (which includes the product receiving and shipping warehouse), assuming the new inventory, are provided in Figures 1.2a and 1.2b, and 1.3a and 1.3b, respectively.

1.2 DEPLETED URANIUM WASTE FORM FOR DISPOSAL

For this analysis, it is assumed that the disposal facility would be located on an arid site that may be either a DOE site, subject to site-specific WAC and DOE orders, or a commercial site, subject to a radioactive material license issued by an Agreement State and regulations promulgated by the NRC in 10 CFR Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste* (NRC 2000). Although there may be other disposal facilities at the location, it is assumed that depleted UF_4 would be disposed of in a separate disposal facility in a waste form that meets the requisite WAC or radioactive material license conditions. Representative DOE and commercial sites for this disposal facility would be the NTS and the Envirocare site in Tooele County, Utah, respectively. It is assumed that the facility for disposal of UF_4 would be required to comply with waste acceptance criteria (e.g., the WAC for the existing disposal facility at NTS) that meet the requirements of DOE M 435.1-1, *Radioactive Waste Management Manual*, or radiological material license conditions (e.g., those for the Envirocare facility) that meet the requirements of 10 CFR Part 61. More information about these requirements is provided in Section 9. A mined cavity would not be land disposal as defined in 10 CFR Part 61; nor does DOE M 435.1-1 address such an option. Hence, regulatory conditions for disposal of UF_4 in a deep mined cavity are not well-defined.

1.3 DISPOSAL IN AN ENGINEERED TRENCH

Engineered trenches are well suited for disposing of low-activity waste in an arid climate. As discussed in the Engineering Analysis Report, the length of a trench is limited by such factors as site conditions and the volume of waste received per unit time. Trench widths may be dictated by the amount of radiation the workers might be exposed to, stability of the trench walls, the volume and/or size of the waste to be buried, types and weights of excavating and compacting machinery, and site conditions, such as topological relief. Factors influencing the depth include the physical aspects of the waste size, stability of the soil slopes, depth to bedrock and to water-bearing zones, permissible proximity of the top of the waste to the ground surface, and the type and amount of cover and liner required. The depth of the water table is the primary factor that limits the depth of a trench. The bottom of a trench should be sufficiently distant from the water table so as not to disturb it. Usually the floor of a trench slopes gently to collect infiltrated water.

Waste must be emplaced in a manner that maintains the structural integrity of the disposal containers and of the disposal facility. To minimize the effects of subsidence of the disposal facility, spaces between containers should be filled with earth, sand, gravel, or like material as each waste layer is placed. The most efficient means of emplacing the disposal containers is to put them on pallets and use forklifts to emplace the loaded pallets. Pallets might introduce some spaces, but are strong enough to hold the disposal containers without deforming. The Engineering Analysis Report assumes that the drums would be placed on wooden pallets and a forklift would be used to place the pallets in engineered trenches. To direct rain away from a trench, backfill should extend to a maximum of 1 meter above the local grade and be sloped. The total estimated area required for the engineered trench disposal facility is given in Tables 1.4a and 1.4b for the original depleted uranium inventory and the new inventory, respectively. Tables 1.5a and 1.5b show the process flow for construction and operation of an engineered trench for the original inventory of depleted uranium and the new inventory, respectively. Figures 1.4a and 1.4b and 1.5a and 1.5b portray the information in Tables 1.5a and 1.5b in graphical format for the new inventory.

1.4 DISPOSAL IN A VAULT

As stated in the Engineering Analysis Report, one option to be addressed is disposal in a concrete vault. In this report, it is assumed that the vault would be made of reinforced concrete and be built just below grade. Excavated material would be mounded above the vault and the original grade as a water/intruder resistant cap. Table 1.6 shows the number of vaults and the site area needed as a function of drum size and depleted uranium inventory. Table 1.7 shows the process flow for construction and operation of one vault. Figures 1.6a and 1.6b and 1.7a and 1.7b portray the information in Table 1.7 in graphical format for the new inventory. Section 2 provides the dimensions and a specific description of the vault.

1.5 DISPOSAL IN A MINED CAVITY

The design for a mined-cavity disposal facility follows the conceptual design found in the Engineering Analysis Report for the oxide waste forms. A mined-cavity disposal facility would consist of (1) surface facilities that provide space for waste receiving and inspection and shafts and ramps for access to and ventilation of the underground portion of the facility; (2) tunnels ("drifts") for the transport of waste for underground emplacement and emplacement itself and tunnels for the removal of excavated rock and for serving the area; (3) a waste ramp to permit transport of waste containers to the underground emplacement facilities; and (4) a ramp that would be used for excavating and constructing the underground facility and for removing excavated rock. The facility would also include shafts for the movement of workers and materials between the surface and underground areas, for utility access, and for ventilation of emplacement areas, underground shops and support areas, and decontamination areas.

Although components of a mined-cavity disposal facility for depleted uranium would be similar to those for the Yucca Mountain repository, emplacement in this facility can be denser than in Yucca Mountain because concerns about shielding of workers, heat generation, and criticality safety are not nearly as acute or are absent for the facility discussed here. As for mined-cavity disposal of depleted uranium in the oxide waste forms, emplacements would be spaced 32 m (105 ft) on centers, which is consistent with other tunneling in other mine media.

Material flows and energy balances for construction and operation of a mined-cavity disposal facility are shown in Tables 1.8a and 1.8b for the original inventory and the new inventory, respectively. Figures 1.8a and 1.8b and 1.9a and 1.9b portray the information in Tables 1.8a and 1.8b in graphical format for the new inventory.

During the construction phase, the primary output of the mined-cavity disposal facility would be material excavated to provide underground access, as well as the drifts in which the palletized waste drums would be stacked. The principal construction material used would be steel-reinforced concrete to line the drifts and to provide for ramps, roadways, and foundations. In addition, major services, such as potable water supply, air-conditioning, and ventilation must be provided. The construction phase would be the most energy-intensive phase because of energy consumption by excavating equipment. In the operating phase, energy consumption would be primarily by materials-handling equipment, such as fork-lifts, conveyors, and elevators. Tables 1.4a and 1.4b show the total length of emplacement drifts and the site area needed for the original inventory and the new inventory, respectively.

TABLE 1.1 Physical Properties of Uranium Tetrafluoride

Melting Point (°C)	Bulk Density (g/cm^3)	Solubility in Water, Neutral pH	Inhalation Solubility Class[a]
960±5	2.0-4.5	Very slightly soluble	W

[a] As established by the International Commission on Radiation Protection, Class "W" material is relatively insoluble; lung retention time is weeks.

Source: Martin Marietta Energy Systems (1990).

TABLE 1.2 Characteristics of Drum Disposal Containers

Drum Capacity (gallons)	Height (cm)	Outside Diameter (cm)	Gauge/Wall Thickness (cm)	Weight (empty) (kg)
55	8.3	57.15	40.6/0.135	34.0
30	4.0	46.4	30.5/0.241	45.4

TABLE 1.3 Content and Number of UF_4 Disposal Containers (3.2 gm/cm^3)

			Number of Drums	
Drum Capacity (gallons)	Weight Drum Contents (te)	Amount of Uranium per Drum (te)	Original Inventory	New Inventory
30	0.364	0.276	1.373E+06	1.729E+06
55	0.667	0.504	0.749E+06	0.943E+06

TABLE 1.4a Area Required for Trench and Underground Mined-Cavity Disposal, Original Inventory

Drum Capacity (gallons)	Trench Disposal Site Area (hectares)	Underground Mined Cavity: Underground Area (hectares)	Underground Mined Cavity: Emplacement Drift Length (meters)
30	20.6	247	28,700
55	17.4	187	22,500

TABLE 1.4b Area Required for Trench and Underground Mined-Cavity Disposal, New Inventory

Drum Capacity (gallons)	Trench Disposal Site Area (hectares)	Underground Mined Cavity: Underground Area (hectares)	Underground Mined Cavity: Emplacement Drift Length (meters)
30	25.5	310	38,428
55	21.6	234	28,743

TABLE 1.5a Annual Utility and Materials Requirements for Construction and Operation of the Engineered Trench Disposal Facility, Original Inventory

Container	Group	Type	Construction	Operations
30-gallon drums	Utilities	Electricity, kW-h	221	1,030
		Water, ML	0.28	0.083
		Diesel fuel, L	5.69E+04	148,300
	Material	Sand, m^3	2,920	
		Gravel, te	122	
		Clay, m^3	424	
		Excavated material, m^3	6.45E+04	
55-gallon drums	Utilities	Electricity, MW-h	190	762
		Water, ML	0.27	0.052
		Diesel fuel, L	4.83E+04	82,100
	Material	Sand, m^3	2,430	
		Gravel, te	102	
		Clay, m^3	385	
		Excavated material, m^3	5.48E+04	

TABLE 1.5b Annual Utility and Materials Requirements for Construction and Operation of the Engineered Trench Disposal Facility, New Inventory

Container	Group	Type	Construction	Operations
30-gallon drums	Utilities	Electricity, kW-h	221	1,034
		Water, ML	0.29	0.084
		Diesel fuel, L	5.69E+04	149,400
	Material	Sand, m^3	2,920	
		Gravel, te	122	
		Clay, m^3	424	
		Excavated material, m^3	6.45E+04	
55-gallon drums	Utilities	Electricity, MW-h	190	765
		Water, ML	0.28	0.052
		Diesel fuel, L	4.83E+04	82,600
	Material	Sand, m^3	2,430	
		Gravel, te	102	
		Clay, m^3	385	
		Excavated material, m^3	5.48E+04	

TABLE 1.6 Number of Disposal Vaults

Drum Capacity (gallons)	Inventory	Number of Vaults Annually	Total Number of Vaults	Site Land Area (hectares)
30	Original	3.8	76	25.4
55	Original	4.2	84	31.6
30	New	3.8	95	31.6
55	New	4.2	105	37.9

TABLE 1.7 Utility and Materials Requirements for Construction and Operation of the Vault Disposal Facility, One Vault

Group	Type	Construction	Operations
Utilities	Electricity, MW-h	12,500	328
	Water, ML	0.78	0.02
	Diesel fuel, L	17,800	51,100
Materials	Redi-mix, m^3	1,750	
	Steel, te	58.5	
	Gravel, te	910	
	Liner, m^3	2,220	
	Excavated material, m^3	7,520	

TABLE 1.8a Utility and Materials Requirements for Construction and Operation of the Mined-Cavity Disposal Facility, Original Inventory (total)

Container	Group	Type	Construction	Operations
30-gallon drums	Utilities	Electricity, GW-h	5,760	166
		Water, ML	16.7	61.8
		Diesel fuel, L	716,000	186,000
	Materials	Redi-Mix, m^3	99,000	
		Steel, te	3,890	
55-gallon drums	Utilities	Electricity, GW-h	4,810	123
		Water, ML	14.0	46.5
		Diesel fuel, L	990,000	125,000
	Materials	Redi-mix, m^3	82,000	
		Steel, te	3,230	

TABLE 1.8b Utility and Materials Requirements for Construction and Operation of the Mined-Cavity Disposal Facility, New Inventory (total)

Container	Group	Type	Construction	Operations
30-gallon drums	Utilities	Electricity, GW-h	6,670	209
		Water, ML	19.4	77.5
		Diesel fuel, L	846,000	234,000
	Materials	Redi-mix, m^3	116,000	
		Steel, te	4,540	
55-gallon drums	Utilities	Electricity, GW-h	5,540	154
		Water, ML	16.1	58.3
		Diesel fuel, L	684,000	157,000
	Materials	Redi-mix, m^3	95,000	
		Steel, te	3,740	

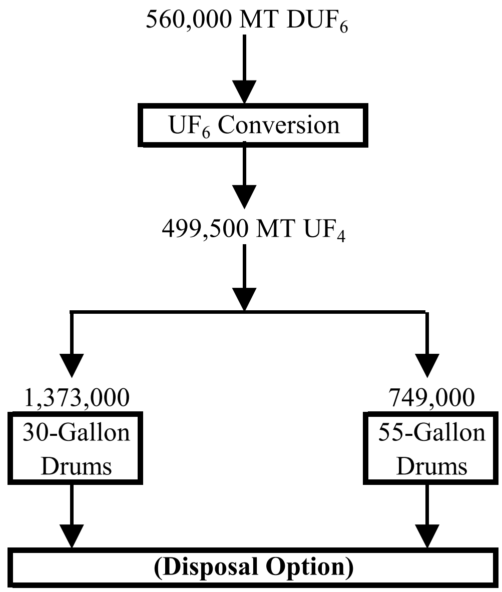

FIGURE 1.1a Material Flow Diagram, Old Inventory

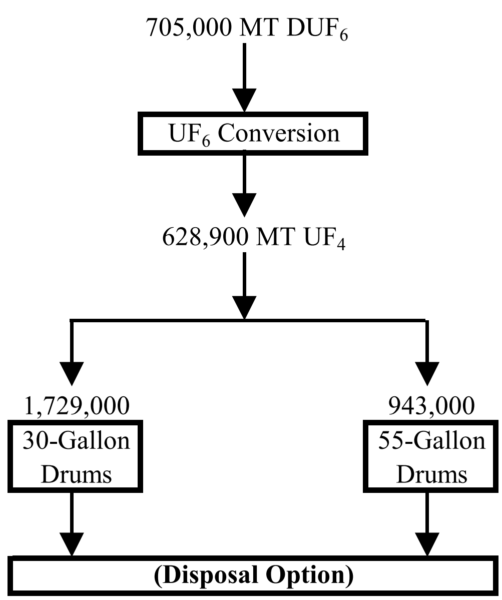

FIGURE 1.1b Material Flow Diagram, New Inventory

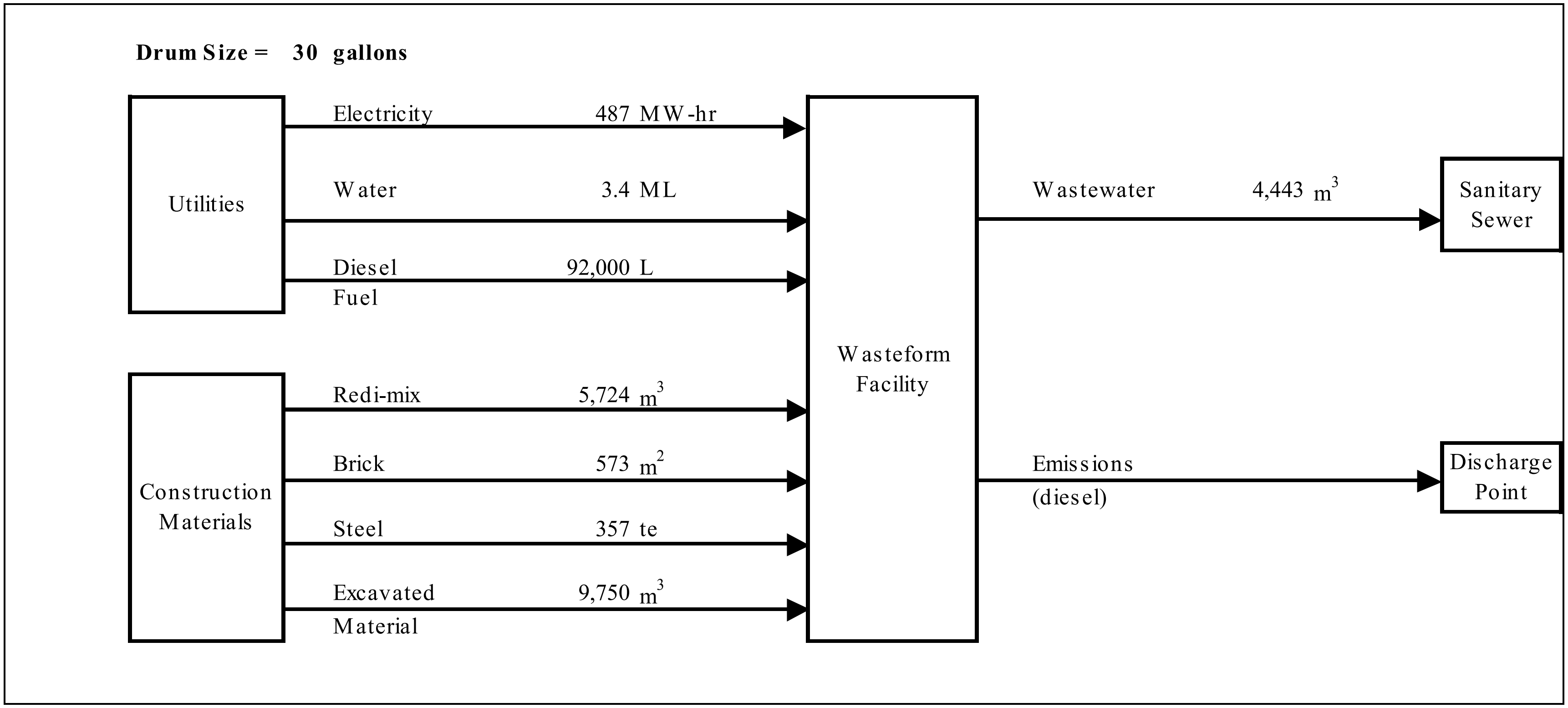

FIGURE 1.2a Wasteform Facility Process Flow Diagram for Construction: New Inventory, 30-Gallon Drums

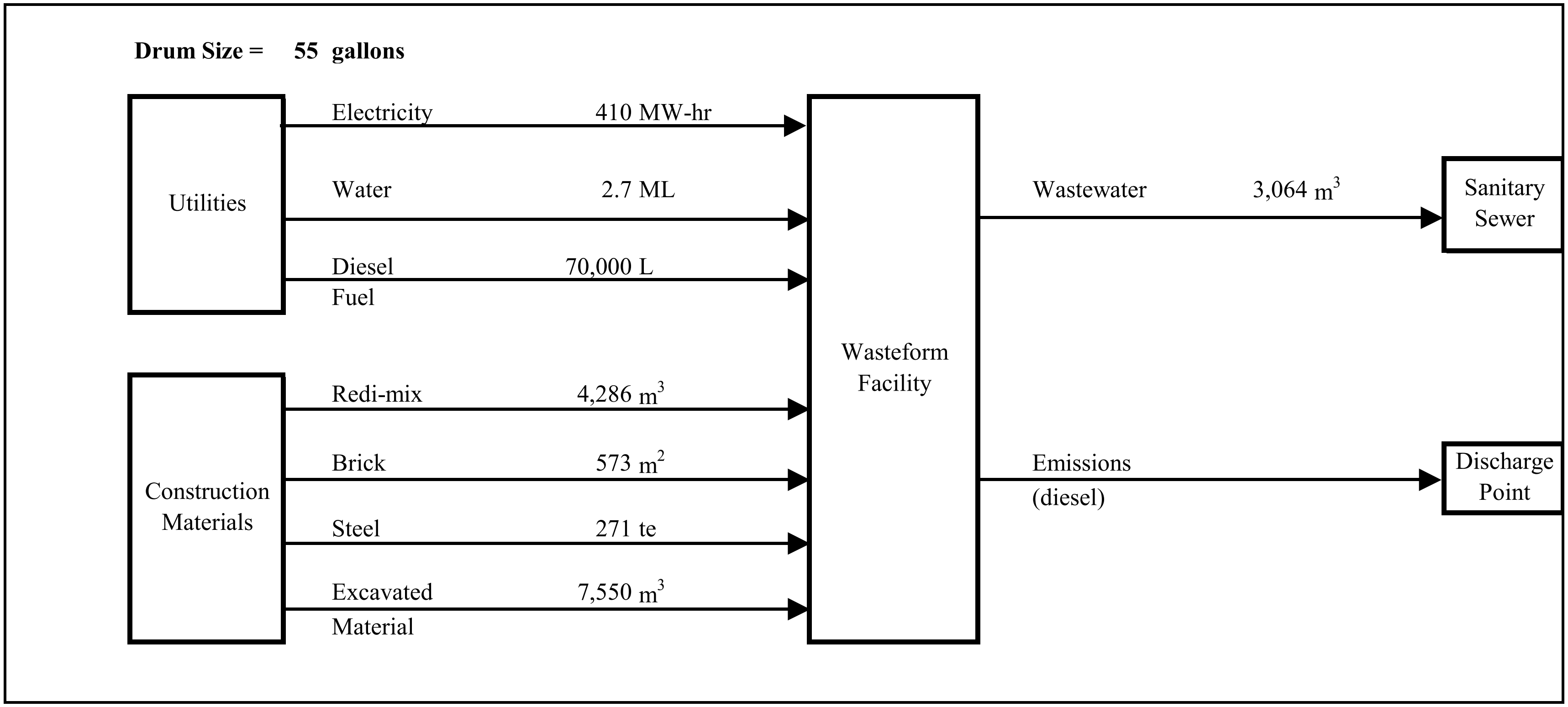

FIGURE 1.2b Wasteform Facility Process Flow Diagram for Construction: New Inventory, 55-Gallon Drums

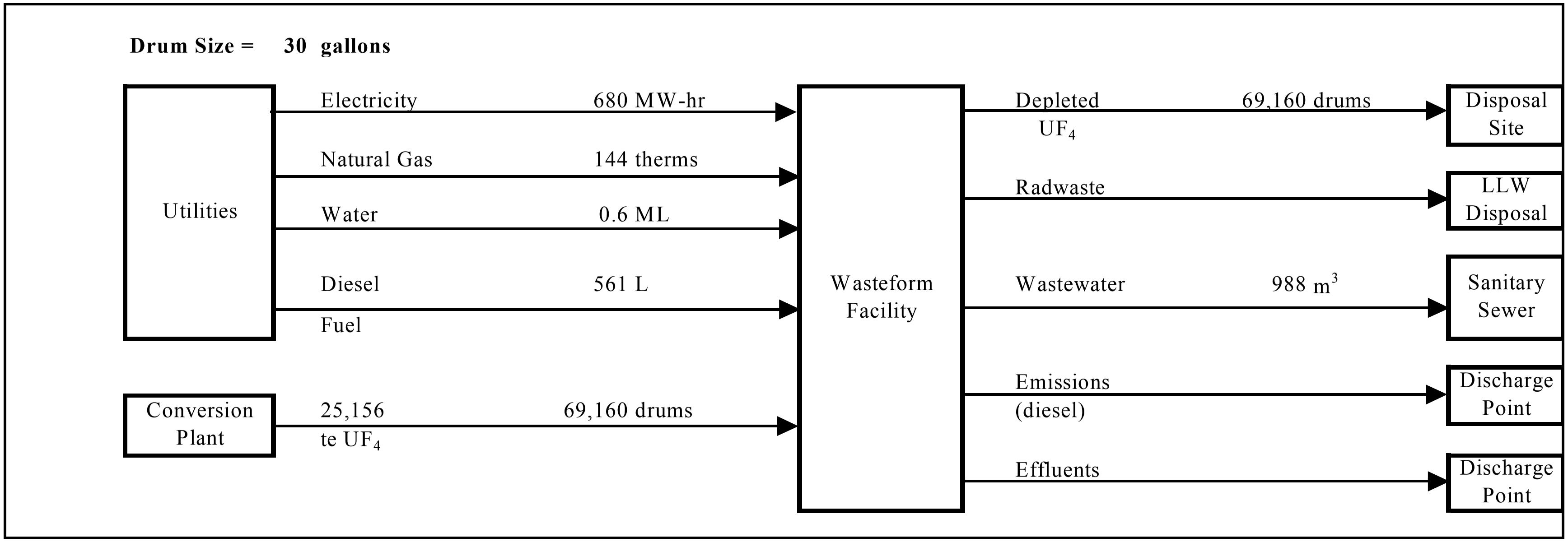

FIGURE 1.3a Wasteform Facility Process Flow Diagram for Operations (annual basis): New Inventory, 30-Gallon Drums

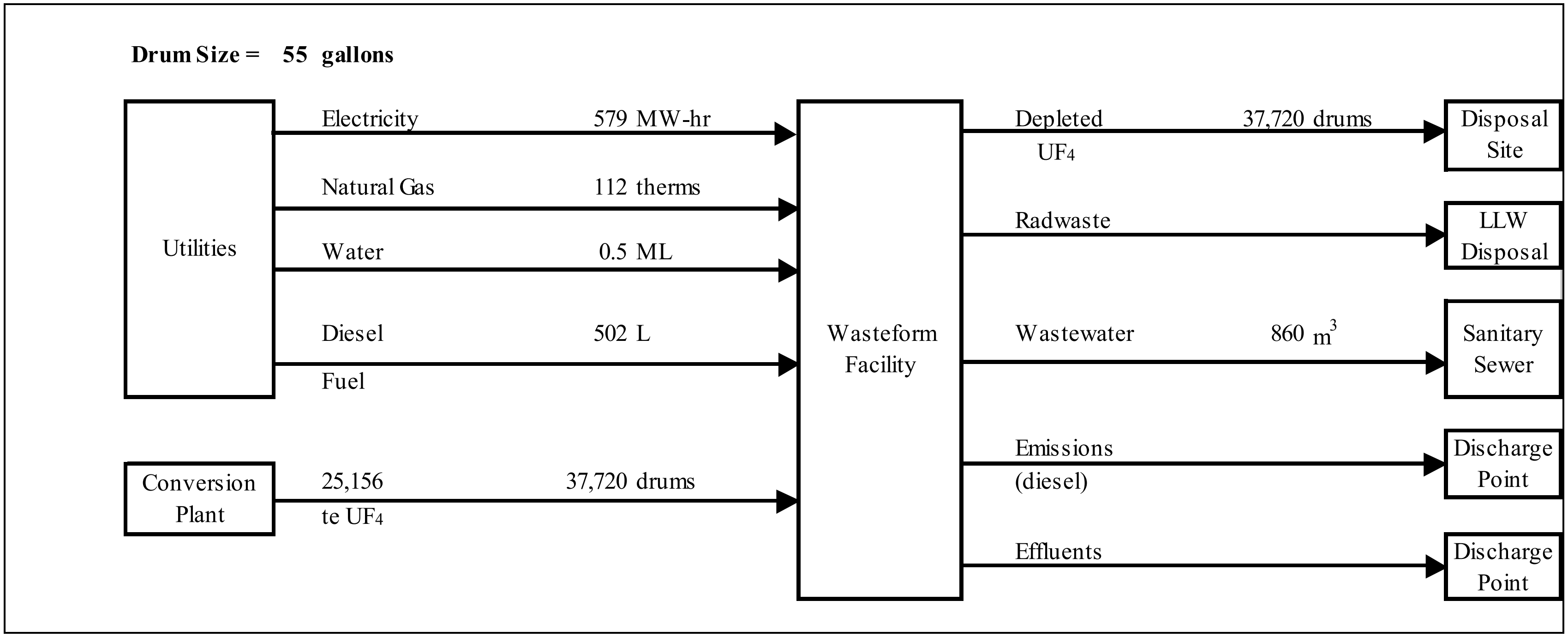

FIGURE 1.3b Wasteform Facility Process Flow Diagram for Operations (annual basis): New Inventory, 55-Gallon Drums

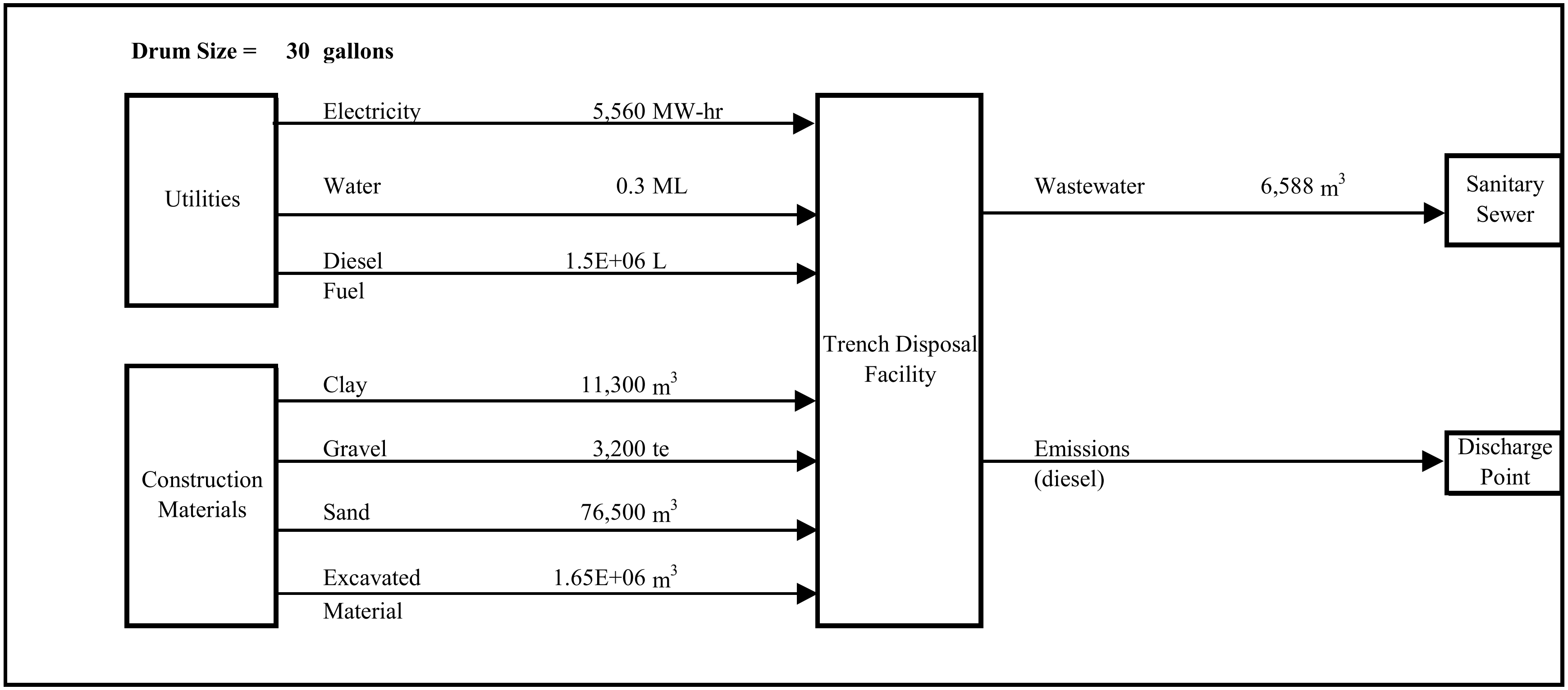

FIGURE 1.4a Trench Disposal Facility Process Flow Diagram for Construction: New Inventory, 30-Gallon Drums

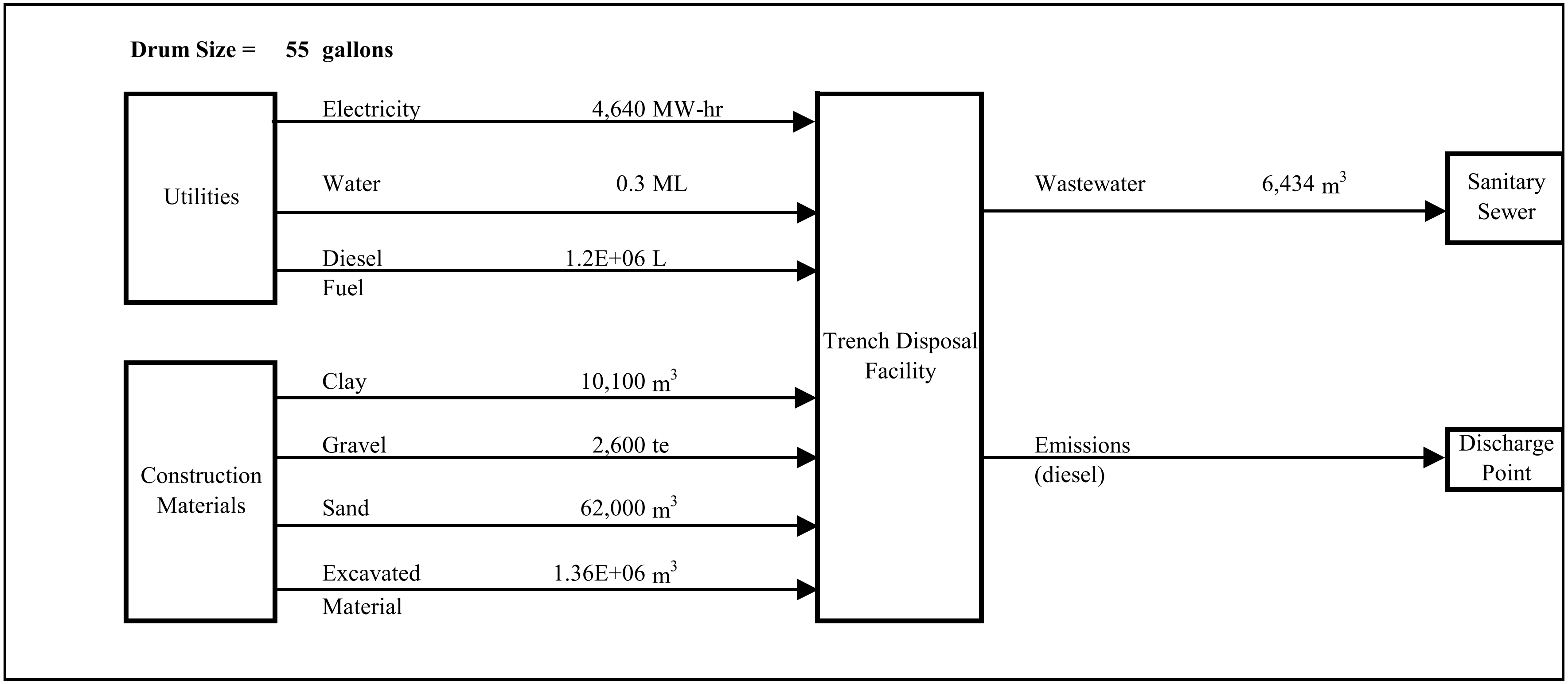

FIGURE 1.4b Trench Disposal Facility Process Flow Diagram for Construction: New Inventory, 55-Gallon Drums

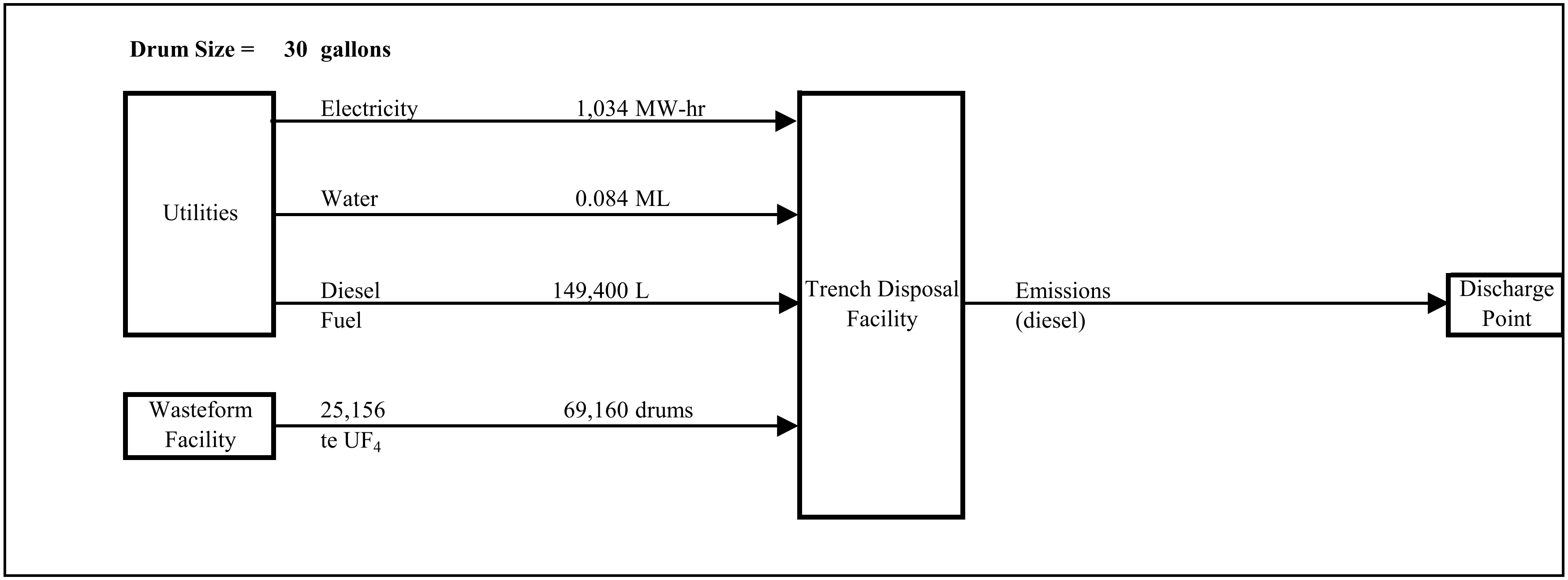

FIGURE 1.5a Trench Disposal Facility Process Flow Diagram for Operations (annual basis): New Inventory, 30-Gallon Drums

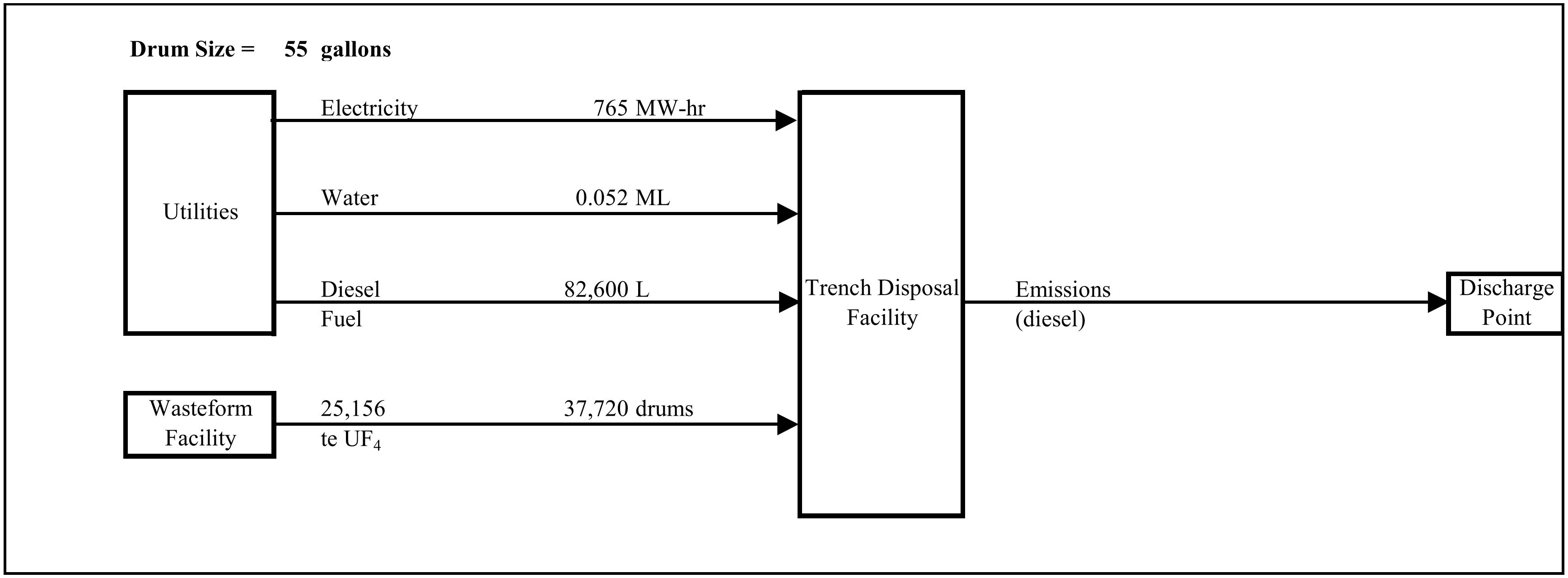

FIGURE 1.5b Trench Disposal Facility Process Flow Diagram for Operations (annual basis): New Inventory, 55-Gallon Drums

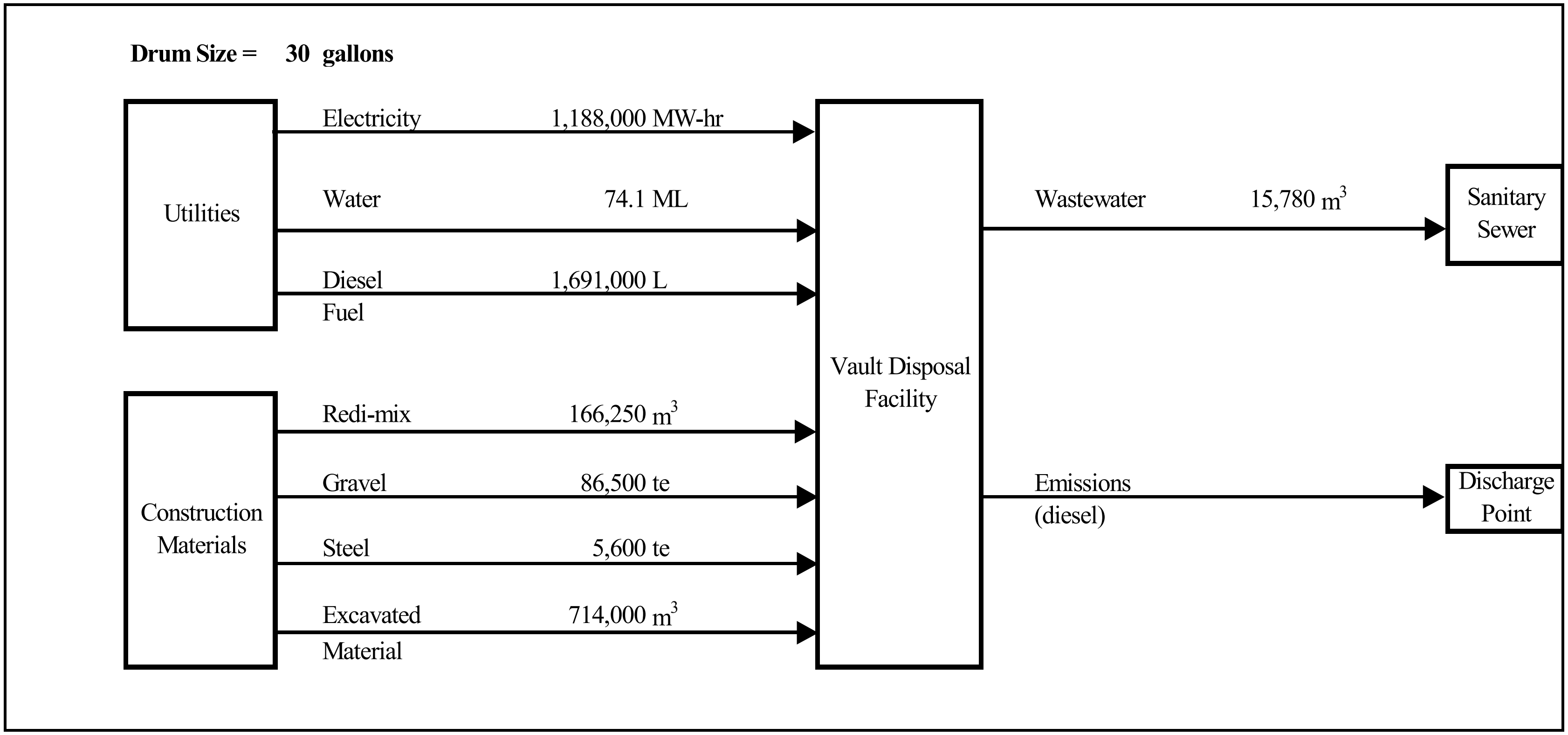

FIGURE 1.6a Vault Disposal Facility Process Flow Diagram for Construction: New Inventory, 30-Gallon Drums

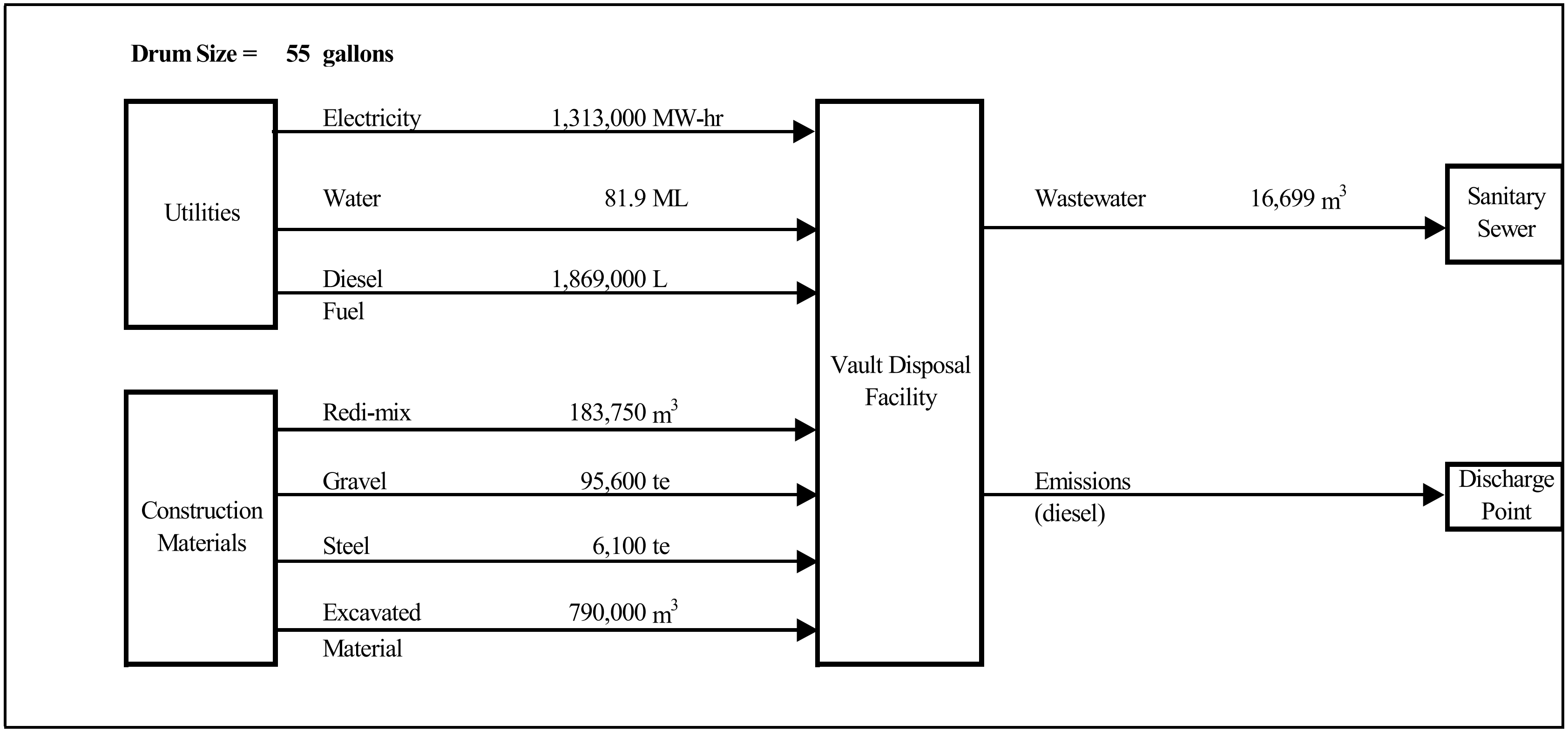

FIGURE 1.6b Vault Disposal Facility Process Flow Diagram for Construction: New Inventory, 55-Gallon Drums

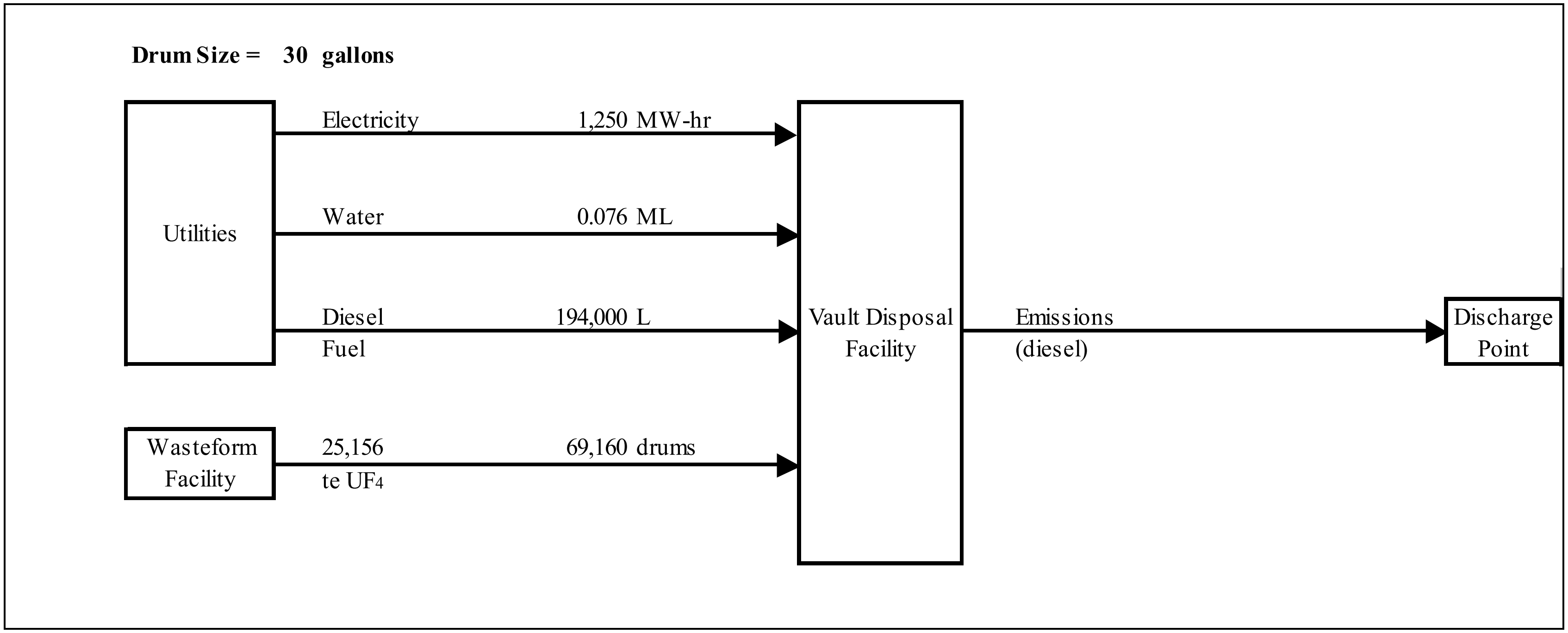

FIGURE 1.7a Vault Disposal Facility Process Flow Diagram for Operations (annual basis): New Inventory, 30-Gallon Drums

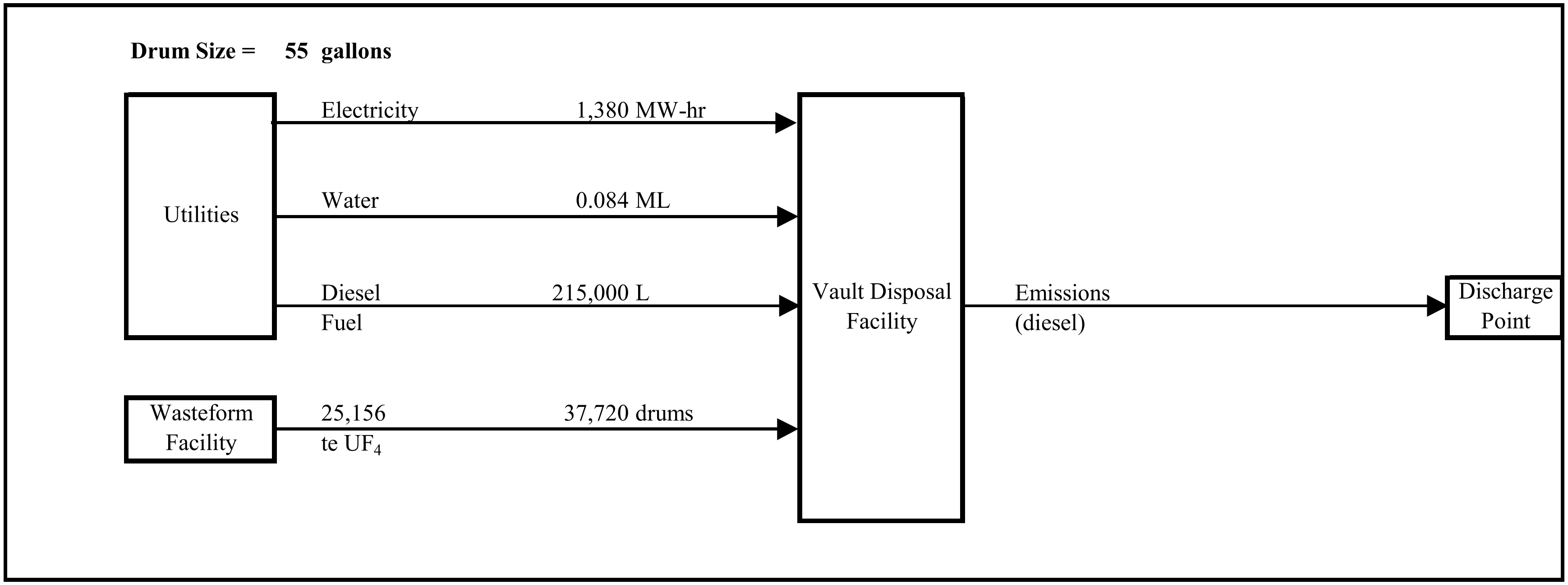

FIGURE 1.7b Vault Disposal Facility Process Flow Diagram for Operations (annual basis): New Inventory, 55-Gallon Drums

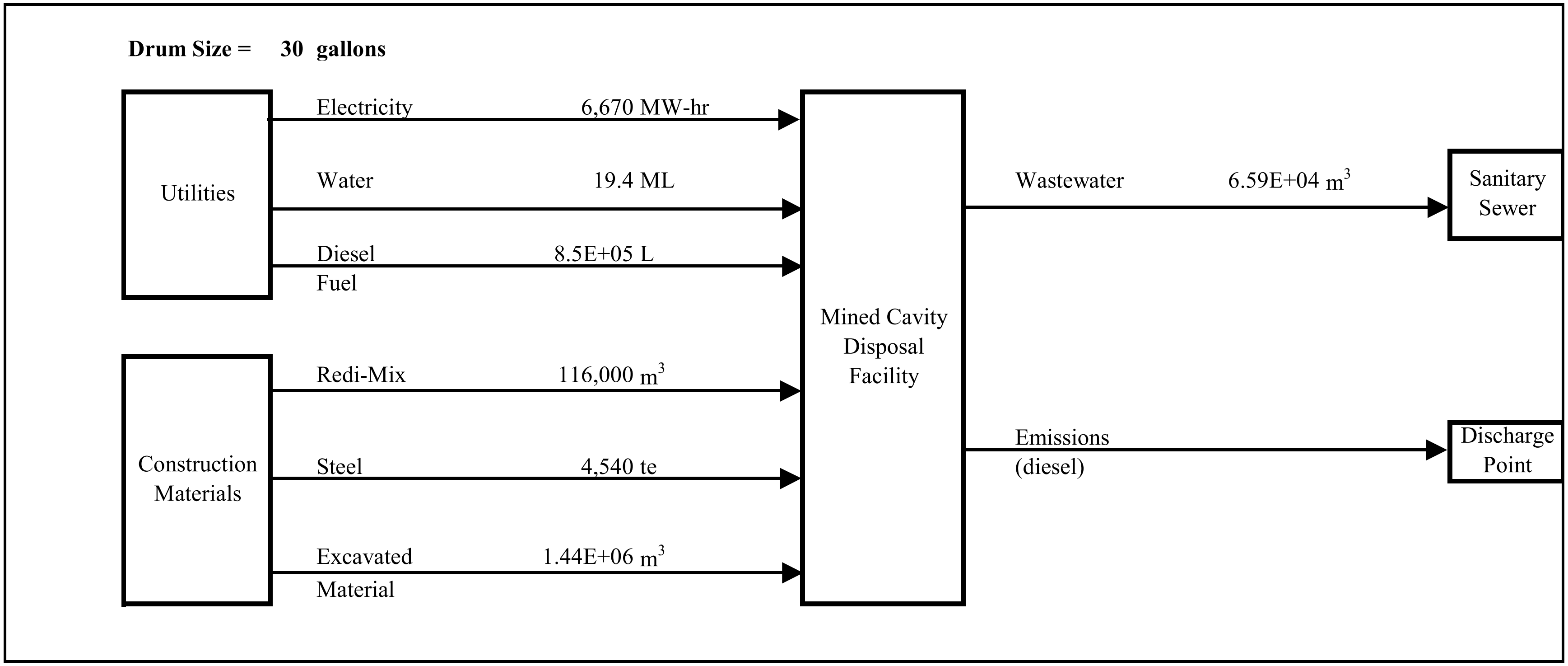

FIGURE 1.8a Mined-Cavity Disposal Facility Process Flow Diagram for Construction: New Inventory, 30-Gallon Drums

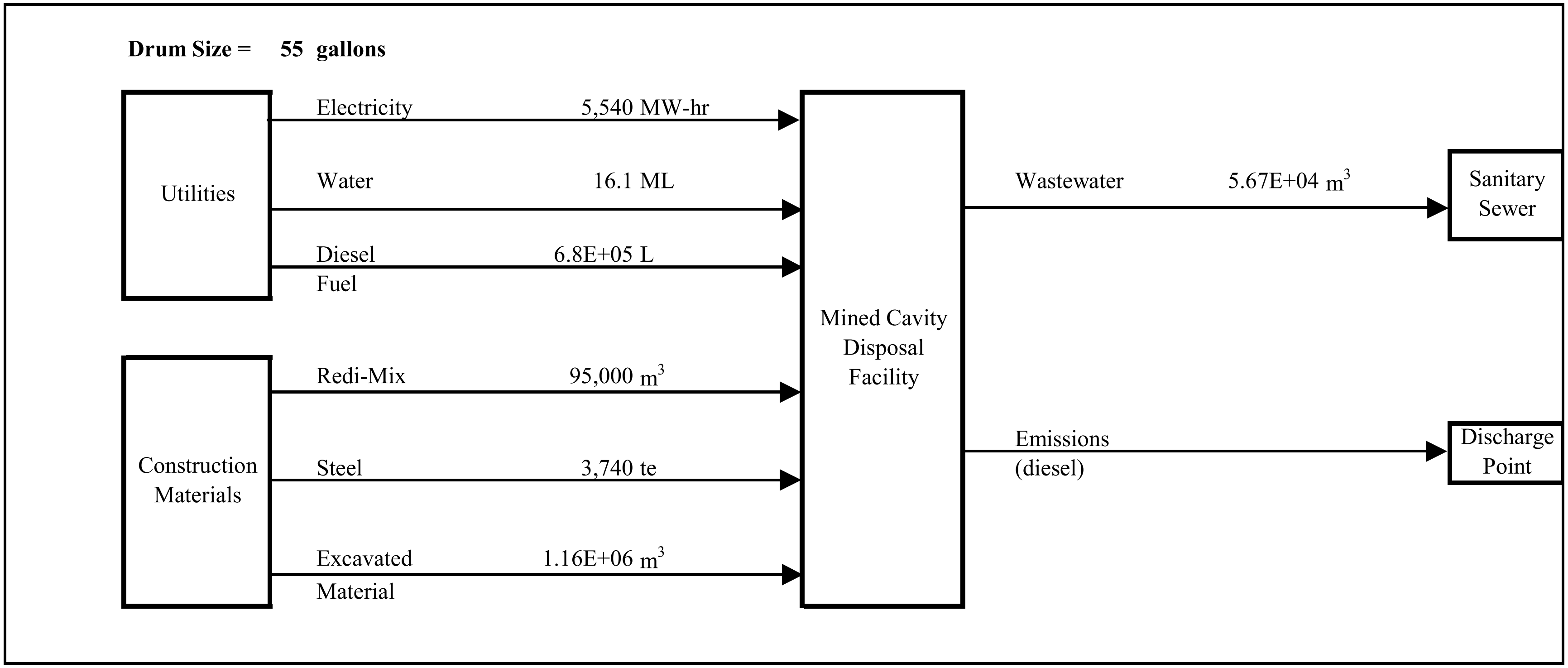

FIGURE 1.8b Mined-Cavity Disposal Facility Process Flow Diagram for Construction: New Inventory, 55-Gallon Drums

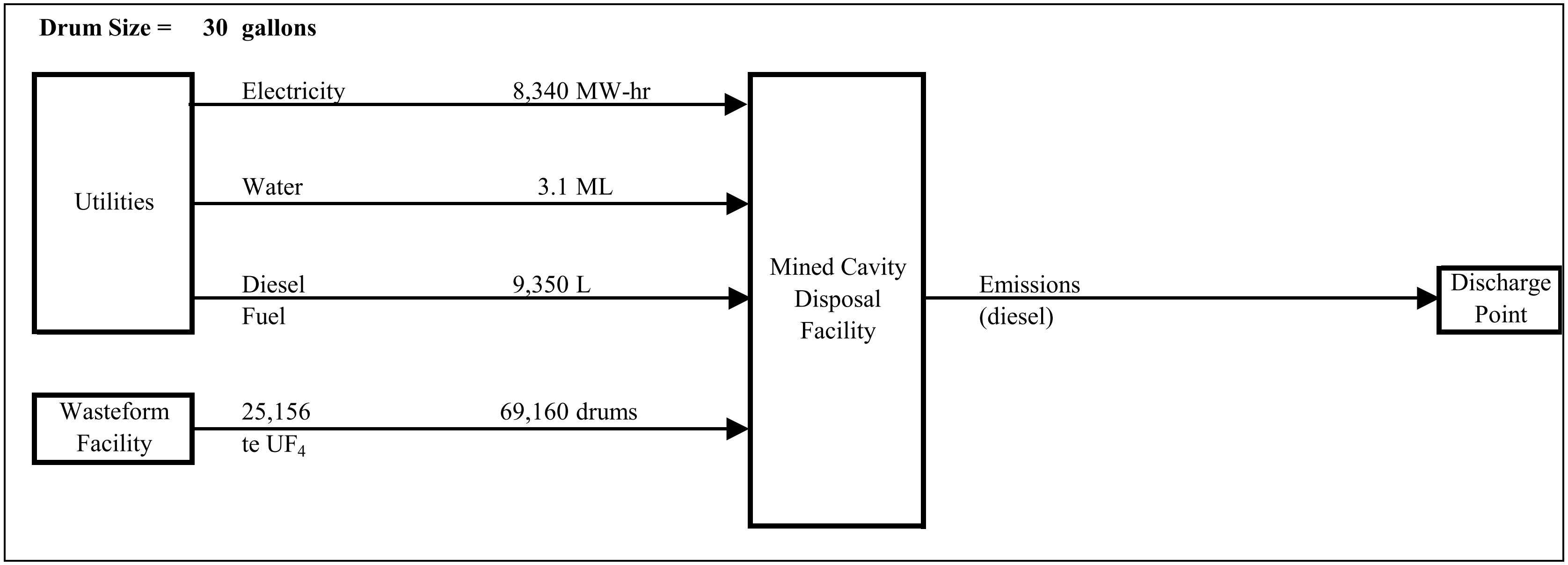

FIGURE 1.9a Mined-Cavity Disposal Facility Process Flow Diagram for Operations (annual basis): New Inventory, 30-Gallon Drums

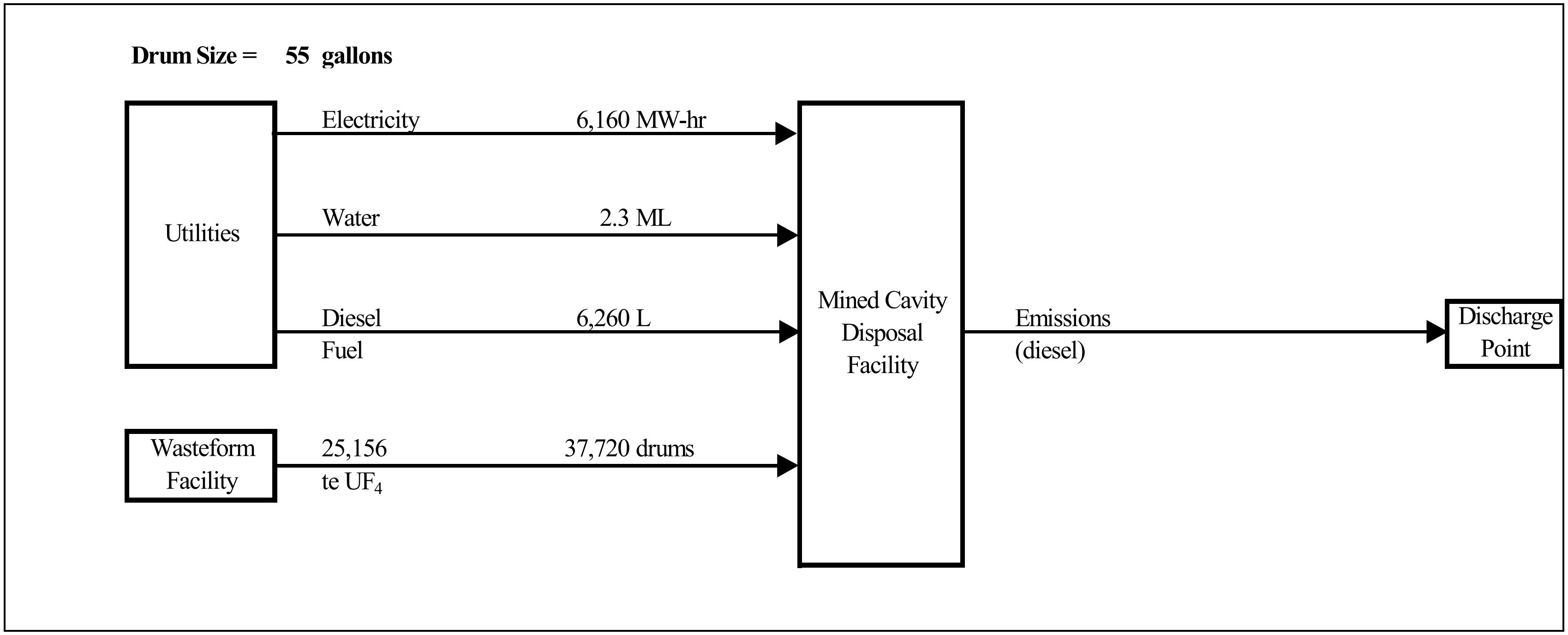

FIGURE 1.9b Mined-Cavity Disposal Facility Process Flow Diagram for Operations (annual basis): New Inventory, 55-Gallon Drums

2 DESCRIPTION OF THE FACILITY

A disposal facility for depleted UF_4 would require two major types of buildings in addition to the disposal area:

- A product receiving and shipping warehouse in which containers shipped to the disposal facility would be temporarily stored and then inspected and transported to a disposal unit. If the inspection showed that a drum was defective, its contents would be repackaged (i.e., transferred to another drum) before being transported to a disposal unit from the shipping part of the building; and

- An administration building incorporating all technical and administrative support functions needed to manage the operation of the storage facility. These functions would include security, facility access control, health physics and radiation badges, sanitary facilities, work control and personnel support, internal and external (public relations) communications, spill or emergency response provisions, analytical laboratory, environmental regulatory reporting, and records management for materials control and accountability (MC&A).

2.1 GENERAL DESIGN AND SAFETY CRITERIA

The following criteria would used in the engineering design of the disposal facility:

- The disposal facility must provide for the receipt of materials over a 20-year period for the original inventory, or over a 25-year period for the new inventory, and for permanent disposal thereafter. Means of ingress for depleted uranium for transportation by rail or truck should be provided.

- The disposal system must provide systems or methods for (1) inspection of the integrity of the drums before emplacement, (2) removal and management of any failed drum, (3) and inventory of material for MC&A reporting.

- The facility must be designed, constructed, and operated to comply with the requirements of DOE O 420.1, *Facility Safety*, in general, and specifically in accordance with the guidance contained in DOE G 420.1-2, *Guide for the Mitigation of Natural Phenomena Hazards for DOE Nuclear Facilities and Non-Nuclear Facilities*. The general impact of this order and guide is that structures, systems, and components (SSCs) shall be designed to withstand the effects of natural phenomena hazards (NPH) to prevent loss of structural integrity that could endanger life safety. The guide provides for a graded approach to NPH protection using performance categories.

Design criteria are contained in DOE-STD-1020-94, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities* (DOE 1994). The NPH standards in DOE-STD-1024-94 have five performance categories for selecting SSCs. The design and evaluation criterion in Performance Categories 0, 1, and 2 are similar to those in model building codes. For SSCs assigned to Performance Category 0, consideration of NPHs may not be needed. For SSCs assigned to Performance Category 1, provisions in model building codes that protect against NPHs are adequate. SSCs assigned to Performance Category 2, which involves criteria slightly more demanding than the design criteria for hospitals or fire or police stations should maintain functionality even when a natural phenomenon event (e.g., earthquake) occurs.

Performance Categories 3 and 4 are appropriate when there is a potential significant threat to the public safety and the environment should there be a SSC failure. SSCs assigned to these categories are designed to control and confine hazardous material so that damage is limited to within confinement barriers. A qualitative assessment of the hazard ranking and performance category for the proposed storage facility has been performed. Table 2.1 summarizes the results of this assessment.[1]

The administration building would be an office building that would not contain any uranium; however, it must continue to function after a seismic event or an accident. Therefore, it is given the lowest hazard and performance category ranking (2) appropriate for continuing operations after a natural phenomenon event.

No energetic processes would be performed in the product receiving and shipping warehouse, only movement of drums and pallets and repackaging. However, there would be a substantial inventory of uranium in the warehouse. Performance Category 2 SSCs and a low hazard ranking appear to be appropriate for this building, as well as for the disposal units.

The NRC requires in 10 CFR 61.12 that an application for a license to dispose of LLW contain specific technical information to address natural phenomenon events. An application should define design basis natural phenomena and their relationship to the principal design criteria. The application should also describe the codes and standards that the applicant has applied to the design and that will apply to construction of the disposal facility. The design criteria required by the NRC or an Agreement State would be expected to be similar to the design criteria required by DOE.

2.2 ENGINEERED TRENCH DISPOSAL FACILITY

As discussed in Section 2.5, the product receiving and shipping warehouse and administration building are collectively referred to as the wasteform facility to be consistent with

[1] For reader convenience, tables referred to in Section 2 are placed at the end of the section.

the terminology of the Engineering Analysis Report. The area occupied by the wasteform facility is not included in the areas of the disposal facilities discussed in Sections 2.2 through 2.4.

Other than the wasteform facility described in Section 2.5, the only structures in an engineered trench disposal facility are the trench disposal units themselves. The design of these trenches is assumed to be the same as described in the Engineering Analysis Report for the disposal of oxide forms of depleted uranium. Before trench excavation, the top layer of soil would be completely removed from the area, and clay would then be brought to the area and compacted to high density to construct an upper barrier wall. The compacted clay would serve two purposes: prevent the walls of a trench from collapsing or caving in and ensure that the waste is surrounded by a relatively impermeable barrier to water infiltration. Then the trench would be excavated to a depth of 8 m (26 ft). This depth would allow pallets with four drums (either 30-gallon or 55-gallon) per pallet to be stacked three high, in accordance with DOE practice. The floor of the trench would slope slightly, and along the floor's lower side a 0.6-m (2-ft) French drain would be constructed and filled with small stones. Monitoring pipes could be installed at 30-m (100-ft) intervals for future sampling capabilities. Two sumps, each 1.2 by 1.2 m (3.8 by 3.8 ft) and extending 1.2 m (3.8 ft) below the trench floor, would be constructed at 152-m (500-ft) intervals and filled with sand. They would serve as collection points for water. Pervious sand would be added to the trench floor to provide (1) a firm and level base for the waste up to 1 m (3.3 ft) thick; (2) a porous medium for rainfall to move to the French drain should it rain while the trench is open; and (3) a buffer zone for an unlikely rise of the water table.

The current plan requires that one trench be opened and closed every year. This plan would result in the need for 20 trenches for the original inventory, or 25 trenches for the new inventory. A distance of 20 m (66 ft) should separate each trench to ensure stability of the trench walls and to allow room for equipment and machinery.

After a trench was full, a minimum of 0.6 m (2 ft) of clay would be added, and a 4,540-kg (10,000-lb) vibrating compactor would be used to accelerate the settling process. Topsoil overburden of at least 1 m (3.3 ft) would be added over the clay. To minimize infiltration of precipitation, all new trench cappings would be overlapped, sloped, and topped with a clay cover. To the extent practical, covers must be designed to minimize water infiltration, direct percolating or surface water away from the waste, and resist degradation by surface geologic processes and biotic activity. Surface features must direct surface water drainage away from disposal units at velocities and gradients that will not result in erosion that would require ongoing active maintenance in the future. Table 2.2 lists dimensions for the engineered trench disposal facility.

2.3 VAULT DISPOSAL FACILITY

The Engineering Analysis Report uses a standard below-grade design that has been modified for the circumstances of depleted uranium disposal for a vault disposal facility for the other disposal forms. This design is adopted for the disposal of UF_4. The design considers a vault to consist of five bays, each approximately 20 m (66 ft) long by 8 m (26 ft) wide. The Engineering Analysis Report specifies that 30-gallon drums would be stacked six high, and 55-gallon drums would be stacked four high without pallets. To accommodate six levels of 30-gallon drums, the height of a vault would have to be at least 4.5-m (15-ft). The outer walls of a vault would be 0.3-m (1-ft) thick reinforced concrete, while the inner walls between bays would be 0.3-m (1-ft) thick concrete blocks. The floor of a vault would be 0.6-m (2-ft) thick reinforced concrete over a gravel subfloor of comparable thickness. The gravel would rest on a low permeability membrane that sloped and directed infiltrated water toward a main drain (there would also be drains within the vault that led to this main drain). The main drain subsequently would flow toward a sump in one corner of the vault for leachate collection and treatment, as necessary. Monitoring pipes could be installed at 30-m (100-ft) intervals for future sampling capabilities.

A crane would be used to fill each bay with drums from the top to be consistent with the Engineering Analysis Report. Appendix D of the Engineering Analysis Report indicates that 30-gallon drums would be lowered into a bay one drum at a time. Once a level within a bay was filled, the interstitial spaces between the drums would be filled with gravel and compacted. A temporary liner would cover each bay until the entire vault was filled. Then a nominal 1-m (3-ft) thick top slab would be cast to cover the entire vault. This top slab would slope gently toward the sides, with approximately a 1% grade. Then several membrane barriers and engineered features would be put in place prior to grading and planting of vegetation. Table 2.3 shows the number of vaults needed as a function of inventory (original or new) and drum size.

2.4 MINED-CAVITY DISPOSAL FACILITY

A mined-cavity disposal facility is described in Section 1.5. A conceptual layout for the facility has a central drift adjacent to an access ramp from the surface. On both sides of the central drift and perpendicular to it are emplacement drifts. These drifts would be 6.5 m (21 ft) wide. The drums would be placed on pallets, four drums per pallet, and stacked two pallets high. Each pallet with 30-gallon drums would require a width of 1 m (3.3 ft). Therefore, six pallets, or 48 30-gallon drums, could be placed width-wise along a 1-m (3.3 ft) section of an emplacement drift. Each pallet with 55-gallon drums would requires a width of 1.2 m (4 ft). Therefore, five pallets, or 40 55-gallon drums, could be placed width-wise along a 1.2-m (4-ft) section of emplacement drift. On the basis of this information, the total length of emplacement drifts is shown in Table 2.4 as a function of inventory (original or new) and drum size.

2.5 WASTEFORM FACILITY

The product receiving and shipping warehouse and administration building are assumed to be the same regardless of whether the disposal units are engineered trenches, vaults, or mined cavities. The size of the product receiving and shipping warehouse would depend, however, on the size and number of drums temporarily stored there. In conformity with the terminology of the Engineering Analysis Report, these two buildings are collectively referred to as the wasteform facility.

2.5.1 Product Receiving and Shipping Warehouse

The wasteform facility would have a building for temporary storage and inspection of drums of UF_4 received at the disposal facility. The building would also house a facility for repackaging damaged drums of UF_4 and shipping drums. This building is referred to as the product receiving and shipping warehouse. The entire building would be equipped with high-efficiency particulate air (HEPA) filtration and served by two overhead cranes. The receiving warehouse would be designed to store drums delivered over a three-month period. Drums would be stored on pallets, four drums per pallet. A stack would be two pallets high and two pallets wide. Rows would be formed by placing four pallet stacks side-by-side. Each pallet for 30-gallon drums is assumed to be 1-m (3.3-ft) wide by 1.1-m (3.5-ft) long, and for 55-gallon drums is assumed to be 1.2 m (4 ft) by 1.2 m (4 ft). There would be a 1-m (3.3-ft) clearance between rows to allow for detailed inspection of the drums. Table 2.5 shows the dimensions, storage configuration, and capacity of the receiving warehouse. Undamaged drums would be moved to a loading bay for removal to a disposal unit. Damaged drums would be moved to an area for transfer of their contents to new drums.

The repackaging area would be an enclosure within the receiving warehouse building that would be kept at a slightly lower pressure than the receiving warehouse. Ingress and egress would be through air locks. The repackaging facility would contain a repackaging station for transferring UF_4 from damaged drums to new drums and a storage area with empty, new drums. The damaged drums would be assumed to be LLW and would be stored pending disposal. In the product receiving area, drums would be moved by bridge crane and to or from trucks or railcars by forklift. A forklift would be used to transfer damaged drums from the receiving warehouse to the repackaging facility.

The product receiving and shipping warehouse would be a standard warehouse-type building with sheet steel for exterior walls, spread footings, and a 30-cm (1-ft) thick concrete floor. The exterior walls would have steel pillars to provide additional support for crane rails as needed. There would be no interior pillars. Steel trestles would support a standard flat roof. The heating, ventilation, and air conditioning (HVAC) system would control temperature and humidity to comfortable working levels. Once-through air flow and single filtration of exhaust air through HEPA filters would also be provided. Table 2.5 contains the dimensions, storage configuration, and capacity of the product receiving warehouse.

The current radioactive material license for the Envirocare disposal facility in Utah limits the amount of on-site and aboveground waste to 300,000 yd^3 (230,000 m^3) (Utah Department of Environmental Quality 2000). However, the total amount of UF_4 to be disposed of would occupy only approximately 200,000 yd^3 (150,000 m^3) for the original inventory of depleted UF_6 and approximately 250,000 yd^3 (190,000 m^3) for the new inventory.

2.5.2 Administration Building

As provided in the Engineering Analysis Report, the administration building would be located on the fenced perimeter of the site. Security offices and a security foyer would be located in the entrance to the building and adjacent to the vehicle gate so that both vehicle and personnel entry could be controlled from one station. In addition to the security function, the administration building would have office space for the site manager and for the operations, health physics, plant engineering, and maintenance supervisors and their staffs. It is important that the administration building be a structurally sound facility because this is where records would be kept and where a medical facility would be located. The administration building would have approximate dimensions of 27 by 25 m (89 by 83 ft) and would need to be a Performance Category 2 building.

TABLE 2.1 Qualitative Assessment of Hazard Ranking for Disposal and Wasteform Facilities

Building/Area	Hazard Ranking/Category	Qualitative Rationale
Administration	None/Performance Category 2	Facilities must continue to function after a seismic event or an accident
Product receiving and shipping warehouse	Low/Performance Category 2	Minimal off-site and on-site releases
Engineered trenches	Low/Performance Category 2	No off-site release, minimal on-site releases, essential to mission
Vault	Low/Performance Category 2	No off-site release, minimal on-site releases, essential to mission
Mined-cavity	Low/Performance Category 2	No off-site release, minimal on-site releases, essential to mission

TABLE 2.2 Dimensions for the Engineered Trench Disposal Facility

Parameter	Original Inventory		New Inventory	
	30-Gallon Drums	55-Gallon Drums	30-Gallon Drums	55-Gallon Drums
Facility length (m)	344	344	427	427
Facility width (m)	597	506	597	506

TABLE 2.3 Number of Vaults Needed for Vault Disposal Facility

Drum Size	Original Inventory	New Inventory
30-gallon	76	95
55-gallon	84	105

TABLE 2.4 Total Length of Emplacement Drifts Needed for Mined-Cavity Disposal Facility

Drum Size	Original Inventory	New Inventory
30-gallon	28,700 m	38,428 m
55-gallon	22,830 m	28,743 m

TABLE 2.5 Dimensions, Storage Configuration, and Capacity of the Product Receiving Warehouse

Drum Size	Inventory	Length (m)	Width (m)	Number of Rows	Containers per Row	Containers, Building Capacity
30-gallon	Original	65	63	20	858	17,163
55-gallon	Original	56	55	15	624	9,363
30-gallon	New	66	63	20	864	17,290
55-gallon	New	56	55	15	632	9,430

3 DISPOSAL SITE LAND USE REQUIREMENTS

The land use requirements for the disposal facility were developed with a methodology consistent with that used in the Engineering Analysis Report for the other depleted uranium waste forms. Those waste forms must be processed before they can be disposed of, and it was assumed that the processing was done on the disposal facility site. For some contexts, the Engineering Analysis Report lumped the administration building, product receiving building, supply and shipping building and several process buildings into a facility called the wasteform facility. To be consistent with the terminology of the Engineering Analysis Report, the administration building and product receiving and shipping warehouse will be referred here to collectively as the wasteform facility when appropriate.

The design assumes a reasonable industrial site is selected. Access to an all-weather road suitable for use by a maximum legal weight semi-tractor is essential. Access to a rail spur is optional. Utilities assumed to be available at the site are electricity, natural gas, potable water, and sanitary sewer. Telephone service would also be required. The approach assumes that clearing and grading would be limited to those areas immediately surrounding the planned locations of the buildings and disposal facilities. These assumptions are consistent with the disposal site being either the Nevada Test Site or the Envirocare site in Utah.

3.1 ENGINEERED TRENCH DISPOSAL FACILITY

In the Engineering Analysis Report, it is assumed that 55-gallon drums with cement-encapsulated U_3O_8 would be emplaced in trenches that are 8 m (26 ft) deep and 61 m (200 ft) wide. The length of a trench is determined from the number of drums disposed of per year, based on the assumption that the drums are on four-drum pallets stacked three high. It was also assumed that trenches would be spaced 20 m (66 ft) apart. To be consistent with the Engineering Analysis Report, the same assumptions are used here. For disposal in 30-gallon drums, a pallet would have dimensions of 1 by 1.1 m (3.3 by 3.6 ft). The width of a trench could accommodate 61 pallets. Therefore, 732 drums could be disposed of in a 61-m (200-ft) width of trench (one row). For disposal in 55-gallon drums, a pallet would have dimensions of 1.2 by 1.2 m (4 by 4 ft) and the width of a trench could accommodate 50 pallets. Therefore, 600 drums could be disposed of in a 61-m (200-ft) width of trench.

It is assumed that drums would be emplaced in one trench per year and that emplacement would take place over a 20-year period for the original inventory and over a 25-year period for the new inventory. The number of rows is calculated from the number of drums that must be disposed of in a year (see Table 1.6) and the number of drums in a row. The length of a trench is calculated from the length of a row and the number of rows. For the original inventory, the length of a trench would be 93.9 m (308 ft) for disposal in 30-gallon drums, or 76.2 m (250 ft) for disposal in 55-gallon drums. For the new inventory, the length of a trench would be 94.5 m (310 ft) for disposal in 30-gallon drums, or 76.8 m (252 ft) for disposal in 55-gallon drums.

Trenches would be excavated in a 4 by 5 array for the original inventory, or in a 5 by 5 array for the new inventory, with 20.1 m (66 ft) separating each trench. Also, there would be a 20.1-m separation between the outer trenches and the boundary of the disposal facility. The resulting land parameters are given in Table 3.1a[1] for disposal of the original inventory in 30-gallon drums, in Table 3.1b for disposal of the new inventory in 30-gallon drums, in Table 3.2a for disposal of the original inventory in 55-gallon drums, and in Table 3.2b for disposal of the new inventory in 55-gallon drums. Figures 3.1a and 3.1b illustrate the facility layout on the basis of the new inventory, for 30-gallon and 55-gallon drums, respectively.

3.2 VAULT DISPOSAL FACILITY

To be consistent with the Engineering Analysis Report, it is assumed that vaults would be divided into five bays, each approximately 20.6 m (68 ft) long by 8 m (26 ft) wide. The Engineering Analysis Report assumed that 30-gallon drums would be emplaced individually (rather than on pallets), with 3,655 drums per bay with six levels of drums. To accommodate six levels of 30-gallon drums, each with a height of 74 cm (29 in.), the height of a vault must be at least 4.5 m (15 ft). The capacity of a vault would then be 18,275 drums. Because 1,373,000 drums would be disposed of for the original inventory, 76 vaults would be needed. For the new inventory, 95 vaults would be needed to dispose of 1,729,000 drums. The Engineering Analysis Report assumed that 55-gallon drums would be emplaced five high in the bays, 1,800 drums per bay, or 9,000 drums per vault. For the original inventory, 84 vaults would be required for disposal of 749,000 drums; for the new inventory, 105 vaults would be required to dispose of 943,000 drums.

As in the Engineering Analysis Report, it was assumed for this report that the disposal area would be organized into 10-vault blocks. Each block would have two rows of five vaults (five columns) except the last block, which would have fewer vaults. For example, disposal of the original inventory in 30-gallon drums would require seven 10-vault blocks and one 6-vault block. A paved, 10-m (33-ft) wide road would surround each block. The distance between rows would be 22.5 m (74 ft), while the distance between columns would be 20 m (66 ft). The overall dimensions of each 10-vault block would thus be 215 m (705 ft) by 125.6 m (412 ft). The area associated with one block is then 2.7 hectares (6.8 acres), excluding the roadways. The resulting land parameters are given in Table 3.1a for disposal of the original inventory in 30-gallon drums, in Table 3.1b for disposal of the new inventory in 30-gallon drums, in Table 3.2a for disposal of the original inventory in 55-gallon drums, and in Table 3.2b for disposal of the new inventory in 55-gallon drums. Figures 3.2a and 3.2b illustrate the facility layout on the basis of the new inventory, for 30-gallon and 55-gallon drums, respectively.

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[1] For reader convenience, tables and figures referred to in Section 3 are place at the end of the section.

3.3 MINED-CAVITY DISPOSAL FACILITY

The general layout of a mined-cavity disposal facility for depleted UF_4 is described in the Engineering Analysis Report for the other waste forms. The same general layout is assumed here. Three main drifts would bisect the underground area: (1) the waste main, connected to the surface by the waste ramp; (2) the rock main, connected to the surface by the rock ramp; and (3) the service main. Intersecting these mains at right angles would be the emplacement drifts. The emplacement drifts are assumed to have a width of 6.5 m (21 ft) and to be spaced 32 m (105 ft). To be consistent with the Engineering Analysis Report, it is assumed that 30-gallon drums would be emplaced in a drift on four-drum pallets stacked two high. Because the size of a pallet would be 1 by 1.1 m (3.3 by 3.6 ft), a drift would be six pallets wide. Therefore, a 1-m (3.3-ft) section of drift could accommodate disposal of 48 drums. If 55-gallon drums were used, the width of a drift could accommodate five 4-drum pallets. Therefore, a 1.22-m (4-ft) section of drift could accommodate 40 drums. If 30-gallon drums were used, the total emplacement drift lengths required would be 30,515 m (100,115 ft) for the original inventory and 38,428 m (126,076 ft) for the new inventory. If 55-gallon drums were used, the total emplacement drift lengths required would be 22,830 m (74,900 ft) for the original inventory and 28,743 m (94,300 ft) for the new inventory.

The resulting land parameters are given in Table 3.1a for disposal of the original inventory in 30-gallon drums, in Table 3.1b for disposal of the new inventory in 30-gallon drums, in Table 3.2a for disposal of the original inventory in 55-gallon drums, and in Table 3.2b for disposal of the new inventory in 55-gallon. Figures 3.3a and 3.3b illustrate the facility layout on the basis of the new inventory, for 30-gallon and 55-gallon drums, respectively.

3.4 WASTEFORM FACILITY

The wasteform facility would consist of the product receiving and shipping warehouse and the administration building. The wasteform facility would be inside a fence. The product receiving part of the warehouse would be adjacent to a rail spur or a road for the delivery of waste inventory. The shipping part of this building would have a portal for loading pallets of drums on trucks for transport to the disposal units. The wasteform facility building footprint areas are given in Table 3.3, and the site land parameters are given in Table 3.4. Figures 3.4a and 3.4b illustrate the facility layout on the basis of the new inventory, for 30-gallon and 55-gallon drums, respectively.

TABLE 3.1a Site Land Parameters for Disposal of Original Inventory in 30-Gallon Drums

Parameter	Engineered Trench	Vaults	Mine
Site land area, ha	20.6	25.4	236
Disturbed land area, ha	18.7	25.4	236
Total fenced area, ha	20.6	25.4	236
Total paved area, ha	0.9	3.5	12
Total excavated material, m^3	1.29E+06	5.71E+05	1.22E+06
Facility length, m	597	552	1,586
Facility width, m	344	460	1,560
Underground site land area, ha			247

TABLE 3.1b Site Land Parameters for Disposal of New Inventory in 30-Gallon Drums

Parameter	Engineered Trench	Vaults	Mine
Site land area, ha	25.5	31.6	310
Disturbed land area, ha	23.4	31.6	310
Total fenced area, ha	25.5	31.6	310
Total paved area, ha	1.0	4.4	12
Total excavated material, m^3	1.65E+06	7.14E+05	1.44E+06
Facility length, m	597	688	1,740
Facility width, m	427	460	1,782
Underground site land area, ha			310

TABLE 3.2a Site Land Parameters for Disposal of Original Inventory in 55-Gallon Drums

Parameter	Engineered Trench	Vaults	Mine
Site land area, ha	17.4	31.6	168
Disturbed land area, ha	15.7	31.6	168
Total fenced area, ha	17.4	31.6	168
Total paved area, ha	0.8	4.4	11
Total excavated material, m^3	1.06E+06	6.31E+05	9.91E+05
Facility length, m	506	688	1,355
Facility width, m	344	460	1,378
Underground site land area, ha			187

TABLE 3.2b Site Land Parameters for Disposal of New Inventory in 55-Gallon Drums

Parameter	Engineered Trench	Vaults	Mine
Site land area, ha	21.6	37.9	220
Disturbed land area, ha	19.7	37.9	220
Total fenced area, ha	21.6	37.9	220
Total paved area, ha	0.9	5.2	12
Total excavated material, m^3	1.36E+06	7.89E+05	1.16E+06
Facility length, m	506	824	1,509
Facility width, m	427	460	1,548
Underground site land area, ha			234

TABLE 3.3 Wasteform Facility Building Footprint Areas

	Original Inventory		New Inventory	
Building	30-Gallon Drums	55-Gallon Drums	30-Gallon Drums	55-Gallon Drums
Product receiving and shipping warehouse, m^2	4,100	3,100	4,200	3,100
Administration building, m^2	675	675	675	675
Total, m^2	4,776	3,776	4,876	3,776

TABLE 3.4 Site Land Parameters at the Wasteform Facility

	Original Inventory		New Inventory	
Parameter	30-Gallon Drums	55-Gallon Drums	30-Gallon Drums	55-Gallon Drums
Site land area, ha	1.7	1.4	1.7	1.4
Disturbed land area, ha	1.7	1.4	1.7	1.4
Total fenced area, ha	1.6	1.3	1.6	1.3
Total paved area, ha	0.33	0.28	0.34	0.28
Total excavated material, m^3	9,550	7,550	9,750	7,550

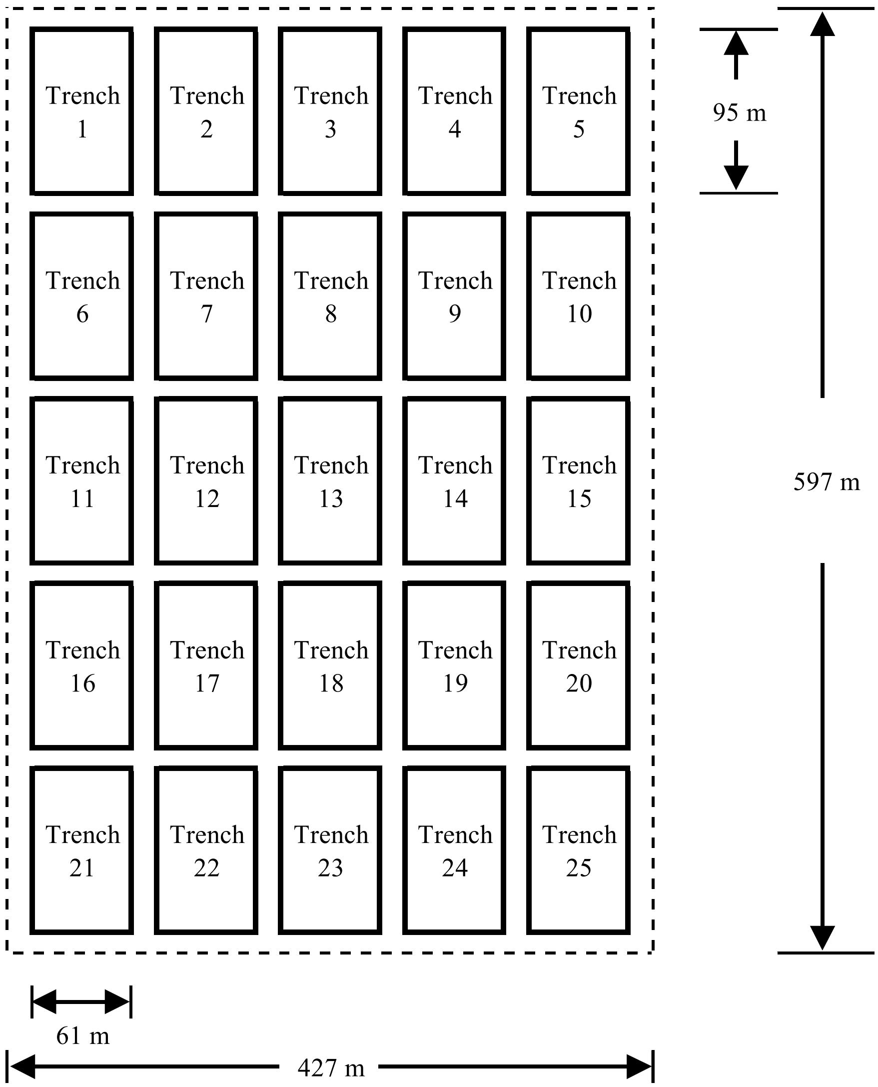

FIGURE 3.1a Site Map and Land Area for Operation of the Engineered Trench Disposal Facility: New Inventory, 30-Gallon Drums (not to scale)

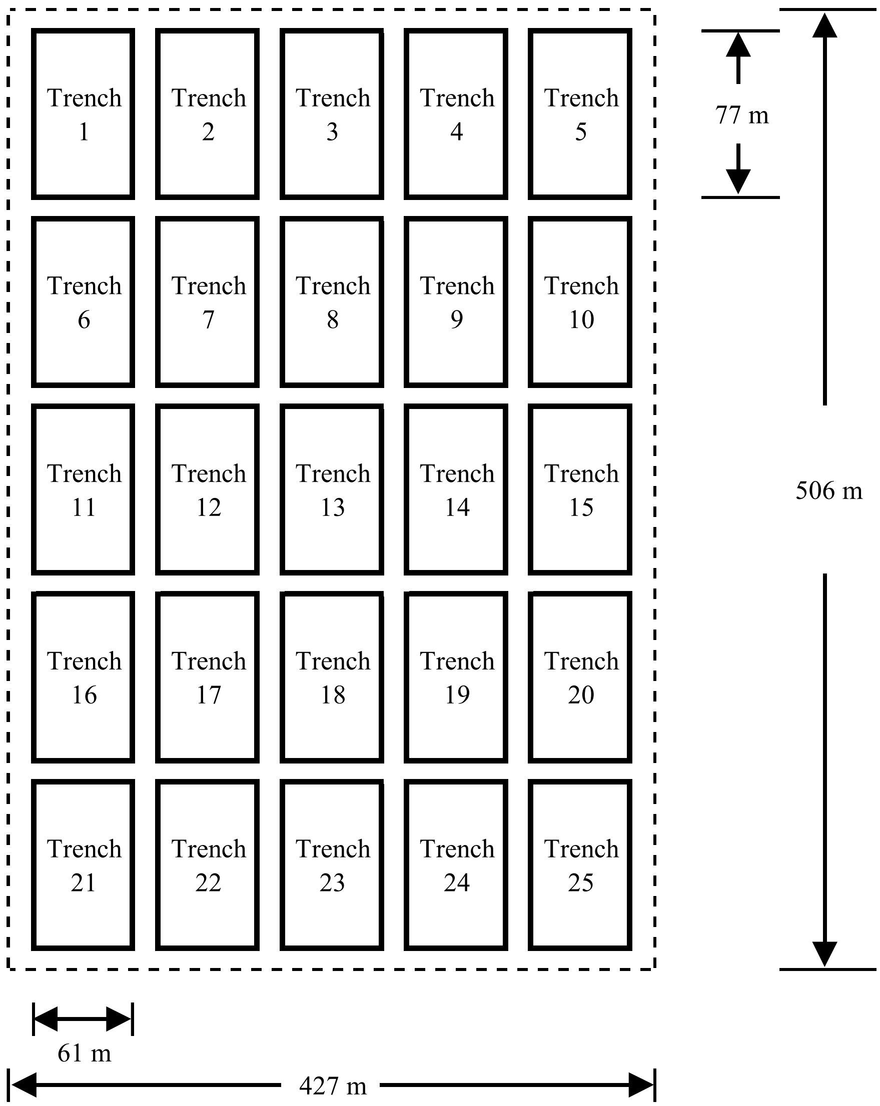

FIGURE 3.1b Site Map and Land Area for Operation of the Engineered Trench Disposal Facility: New Inventory, 55-Gallon Drums (not to scale)

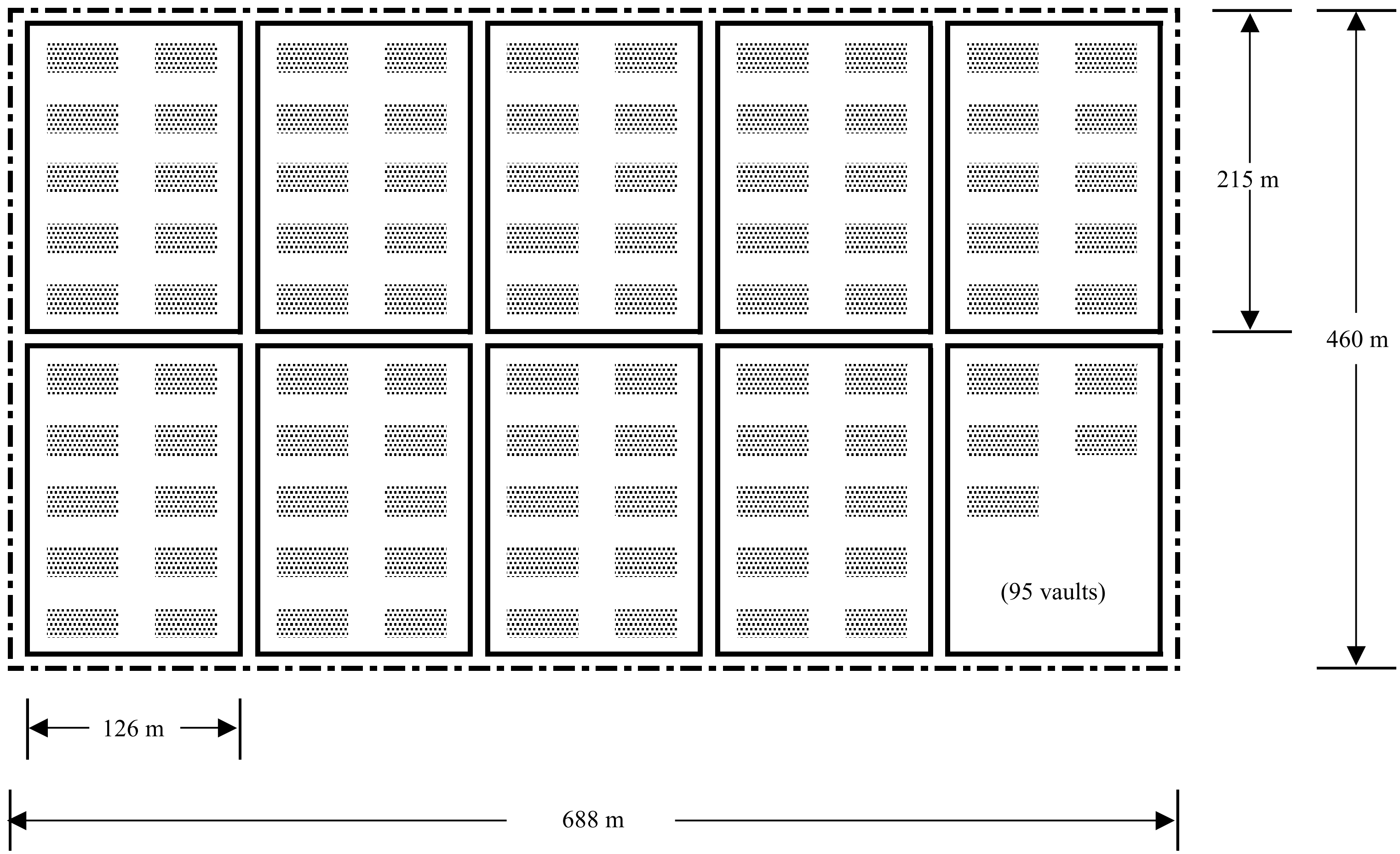

FIGURE 3.2a Site Map for Construction of the Vault Disposal Facility: New Inventory, 30-Gallon Drums (not to scale)

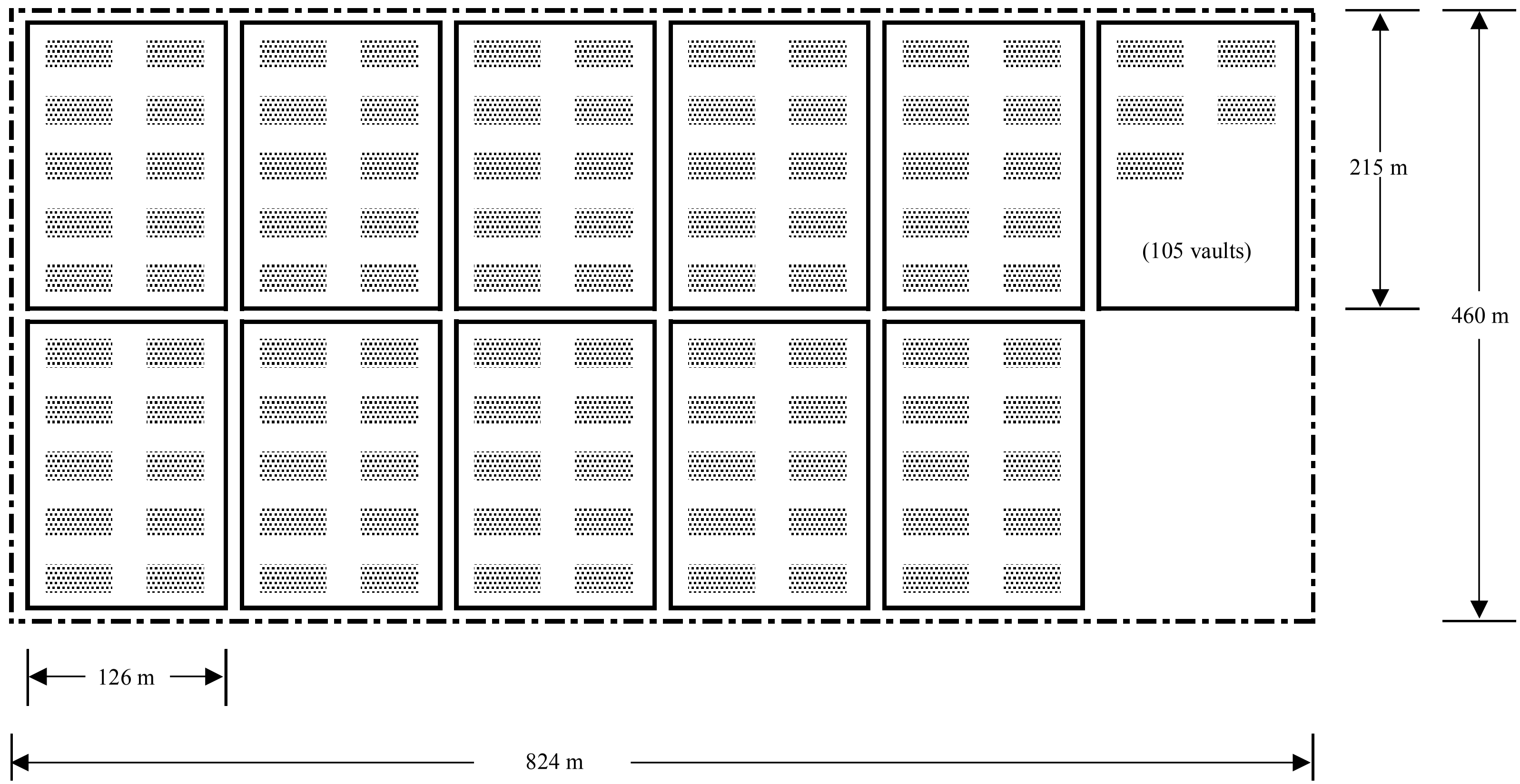

FIGURE 3.2b Site Map for Construction of the Vault Disposal Facility: New Inventory, 55-Gallon Drums (not to scale)

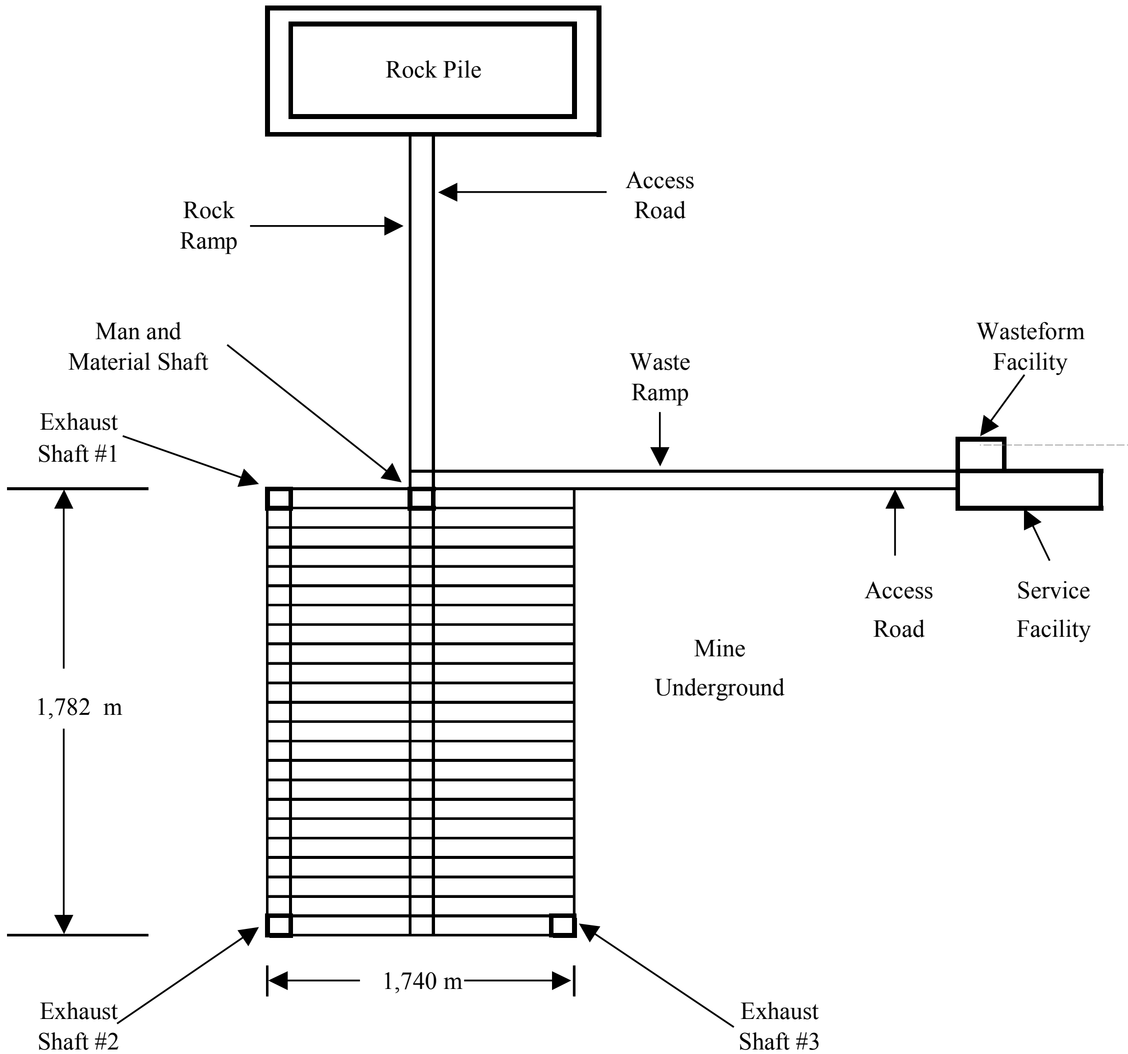

FIGURE 3.3a Site Map and Land Area during Operation of the Mined-Cavity Disposal Facility: New Inventory, 30-Gallon Drums (not to scale)

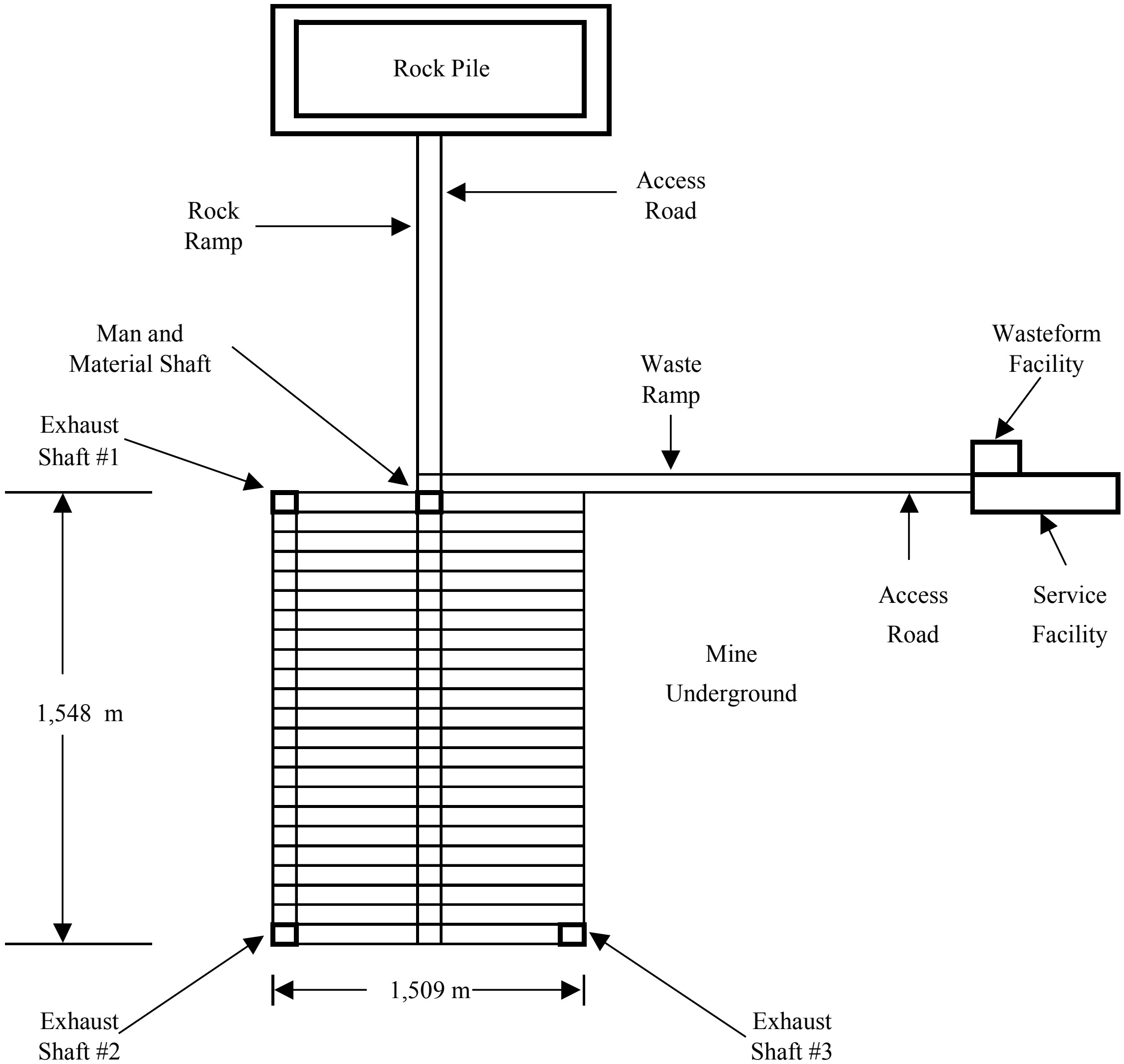

FIGURE 3.3b Site Map and Land Area during Operation of the Mined-Cavity Disposal Facility: New Inventory, 55-Gallon Drums (not to scale)

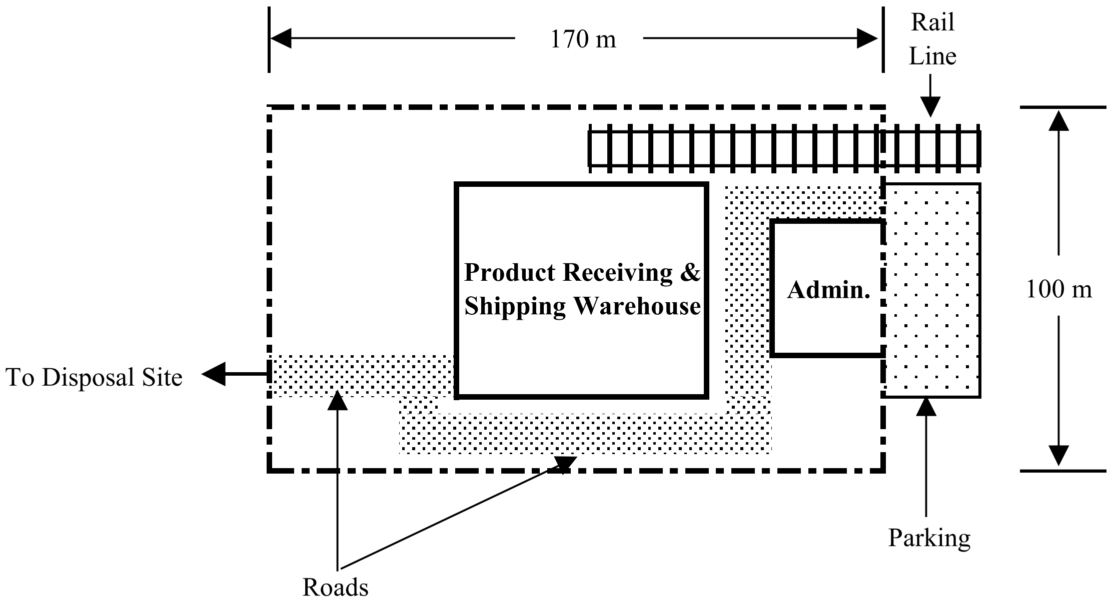

FIGURE 3.4a Site Map during Operation of the Wasteform Facility: New Inventory, 30-Gallon Drums (not to scale)

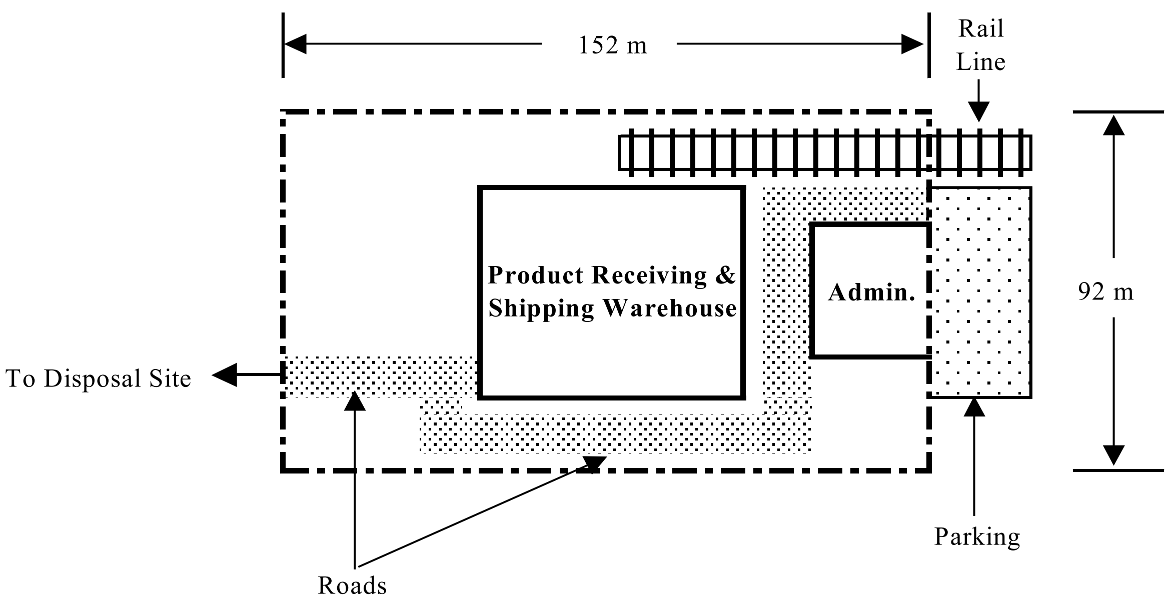

FIGURE 3.4b Site Map during Operation of the Wasteform Facility: New Inventory, 55-Gallon Drums (not to scale)

4 RESOURCE NEEDS

Resources needed for the construction and operation of a depleted uranium disposal facility are divided into two classes: materials and utilities. Materials are the substances used to construct the disposal units, such as sand, clay, gravel, and Redi-Mix concrete. This category also includes the materials excavated from the trenches, vaults, or mined cavities. Utilities include electricity, natural gas, water, and diesel fuel. Materials would be consumed only by construction activities. Utilities would be consumed both by construction activities and operations.

Operations activities would include receiving drums of waste, inspecting them, repacking them if necessary, transporting the drums to disposal units, and emplacing them. To some extent, construction activities and operational activities would be concurrent. For example, one trench would be in the process of being filled while another was being constructed. However, the disposal facility would not be abandoned once all the depleted uranium had been emplaced and the facility had undergone closure. For example, the NRC in 10 CFR 61.59 requires a period of institutional control, which cannot be relied on for more than 100 years. An institutional control program should include physical control of access to the site, an environmental monitoring program, periodic surveillance, and custodial care. The use of utilities would be much greater during the operational period than during the period of institutional control. Therefore, utility use during the institutional control period is not considered here, consistent with the Engineering Analysis Report. However, the workforce utilized during the maintenance period is estimated in Appendix B.

4.1 ENGINEERED TRENCH DISPOSAL FACILITY

The one factor that is most likely to affect the containment capability of an engineered trench disposal facility is the degree to which groundwater and surface water can contact the waste and subsequently cause migration of radionuclides. An effective way to avoid such contact is to place a permanent water-resistant cover over the trenches to restrict percolation of surface water through the waste. Clay, soil additives, asphalt, plastic membranes, concrete, and stainless steel could be used for this protective cover. To be consistent with the Engineering Analysis Report, it is assumed here that clay would be used for this protective cover.

During construction, water (mainly for personnel usage), diesel fuel, electricity, and trench material would be needed. During operations, water needs would be primarily for potable water for site personnel. Wastewater in the form of sanitary waste would be generated by site personnel. Diesel fuel and electricity would be used by emplacement equipment. Tables 4.1a and 4.1b[1] show estimates of the materials and resources required for construction of an engineered trench facility for the disposal of UF_4 for the original inventory and new inventory,

[1] For reader convenience, tables referred to in Section 4 are placed at the end of the section.

respectively. Tables 4.2a and 4.2b show estimates of the materials and resources required for routine operation of an engineered trench facility for the original inventory and the new inventory, respectively.

4.2 VAULT DISPOSAL FACILITY

Tables 4.3a and 4.3b summarize materials and resources consumed during construction of a vault disposal facility for the original inventory and the new inventory, respectively. Tables 4.4a and 4.4b summarize materials and resources consumed during routine operation of a vault disposal facility for the original inventory and the new inventory, respectively. Diesel fuel would be required for trucks and emplacement cranes. Concrete would be used for constructing and sealing the vaults.

4.3 MINED-CAVITY DISPOSAL FACILITY

A major material associated with a mined-cavity disposal facility would be the rock excavated from the underground area to provide for (1) the three main drifts for services, tuff movement, and waste movement; (2) a perimeter drift that would encircle the underground area; (3) the emplacement drifts; (4) ramps connecting the rock and waste drifts with the surface; and (5) shafts drilled from the surface to the underground area to provide access for workers, materials, and utilities.

Considerable diesel fuel and electricity would be expended in excavating a mined-cavity disposal facility. The walls of all drifts and ramps would have to be lined with steel-reinforced concrete, which is shot in place. This process requires in situ mixing of the concrete components, including water. Tables 4.5a and 4.5b summarize material used to construct a mined-cavity disposal facility for the original inventory and the new inventory, respectively.

In accordance with the Engineering Analysis Report, it is assumed here that the mined-cavity disposal facility would operate on a one shift per day basis over a 20-year period for the original inventory and over a 25-year period for the new inventory. The principal utility required would be electric power for operation of ventilation systems, industrial power equipment (e.g., forklifts), and for lighting and heating. Tables 4.6a and 4.6b summarize utilities needed for operations of a mined-cavity disposal facility for the original inventory and the new inventory, respectively.

4.4 WASTEFORM FACILITY

Estimates of materials and resources used during construction and operation of the wasteform facility follow the methodology used in the Engineering Analysis Report. Tables 4.7a and 4.7b summarize the estimates of resource requirements during construction of the wasteform facility using approximate, order of magnitude values for the original inventory and the new inventory, respectively. Tables 4.8a and 4.8b present estimates of the amount of concrete used for each building that makes up the wasteform facility. Tables 4.9a and 4.9b present the estimated resource requirements for operation of the facility. The wasteform facility would be larger for the new inventory than for the original inventory when 30-gallon drums would be used, but not when 55-gallon drums would be used. This situation arises because there would be an addition row of pallets of 30-gallon stored in the product receiving and shipping warehouse for the new inventory, but not an additional row of pallets of 55-gallon drums.

TABLE 4.1a Materials and Resources Required during Construction of Engineered Trenches, Original Inventory

	30-Gallon Disposal Containers		55-Gallon Disposal Containers	
Item	Annually	Over 20 Years	Annually	Over 20 Years
Water, ML	0.014	0.28	0.014	0.27
Excavated material, m^3	6.44E+04	1.29E+06	5.32E+04	1.06E+06
Clay, m^3	437	8,740	392	7,840
Sand, m^3	2,910	5.83E+04	2,340	4.69E+04
Gravel, te	122	2,440	99	1,970
Electricity, MW-h	220	4,410	185	3,700
Diesel fuel, L	5.68E+04	1.14E+06	4.69E+04	9.38E+05

TABLE 4.1b Materials and Resources Required during Construction of Engineered Trenches, New Inventory

	30-Gallon Disposal Containers		55-Gallon Disposal Containers	
Item	Annually	Over 25 Years	Annually	Over 25 Years
Water, ML	0.12	0.29	0.011	0.28
Excavated material, m^3	6.58E+04	1.65E+06	5.44E+04	1.36E+06
Clay, m^3	452	11,300	406	1.01E+04
Sand, m^3	3,060	7.65E+04	2,480	6.20E+04
Gravel, te	128	3,200	104	2,600
Electricity, MW-h	222	5,560	186	4,640
Diesel fuel, L	5.82E+04	1.45E+06	4.81E+04	1.20E+06

TABLE 4.2a Resources Required during Operation of the Engineered Trench Disposal Facility, Original Inventory

	30-Gallon Disposal Containers		55-Gallon Disposal Containers	
Item	Annually	Over 20 Years	Annually	Over 20 Years
Water, ML	0.083	1.66	0.052	1.04
Electricity, MW-h	1,030	2.06E+04	762	1.52E+04
Diesel fuel, L	1.48E+05	2.97E+06	8.21E+04	1.64E+06

TABLE 4.2b Resources Required during Operation of the Engineered Trench Disposal Facility, New Inventory

Item	30-Gallon Disposal Containers		55-Gallon Disposal Containers	
	Annually	Over 25 Years	Annually	Over 25 Years
Water, ML	0.084	2.09	0.052	1.31
Electricity, MW-h	1,030	2.58E+04	765	1.91E+04
Diesel fuel, L	1.49E+05	3.73E+06	8.26E+04	2.07E+06

TABLE 4.3a Materials and Resources Required during Construction of the Vault Disposal Facility, Original Inventory

Item	Per Vault	30-Gallon Disposal Containers		55-Gallon Disposal Containers	
		Annually	Total	Annually	Total
Number of vaults	1	3.8	76	4.2	84
Concrete, redi-mix, m^3	1,750	6,650	133,000	7,350	147,000
Gravel, te	910	3,460	69,200	3,820	76,400
Liner, m^2	2,220	8,440	168,700	9,320	186,500
Steel, te	58.5	220	4,400	250	4,900
Water, ML	0.78	2.96	59.3	3.28	65.5
Excavated material, m^3	7,520	28,600	572,000	31,600	632,000
Electricity, kW-h	12,500	47,500	950,000	52,500	1,050,000
Diesel fuel, L	17,800	67,600	1,353,000	74,800	1,495,000

TABLE 4.3b Materials and Resources Required during Construction of the Vault Disposal Facility, New Inventory

Item	Per Vault	30-Gallon Disposal Containers		55-Gallon Disposal Containers	
		Annually	Total	Annually	Total
Number of vaults	1	3.8	95	4.2	105
Concrete, redi-mix, m^3	1,750	6,650	1.66E+05	7,350	1.84E+05
Gravel, te	910	3,460	8.65E+04	3,820	9.56E+04
Liner, m^2	2,220	8,440	2.11E+05	9,320	2.33E+05
Steel, te	58.5	58.5	5,600	250	6,100
Water, ML	0.78	2.96	74.1	3.28	81.9
Excavated material, m^3	7,520	2.86E+04	7.14E+05	3.16E+04	7.90E+05
Electricity, kW-h	1.25E+04	4.75E+04	1.19E+06	5.25E+04	1.31E+06
Diesel fuel, L	1.78E+04	6.76E+04	1.69E+06	7.48E+04	1.87E+06

TABLE 4.4a Resources Required during Operation of the Vault Disposal Facility, Original Inventory

Item	30-Gallon Disposal Containers			55-Gallon Disposal Containers		
	Per Vault	Annually	Over 20 Years	Per Vault	Annually	Over 20 Years
Number of vaults	1	3.8	76	1	4.2	84
Water, ML	0.02	0.076	1.52	0.02	0.084	1.68
Electricity, kW-h	328	1,250	2.49E+04	328	1,380	2.76E+04
Diesel fuel, L	5.11E+04	1.94E+05	3.88E+06	5.11E+04	2.15E+05	4.29E+06

TABLE 4.4b Resources Required during Operation of the Vault Disposal Facility, New Inventory

Item	30-Gallon Disposal Containers			55-Gallon Disposal Containers		
	Per Vault	Annually	Over 25 Years	Per Vault	Annually	Over 25 Years
Number of vaults	1	3.8	95	1	4.2	105
Water, ML	0.02	0.076	1.9	0.02	0.084	2.1
Electricity, kW-h	328	1,250	3.12E+04	328	1,380	3.44E+04
Diesel fuel, L	5.11E+04	1.94E+05	4.85E+06	5.11E+04	2.15E+05	5.37E+06

TABLE 4.5a Materials and Resources Required during Construction of the Mined-Cavity Facility, Original Inventory

Item	30-Gallon Disposal Containers	55-Gallon Disposal Containers
Water, ML	16.7	14.0
Concrete, redi-mix, m^3	9.90E+04	8.20E+04
Steel, te	3,890	3,230
Electricity, GW-h	5,760	4,810
Diesel fuel, L	7.16E+05	5.83E+05
Excavated material, m^3	1.22E+06	9.90E+05

TABLE 4.5b Materials and Resources Required during Construction of the Mined-Cavity Facility, New Inventory

Item	30-Gallon Disposal Containers	55-Gallon Disposal Containers
Water, ML	19.4	16.1
Concrete, redi-mix, m^3	1.16E+05	9.50E+04
Steel, te	4,540	3,740
Electricity, GW-h	6,670	5,540
Diesel fuel, L	8.46E+05	6.84E+05
Excavated material, m^3	1.44E+06	1.16E+06

TABLE 4.6a Resources Required during Operation of the Mined-Cavity Facility, Original Inventory

	30-Gallon Disposal Containers		55-Gallon Disposal Containers	
Item	Annually	Over 20 Years	Annually	Over 20 Years
Water, ML	3.09	61.8	2.33	46.5
Electricity, MW-h	8,310	1.66E+05	6,140	1.23E+05
Diesel fuel, L	9,300	1.86E+05	6,230	1.25E+05

TABLE 4.6b Resources Required during Operation of the Mined-Cavity Facility, New Inventory

Item	30-Gallon Disposal Containers		55-Gallon Disposal Containers	
	Annually	Total	Annually	Total
Water, ML	3.10	77.5	2.33	58.3
Electricity, GW-h	8,340	2.09E+05	6,160	1,54E+05
Diesel fuel, L	9,350	2.34E+05	6,260	1.57E+05

TABLE 4.7a Materials and Resources Required during Construction of the Wasteform Facility, Original Inventory

Item	30-Gallon Disposal Containers	55-Gallon Disposal Containers
Water, ML	3.3	2.7
Concrete, redi-mix, m^3	5,591	4,286
Steel, te	349	271
Excavated material, m^3	9,550	7,550
Electricity, MW-h	480	410
Masonry brick, m^2	573	573
Diesel fuel, L	90,000	70,000

TABLE 4.7b Materials and Resources Required during Construction of the Wasteform Facility, New Inventory

Item	30-Gallon Disposal Containers	55-Gallon Disposal Containers
Water, ML	3.4	2.7
Concrete, redi-mix, m^3	5,724	4,286
Steel, te	357	271
Excavated material, m^3	9,750	7,550
Electricity, MW-h	487	410
Masonry brick, m^2	573	573
Diesel fuel, L	92,000	70,000

TABLE 4.8a Estimated Volume of Concrete Required for the Wasteform Facility, Original Inventory

Structure	Concrete Required (m^3)			
	Floor	Walls	Roof	Total
Product receiving and shipping warehouse, 30-gal disposal containers	2,482	759	2,068	5,308
Product receiving and shipping warehouse, 55-gal disposal containers	1,871	572	1,559	4,003
Administration building	88	94	101	283

TABLE 4.8b Estimated Volume of Concrete Required for the Wasteform Facility, New Inventory

Structure	Concrete Required (m^3)			
	Floor	Walls	Roof	Total
Product receiving and shipping warehouse, 30-gal disposal containers	2,544	778	2,120	5,441
Product receiving and shipping warehouse, 55-gal disposal containers	1,871	572	1,559	4,003
Administration building	88	94	101	283

TABLE 4.9a Resources Required during Operation of the Wasteform Facility, Original Inventory

Item	30-Gallon Disposal Containers		55-Gallon Disposal Containers	
	Annually	Over 20 Years	Annually	Over 20 Years
Water, ML	0.62	12	0.52	10
Natural gas, therms (1E+05 Btu)	141	2,830	112	2,240
Electricity, MW-h	671	13,400	579	11,600
Diesel fuel, L	556	11,100	502	10,000

TABLE 4.9b Resources Required during Operation of the Wasteform Facility, New Inventory

Item	30-Gallon Disposal Containers		55-Gallon Disposal Containers	
	Annually	Over 25 Years	Annually	Over 25 Years
Water, ML	0.63	16	0.52	13
Natural gas, therms (1E+05 Btu)	144	3,610	112	2,800
Electricity, MW-h	680	17,000	579	14,500
Diesel fuel, L	561	14,000	502	12,600

5 PERSONNEL STAFFING ESTIMATES

The preconceptual staffing estimates presented here are based on the same methodology as used in the Engineering Analysis Report. The staffing estimates are divided into construction and operational personnel requirements.

5.1 CONSTRUCTION LABOR FORCE

The construction labor force would be organized into at least five groups, as described below.

Management, Engineering, Design, Permitting (Home Office): This group includes management, planning, engineering through Title III, and permitting personnel. Permitting includes licensing activities and National Environmental Policy Act (NEPA) documentation. This group is typically located at the contractors' home or regional office, rather than in the field.

Management and Supervision at the Construction Site (Field Office): This group represents overall field management and supervision during actual construction and excavation. Personnel would be stationed in trailers initially. They would relocate to finished buildings (e.g., administration building) upon their completion. This group would remain at one relatively constant level for construction of the wasteform facility and another relatively constant level during construction of the disposal facility.

Site Preparation: This group includes the surveyors, operating engineers, truck drivers, and laborer who would provide the initial construction entrance, temporary (gravel) roads, storm water management, initial grubbing, installation of utility service, and associated activities. The level of effort for this group would be greatest during construction of the wasteform facility, but would continue for the first couple of years of construction of the disposal facility.

Construction: This group includes those who would be involved in building the wasteform facility and constructing the disposal facilities.

Checkout and Startup: This group includes those involved in readiness assessments, final licensing and permitting activities, and training and certification of the operating staff.

Construction labor estimates (full-time equivalent-years [FTE-yr]) are summarized for the three disposal options in Tables 5.1a[1] and 5.1b for the original inventory and the new inventory, respectively. Tables 5.2a and 5.2b provide estimates of the employment buildup by year during construction of the wasteform facility for the original inventory and the new inventory, respectively. Tables 5.3a and 5.3b provide estimates of the employment buildup by year during construction of the mined-cavity disposal facility for the original inventory and the new inventory, respectively. For the other two disposal options, a constant number of construction employees over the 20-year construction period can be assumed.

5.2 OPERATIONS LABOR FORCE

Operation labor estimates (in FTEs) are summarized in Tables 5.4a and 5.4b for the original inventory and the new inventory, respectively. These estimates are based on the operations that occur in the disposal facility and the wasteform facility that are presented in detail in Appendix B.

Product Receiving and Shipping Warehouse: The operations in the warehouse facility would include unloading and inspecting arriving pallets, transferring them to storage, transferring the pallets from storage to the shipping bay, and loading the pallets for transport to the disposal units.

Disposal Facility: Some operations would be common to all three types of disposal facilities, while other operations would be specific to one type. Common operations include transporting the drums to the disposal units and emplacing them in the disposal units. For the engineered trench and vault facilities, the area around the drums in the disposal unit must be filled with material and the trench or vault must undergo a closure operation. Although the fill and trench/vault closure operations would not apply to a mined cavity, there would be extra loading and unloading operations for the latter. To preserve the quality of the underground air in the mined cavity, an electric vehicle would be used to transport pallets underground. Therefore, pallets must be unloaded from diesel-fuel vehicles used aboveground and reloaded onto the electric vehicles used underground.

[1] For reader convenience, tables referred to in Section 5 are placed at the end of the section.

TABLE 5.1a Summary of Construction Labor Estimates (FTE-yr), Original Inventory

	30-Gallon Disposal Containers			55-Gallon Disposal Containers		
Disposal Approach	Wasteform Facility	Disposal Facility	Total	Wasteform Facility	Disposal Facility	Total
Trenches	283	430	713	204	420	624
Vaults	283	900	1,183	204	960	1,164
Mined cavity	283	3,800	4,083	204	3,400	3,604

TABLE 5.1b Summary of Construction Labor Estimates (FTE-yr), New Inventory

	30-Gallon Disposal Containers			55-Gallon Disposal Containers		
Disposal Approach	Wasteform Facility	Disposal Facility	Total	Wasteform Facility	Disposal Facility	Total
Trenches	292	450	742	204	430	34
Vaults	292	1,030	1,322	204	1,090	1,294
Mined cavity	292	4,300	4,592	204	3,700	3,904

TABLE 5.2a Number of Construction Workers Needed by Year for the Wasteform Facility, Original Inventory

	30-Gallon Disposal Containers				55-Gallon Disposal Containers			
Employees	Year 1	Year 2	Year 3	Subtotal	Year 1	Year 2	Year 3	Subtotal
Total craft workers	65	86	86	237	46	62	62	169
Construction management and support staff	7	14	22	43	5	10	15	31
Total	72	101	108	280	51	72	77	200

TABLE 5.2b Number of Construction Workers Needed by Year for the Wasteform Facility, New Inventory

	30-Gallon Disposal Containers				55-Gallon Disposal Containers			
Employees	Year 1	Year 2	Year 3	Subtotal	Year 1	Year 2	Year 3	Subtotal
Total craft workers	67	89	89	245	46	62	62	169
Construction management and support staff	7	15	22	45	5	10	15	31
Total	74	104	112	290	51	72	77	200

TABLE 5.3a Number of Construction Workers Needed by Year for Mined-Cavity Disposal Facility, Original Inventory

Employees	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Total
30-Gallon Drums									
Total craft workers	111	287	456	583	697	697	473	171	3,474
Construction management and Support staff	16	33	51	51	63	63	33	16	326
Total	127	320	507	633	760	760	507	187	3,800
55-Gallon Drums									
Total craft workers	99	256	408	521	623	623	424	153	3,109
Construction management and support staff	14	30	45	45	57	57	30	14	291
Total	113	286	453	567	680	680	453	167	3,400

TABLE 5.3b Number of Construction Workers Needed by Year for Mined-Cavity Disposal Facility, New Inventory

Employees	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Total
30-Gallon Drums									
Total craft workers	126	324	516	659	788	788	536	194	3,931
Construction management and support staff	18	38	58	58	72	72	38	18	369
Total	143	362	573	717	860	860	573	212	4,300
55-Gallon Drums									
Total craft workers	108	279	444	567	678	678	461	167	3,383
Construction management and support staff	15	32	49	49	62	62	32	15	317
Total	123	311	493	617	740	740	493	182	3,700

TABLE 5.4a Summary of Operational Labor Estimates (FTEs), Original Inventory

	30-Gallon Disposal Containers			55-Gallon Disposal Containers		
Disposal Approach	Wasteform Facility	Disposal Facility	Total	Wasteform Facility	Disposal Facility	Total
Trenches	40	22	62	34	17	52
Vaults	40	47	86	34	36	71
Mined cavity	41	30	71	35	25	61

TABLE 5.4b Summary of Operational Labor Estimates (FTEs), New Inventory

Disposal Approach	30-Gallon Disposal Containers: Wasteform Facility	30-Gallon Disposal Containers: Disposal Facility	30-Gallon Disposal Containers: Total	55-Gallon Disposal Containers: Wasteform Facility	55-Gallon Disposal Containers: Disposal Facility	55-Gallon Disposal Containers: Total
Trenches	40	22	62	35	17	2
Vaults	40	47	86	35	36	71
Mined cavity	41	30	71	36	25	61

6 FACILITY EMISSIONS AND WASTES

6.1 ESTIMATES OF EMISSIONS AND WASTES GENERATED DURING CONSTRUCTION

Wastes generated during construction of the disposal facility would be typical of large construction projects. Wastes would be primarily construction debris, including concrete fragments, and sanitary wastes of the labor force. Emissions would result primarily from the use of fuels in construction, removing construction debris, and disturbing the land (dust). To be consistent with the Engineering Analysis Report, the amount of concrete waste was estimated on the basis of the assumption that 2% of the concrete usage would be spoilage. The other solid wastes, which would include construction debris and rock cuttings, were taken to be eight times the volume of the concrete spoilage. Steel waste was taken to be 0.5% of the steel requirements. These solid nonhazardous wastes would be to be disposed of in a municipal solid waste landfill. The amount of sanitary waste was estimated on the basis of total construction workforce. Liquid (sanitary) nonhazardous wastes would either be treated in a portable system or hauled to off-site facilities for treatment and disposal.

Estimates of criteria pollutant emissions generated during construction were based on the estimated amounts of fuel used by the trucks and cranes during construction. Standard U.S. Environmental Protection Agency (EPA) emission factors were used in these calculations (EPA 1993). Emissions were calculated from the total quantity of liquid fuel consumed (gasoline and diesel). Dust was estimated from the amount of disturbed land area and the duration that the disturbed area would be under construction.

National Ambient Air Quality Standards (NAAQS) for criteria air pollutants are given in Table 6.1.[1] Estimates of construction wastes and emissions are given in Table 6.2 for the engineered trench disposal facility, in Table 6.3 for the vault disposal facility, in Table 6.4 for the mined-cavity disposal facility, and in Table 6.5 for the wasteform facility. The construction period was taken as 20 years for the engineered trench and vault disposal facilities for the original inventory and 25 years for the new inventory, 7.5 years for the mined-cavity disposal facility for both inventories, and 3 years for the wasteform facility for both inventories. Emissions of the following criteria air pollutants were estimated: sulfur dioxide (SO_2), nitrogen oxides (NO_x), nonmethane hydrocarbons (NMHCs), carbon monoxide (CO), methane (CH_4), and particulate matter with a diameter of less than or equal to 10 micrometers (PM_{10}).

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[1] For reader convenience, tables referred to in Section 6 are placed at the end of the section.

6.2 ESTIMATES OF EMISSIONS AND WASTES GENERATED DURING OPERATIONS

Operation of the disposal facility would involve the receipt, inspection, and repackaging (if damaged) of drums containing depleted UF_4 at the wasteform facility, transfer of these drums to the disposal units, and emplacement in the disposal units. The major wastes and emissions generated during operation would be sanitary wastes of the on-site labor force and criteria pollutant emissions from transportation of the drums and from facility space heating. Emissions of criteria pollutants were calculated on the basis of the amount of diesel fuel, gasoline, and natural gas used each year. Under normal conditions (nonaccident) of operation, radioactive waste would be generated in the wasteform facility from spent high-efficiency particulate air (HEPA) filters, damaged drums, contaminated protective clothing, and similar sources. A very small amount of liquid low-level mixed waste (LLMW) would be generated in the wasteform facility from wiping of drums (with a dilute acid and detergent wash) that do not pass visual inspection. Small amounts of nonhazardous waste (e.g., domestic and office trash) and recyclable waste (e.g., paper, aluminum) would also be generated in the wasteform facility.

Annual emissions from operations of the disposal facilities are presented in Tables 6.6a and 6.6b for the original inventory and new inventory, respectively. Annual emissions and wastes from operations of the wasteform facility are found in Tables 6.7a and 6.7b for the original inventory and the new inventory, respectively, in a form consistent with the Engineering Analysis Report.

TABLE 6.1 National Ambient Air Quality Standards (NAAQS) for Criteria Air Pollutants

Criteria Air Pollutant	Averaging Time	Primary Standard
CO	1 hour 8 hours	40 mg/m^3 10 mg/m^3
Hydrocarbons	3 hours	160 µg/m^3
NO_x (as NO_2)	Annual	100 µg/m^3
SO_x (as SO_2)	24-hours[a] Annual	365 µg/m^3 80 µg/m^3
PM_{10}	24-hours[a] Annual	150 µg/m^3 50 µg/m^3

[a] Not to be exceeded more than once a year.

Source: 40 CFR 50.0 et seq.

TABLE 6.2 Estimated Emissions and Wastes from Construction of Trench Disposal Facility

		Original Inventory		New Inventory	
Material	Units	30-Gallon Drums	55-Gallon Drums	30-Gallon Drums	55-Gallon Drums
Emissions (per year)					
CO	te	2.35	1.30	2.36	1.31
NMHC	te	0.82	0.46	0.83	0.46
NO_x	te	10.9	6.02	11.0	6.06
SO_2	te	0.72	0.40	0.72	0.40
PM_{10}	te	51	43	63	53
Methane	te	6.74E-02	3.73E-02	6.79E-02	3.75E-02
Wastes (total)					
Hazardous solids	m^3	23	22	24	23
Hazardous liquids	m^3	46	45	48	46
Sanitary liquids	m^3	6.60E+03	6.40E+03	6.90E+03	6.60E+03
Other liquids	m^3	2.90E+03	2.90E+03	3.10E+03	2.90E+03

TABLE 6.3 Estimated Emissions and Wastes from Construction of Vault Disposal Facility

Material	Units	Original Inventory 30-Gallon Drums	Original Inventory 55-Gallon Drums	New Inventory 30-Gallon Drums	New Inventory 55-Gallon Drums
Emissions (per year)					
CO	te	1.07	1.18	1.07	1.18
NMHC	te	0.38	0.42	0.38	0.42
NO_x	te	4.96	5.49	4.96	5.49
SO_2	te	0.33	0.36	0.33	0.36
PM_{10}	te	69	85	85	102
Methane	te	3.07E-02	3.40E-02	3.07E-02	3.40E-02
Wastes (total)					
Hazardous solids	m^3	47	51	54	58
Hazardous liquids	m^3	96	102	110	116
Concrete	m^3	2.66E+03	2.94E+03	3.33E+03	3.68E+03
Steel	te	22.0	24.5	28.0	30.5
Other solid waste	m^3	2.10E+04	2.40E+04	2.70E+04	2.90E+04
Sanitary liquids	m^3	1.40E+04	1.50E+04	1.60E+04	1.70E+04
Other liquids	m^3	6.10E+03	6.50E+03	7.03E+03	7.4E+03

TABLE 6.4 Estimated Emissions and Wastes from Construction of Mined-Cavity Disposal Facility

Material	Units	Original Inventory 30-Gallon Drums	Original Inventory 55-Gallon Drums	New Inventory 30-Gallon Drums	New Inventory 55-Gallon Drums
Emissions (per year)					
CO	te	1.51	1.23	1.78	1.44
NMHC	te	0.53	0.43	0.63	0.51
NO_x	te	7.00	5.70	8.28	6.69
SO_2	te	0.46	0.38	0.55	0.44
PM_{10}	te	636	452	837	593
Methane	te	4.34E-02	3.53E-02	3.07E-02	4.15E-02
Wastes (total)					
Hazardous solids	m^3	200	179	227	195
Hazardous liquids	m^3	406	363	459	395
Concrete	m^3	1.98E+03	1.64E+03	2.3E+03	1.90E+03
Steel	m^3	19.5	16.2	22.7	18.7
Other solid waste	m^3	1.60E+04	1.30E+04	1.90E+04	1.50E+04
Sanitary liquids	m^3	5.80E+04	5.20E+04	6.60E+04	5.70E+04
Other liquids	m^3	2.60E+04	2.30E+04	2.90E+04	2.50E+04

TABLE 6.5 Estimated Emissions and Wastes from Construction of Wasteform Facility

		Original Inventory		New Inventory	
Material	Units	30-Gallon Drums	55-Gallon Drums	30-Gallon Drums	55-Gallon Drums
Emissions (per year)					
CO	te	0.712	0.554	0.728	0.554
NMHC	te	0.250	0.194	0.256	0.194
NO_x	te	3.30	2.57	3.37	2.57
SO_2	te	0.218	0.169	0.222	0.169
PM_{10}	te	17.9	14.6	18.2	14.6
Methane	te	2.05E-02	1.59E-02	2.09E-02	1.59E-02
Wastes (total)					
Hazardous solids	m^3	14.8	10.6	15.3	10.6
Hazardous liquids	m^3	29.9	21.3	30.9	21.3
Concrete	m^3	110	90	110	90
Steel	te	1.7	1.4	1.8	1.4
Other solid waste	m^3	890	690	920	690
Sanitary liquids	m^3	4.30E+03	3.10E+03	4.40E+03	3.10E+03
Other liquids	m^3	1.90E+03	1.40E+03	2.00E+03	1.40E+03

TABLE 6.6a Estimated Average Annual Emissions (in te/yr) from Operation of Disposal Facilities, Original Inventory

	30-Gallon Drums			55-Gallon Drums		
Emission	Trench	Vault	Mine	Trench	Vault	Mine
SO_2	0.71	0.93	4.5E-02	0.39	1.0	3.0E-02
NO_x	11	14	0.68	6.0	16	0.46
Hydrocarbons	0.89	1.2	5.6E-02	0.49	1.3	3.7E-02
CO	2.3	3.0	0.15	1.3	3.4	9.7E-02
PM_{10}	0.77	1.0	4.8E-02	0.42	1.1	3.2E-02

TABLE 6.6b Estimated Average Annual Emissions (in te/yr) from Operation of Disposal Facilities, New Inventory

	30-Gallon Drums			55-Gallon Drums		
Emission	Trench	Vault	Mine	Trench	Vault	Mine
SO_2	0.72	0.93	4.5E-02	0.40	1.0	3.0E-02
NO_x	11	14	0.68	6.1	16	0.46
Hydrocarbons	0.90	1.2	5.6E-02	0.50	1.3	3.8E-02
CO	2.3	3.0	0.15	1.3	3.4	9.8E-02
PM_{10}	0.77	1.0	4.8E-02	0.43	1.1	3.2E-02

TABLE 6.7a Estimated Annual Emissions and Wastes from Operation of the Wasteform Facility, Original Inventory

Material	Units	Treatability Category	30-Gallon Drums	55-Gallon Drums
Emissions (per year)				
SO_2	te	NA[a]	2.7E-03	2.4E-03
NO_x	te	NA	4.1E-02	3.7E-02
Hydrocarbons	te	NA	3.3E-03	3.0E-03
Carbon monoxide	te	NA	8.9E-03	8.0E-03
PM_{10}	te	NA	2.9E-03	2.6E-03
Wastes				
Spent HEPA filters	m^3 (total)	Noncombustible compactable LLW	23.8	23.8
Damaged drums	m^3 (total)	Surface-contaminated metal LLW	7.8	7.8
Other LLW	m^3/yr	Combustible solid LLW	47.6	26.2
Inorganic solutions	m^3/yr	Liquid LLMW	0.26	0.18
Nonhazardous (sanitary) wastes	m^3/yr	NA	986	859
Nonhazardous (other) wastes	m^3/yr	NA	78	68
Recyclable wastes	m^3/yr	NA	31	27

[a] NA = not applicable.

TABLE 6.7b Estimated Annual Emissions and Wastes from Operation of the Wasteform Facility, New Inventory

Material	Units	Treatability Category	30-Gallon Drums	55-Gallon Drums
Emissions (per year)				
SO_2	te	NA[a]	2.7E-03	2.4E-03
NO_x	te	NA	4.2E-02	3.7E-02
Hydrocarbons	te	NA	3.4E-03	3.0E-03
Carbon monoxide	te	NA	9.0E-03	8.0E-03
PM_{10}	te	NA	2.9E-03	2.6E-03
Wastes				
Spent HEPA filters	m^3 (total)	Noncombustible compactable LLW	23.8	23.8
Damaged drums	m^3 (total)	Surface-contaminated metal LLW	7.9	7.9
Other LLW	m^3/yr	Combustible solid LLW	47.9	26.5
Inorganic solutions	m^3/yr	Liquid LLMW	0.26	0.18
Nonhazardous (sanitary) wastes	m^3/yr	NA	988	860
Nonhazardous (other) wastes	m^3/yr	NA	78	68
Recyclable wastes	m^3/yr	NA	31	27

[a] NA = not applicable.

7 DESCRIPTION OF POTENTIAL ACCIDENTS

Accidents that could occur at the disposal and wasteform facilities are analyzed in this section. Accidents could be initiated during facility operations or could be caused by external events, including natural phenomena (earthquake and wind). Reasonably foreseeable accidents have been screened to identify the accidents that would have the greatest consequences to workers and the public. These are the “bounding” accidents that provide an envelope for the consequences of the other potential accidents that would have less impact on workers and the public. Because uranium is both radioactive and chemically toxic, the bounding accidents all involve the release of uranium. The uranium would be released in the form of UF_4, except for a potential fire or explosion accident, in which uranium might be released in the form of UO_2.

Four types of events were considered credible: a handling accident, a fire or explosion, an earthquake, and a tornado. Table 7.1[1] summarizes the results of the accident analysis, giving the accident scenario, a description of the accident, the frequency range, and information about the source term.

A flood was not considered to be credible because it is assumed that the facility would be sited to preclude severe flooding. It is assumed that the location and design of the disposal facilities would bring the frequency below 1×10^{-6}/yr. For example, NRC’s regulations in 10 CFR 61.50 and 61.51 require, inter alia, that waste disposal shall not take place in a 100-year floodplain and that covers must be designed to minimize water infiltration and to direct surface water drainage away from the disposed waste.

In analyzing the potential consequences of postulated accidents, the source term, which is the amount of radioactive material released, is evaluated. The source term is the product of four factors: the material at risk (MAR); the damage fraction (DF); the respirable airborne release fraction (RARF); and the fraction of respirable airborne material released to the environment, or leak path factor (LPF).

7.1 HANDLING ACCIDENT

Mechanical upsets are events such as spills, forklift punctures, loss of filtration, and piping failures. In general, mechanical upset-initiated accidents would result in small releases to the atmosphere. For this analysis, the assumption is made that a forklift damages a drum and causes the drum’s entire contents to be spilled. Two cases are considered. In one case, the spill occurs within the product receiving and shipping warehouse; in the other case, the spill occurs outside the warehouse. The MAR is the total radioactive material, UF_4, in one drum (364 kg [802 lb] for a 30-gallon drum, 667 kg [1,407 lb] for a 55-gallon drum). It is assumed that the

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[1] For reader convenience, Table 7.1 is placed at the end of the section.

damage fraction is one-half, that is, half of the UF_4 becomes airborne, and that the fraction of the released material in the respirable range (RARF) is 2×10^{-4}. As in the Engineering Analysis Report, it is assumed that for the indoors accident, the UF_4 release would be filtered as it passed through HEPA filters with an efficiency of 99.9% (LPF = 0.001) as a puff. (The accident scenario would not result in failure of off-gas filters because of the absence of energetic processes.) The source term for the accident when it occurs inside the product receiving and shipping warehouse is then 3.64×10^{-5} kg (8.02×10^{-5} lb) for damage of a 30-gallon drum and 6.7×10^{-5} kg (1.5×10^{-4} lb) for a 55-gallon drum. If the accident occurred outside the warehouse, the leak path factor would be unity, and consequently the release amount would 1,000 times greater.

The frequency of this accident per year is the product of the number of drums received per year, the number of operations per pallet, and the probability that a mishandling accident would cause damage to a drum resulting in release of radioactive material per operation. It is assumed that the mishandling accident probability (1.1×10^{-5}) and two handling operations per drum are the same as for mishandling of drums in the Engineering Analysis Report. For disposal in 30-gallon drums (68,650 drums would be handled per year), the frequency of this accident would be 1.5/yr. For disposal in 55-gallon drums (37,450 drums would be handled per year), the frequency of this accident would be 0.8/yr. This accident is considered to be anticipated because it has a frequency greater than 0.01/yr.

7.2 FIRE OR EXPLOSION

For this analysis, it is assumed that there is a fire or explosion within the product receiving and shipping warehouse that affects the contents of four drums on a pallet. The absence of combustible materials or a fire source within the warehouse building would limit the material at risk to a single pallet. This accident scenario assumes that the fire is initiated by a fuel leak from the forklift, which could be ignited by a number of sources.

The fire or explosion would cause UF_4 to react with water in the atmosphere to form UO_2 and HF. The entire contents of four drums would be affected (DF = 1). All of the HF is assumed to be airborne and respirable (RARF = 1). Only 0.1% of the UO_2 is assumed to be airborne and respirable (RARF = 0.001). The LPF for UO_2 as for UF_4 is taken as 0.001. It is assumed that the warehouse has a calcium carbonate trap with a 95% efficiency (LPF = 0.05) for HF. The release is assumed to have a 30-minute duration. For 30-gallon drums with a material at risk of 1,455 kg (3,208 lb), the source term would be 1.3 g (0.05 oz) of UO_2 and 19 kg (42 lb) of HF. For 55-gallon drums with a material at risk of 2,668 kg, the source term would be 2.3 g (0.08 oz) of UO_2 and 34 kg (75 lb) of HF. The frequency of this accident (9.6×10^{-6}/yr) is the same as was used for the fire or explosion accident in the wasteform facility in the Engineering Analysis Report. This accident is considered to extremely unlikely because its frequency is greater than 1×10^{-6}/yr and less than 1×10^{-4}/yr.

7.3 EARTHQUAKE

For this analysis, the product receiving and shipping warehouse is assumed to be damaged during a design basis earthquake. Review of the on-site structures indicated that this building had the greatest potential for a significant airborne release because of the potential for the overhead crane to fall during the earthquake and crush drums located beneath it, with subsequent atmospheric release of the UF_4.

The material at risk would be the entire amount of depleted UF_4 in storage at the product receiving and shipping warehouse, that is, the material received during a three-month period. Because the amount of UF_4 received at the facility would be independent of drum size, the release would not depend on drum size. Therefore, the material at risk would be 6.24×10^6 kg (1.38×10^7 lb). The damage fraction is taken as 10%. The RARF would be the same as for the handling accident (Section 7.1). The seismic event is assumed to cause failure of the building structure and its confinement system so that 100% of the UF_4 released from the drums would be released from the building (LPF = 1), resulting in ground-level unfiltered release of 125 kg (276 lb) of UF_4. The release is assumed to continue for a 30-minute period. The frequency of this event (5×10^{-4}/yr), as well as the LPF (1), DF, and release duration, are assumed to be the same as for the earthquake event analyzed in the Engineering Analysis Report. DOE hazard category 2 buildings are constructed such that earthquakes (tornadoes as well) could cause failure of the building structure and confinement at this annual frequency.

Although it might appear intuitively that the potential consequences of an earthquake on an underground facility would be more severe than on a surface facility, that does not appear to be the case. Available data on the effects of earthquakes in underground mines and tunnels indicate that they are significantly less susceptible to damage from earthquakes than are surface facilities (DOE 1980). Investigations measuring earthquake acceleration underground and at the surface indicated that underground motion was four to six times less than at the surface. A study of the Alaskan earthquake of 1964 by the U.S. Geological Survey reported no significant damage to underground facilities, such as mines and tunnels, although some rocks were shaken loose in places. Therefore, it is expected that damage to mined cavities would be much less than for aboveground facilities, such as the product receiving and shipping warehouse.

7.4 TORNADO

For this accident analysis, it is assumed that the product receiving and shipping warehouse would be damaged when a major tornado, with associated tornado debris missiles, sweeps across the building in 30 seconds. It is assumed that a tornado wind-driven missile would hit a pallet of four drums and that all four drums would rupture and release their entire contents. In view of the close packing of drums within this building, the assumption of an entire pallet being affected is reasonable. It is assumed that all of the powder released from the drums becomes airborne with 5% in the respirable size range (this assumption is similar to that made in the Engineering Analysis Report for accidents involving U_3O_8, such as during defluorination of UF_6). There would be failure of the building structure and its confinement system so that 100% of the UF_4 released from the drums would be released from the building. This situation would result in ground-level unfiltered release of 73 kg (160 lb) for 30-gallon drums or 133 kg (293 lb) for 55-gallon drums. The released material would be highly dispersed by the tornadic winds. The release is assumed to continue for a 30-second period. The frequency of this event (5×10^{-4}/yr) is assumed to be the same as for the earthquake event in the Engineering Analysis Report. It should be noted that the tornado accident analyzed in the Engineering Analysis Report assumed that the entire product receiving and shipping warehouse would be destroyed so the material at risk was the entire contents of the warehouse.

TABLE 7.1 Assessment of Accidents

Accident Scenario	Accident Description	Frequency Range	Release (Source Term)					Release Level
				Amount (kg)				
			Chemical Form	30-Gallon Drums	55-Gallon Drums	Duration (minutes)		
Mishandling or drop of drum or billet inside building	A single UF_4 drum is damaged by a forklift and spills its contents onto the ground inside the product receiving and shipping warehouse and repackaging building.	>1E-2/yr	UF_4	3.6E-05	6.7E-05	Puff		Stack
Mishandling or drop of drum or billet outside building	A single UF_4 drum is damaged by a forklift and spills its contents onto the ground outside the product receiving and shipping warehouse and repackaging building.	1E-2/yr	UF_4	3.6E-02	6.7E-02	Puff		Stack
Fire or explosion within the product receiving and shipping warehouse	A fire or explosion within the product receiving and shipping warehouse affects the contents of a single pallet of four drums containing depleted UF_4.	1E-6/yr - 1E-4/yr	UO_2 HF	1.3E-03 19	2.3E-03 34	30		Stack
Earthquake	The product receiving and shipping warehouse is assumed to be damaged during a design basis earthquake, with resulting failure of the structure and confinement.	1E-4/yr - 1E-2/yr	UF_4	125[a]	125[a]	30		Ground
Tornado	A major tornado with associated tornado missiles results in failure of the product receiving and shipping warehouse structure and confinement systems.	1E-4/yr - 1E-2/yr	UF_4	73	133	0.5		Ground
Flood	It is assumed that the facility would be sited to preclude severe flooding.	<1E-6/yr	No Release	NA	NA	NA		NA

[a] Release amount for an earthquake is independent of drum size.

8 TRANSPORTATION

Intrasite transportation of radioactive materials would be limited to transport of drums from the product receiving area to the shipping area of the product receiving and shipping warehouse; transport of damaged drums from the product receiving area to the repackaging area in the product receiving and shipping warehouse; and transport of compliant drums by forklift from the shipping area to the disposal site.

Low-level radioactive waste (LLW) would not be a routine by-product of the wasteform facility. Any LLW that would be generated from spent HEPA filters or as a result of drums being damaged would be packaged in accordance with DOE or NRC/Agreement State requirements and transported by forklift to the shipping area for storage until appropriate disposal was arranged. Hazardous waste materials and LLMW (e.g., waste cleaning solutions, spent lubricants) requiring special treatment before disposal would be packaged and transported by forklift to the shipping area of the product receiving and shipping warehouse for treatment and disposal off-site.

Off-site transportation of radioactive material would be limited to receipt of drums of UF_4 that were shipped by truck or rail, except for out-shipment of hazardous and/or LLMW for disposal. Tables 8.1a and 8.1b summarize the materials and supplies received at the wasteform facility for the original inventory and the new inventory, respectively. For transport by truck, it is assumed that the truck would have a net payload of 19,545 kg (43,000 lb) and could convey either 28 55-gallon drums or 48 30-gallon drums. For transportation by rail, it is assumed that a single railcar would have a payload of 54,545 kg (120,000 lb) and could convey either 76 55-gallon drums or 132 30-gallon drums. A single rail shipment is assumed to have four railcars.

TABLE 8.1a Off-Site Transport of Supplies and Input Materials for the Wasteform Facility, Original Inventory

	30-Gallon Drums		55-Gallon Drums	
Item	Truck	Rail	Truck	Rail
Transported Material				
Type/chemical	UF_4	UF_4	UF_4	UF_4
Physical form	Solid, granular	Solid, granular	Solid, granular	Solid, granular
Chemical composition/ temperature, pressure	UF_4/ambient	UF_4/ambient	UF_4/ambient	UF_4/ambient
Packaging				
Type	30-gal drum	30-gal drum	55-gal drum	55-gal drum
Container volume (m^3)	0.11	0.11	0.21	0.21
Certified by	DOT	DOT	DOT	DOT
Identifier	Varies	Varies	Varies	Varies
Container weight (kg)	45	45	34	34
Material weight (kg)	364	364	667	667
Chemical content (wt%)	100% UF_4	100% UF_4	100% UF_4	100% UF_4
Shipments				
Average volume (m^3)/yr	7,796	7,796	7,797	7,797
Packages/year	68,680	68,680	37,450	37,450
Packages/life of project	1,373,000	1,373,000	749,000	749,000
Packages/shipment	48	528	28	304
Shipments/year	1,431	131	1,338	124
Shipments/life of project	28,620	2,620	26,760	2,480
Form of Transport/Routing				
Form of transportation	Truck	Rail	Truck	Rail
Destination – facility type	Wasteform facility	Wasteform facility	Wasteform facility	Wasteform facility

TABLE 8.1b Off-Site Transport of Supplies and Input Materials for the Wasteform Facility, New Inventory

Item	30-Gallon Drums: Truck	30-Gallon Drums: Rail	55-Gallon Drums: Truck	55-Gallon Drums: Rail
Transported Material				
Type/chemical	UF_4	UF_4	UF_4	UF_4
Physical form	Solid, granular	Solid, granular	Solid, granular	Solid, granular
Chemical composition/ temperature, pressure	UF_4/ambient	UF_4/ambient	UF_4/ambient	UF_4/ambient
Packaging				
Type	30-gal drum	30-gal drum	55-gal drum	55-gal drum
Container volume (m^3)	0.11	0.11	0.21	0.21
Certified by	DOT	DOT	DOT	DOT
Identifier	Varies	Varies	Varies	Varies
Container weight (kg)	45	45	34	34
Material weight (kg)	364	364	667	667
Chemical content (wt%)	100% UF_4	100% UF_4	100% UF_4	100% UF_4
Shipments				
Average volume (m^3)/yr	7,854	7,854	7,853	7,853
Packages/year	69,160	69,160	37,720	37,720
Packages/life of project	1,729,000	1,729,000	943,000	943,000
Packages/shipment	48	528	28	304
Shipments/year	1,441	131	1,348	125
Shipments/life of project	36,025	3,275	33,700	3,125
Form of Transport/Routing				
Form of transportation	Truck	Rail	Truck	Rail
Destination – facility type	Wasteform facility	Wasteform facility	Wasteform facility	Wasteform facility

9 PERMITTING AND REGULATORY COMPLIANCE

This section addresses requirements for disposal of depleted UF_4 at a DOE facility subject to DOE orders and at a commercial disposal facility subject to NRC or Agreement State regulations. Because depleted UF_4 would be disposed of at an arid or semiarid site, the waste acceptance criteria (WAC) of the NTS and the radioactive license conditions for the private Envirocare facility in Utah are discussed as representative disposal requirements under the two regulatory regimes (DOE and NRC). Disposal at NTS would be in accordance with DOE orders. Disposal at Envirocare would in accordance with a radioactive material license issued by the State of Utah because Utah is a state with which the NRC has executed an agreement to delegate regulatory authority over land disposal facilities for LLW. As in the Engineering Analysis Report, the scope of this section is limited to nuclear and radiation safety requirements promulgated by DOE or NRC and Agreement States pursuant to the Atomic Energy Act of 1954 and other laws specifying radioactive waste management procedures.

Low-level radioactive waste is defined by the Low-Level Radioactive Waste Policy Amendments Act of 1985 (LLWPAA) (Pub. L. 99-240) as radioactive material that (A) is not high-level radioactive waste, spent nuclear fuel, or by-product material [as defined in Section 11(e)(2) of the Atomic Energy Act]; and (B) the NRC, consistent with existing law and in accordance with paragraph (A), classifies as low-level radioactive waste. The depleted uranium of interest would not be spend nuclear fuel because it was not irradiated in a nuclear reactor; it would not be high-level radioactive waste because it did not result from the reprocessing of spent nuclear fuel; and it would not be Section 11(e)(2) by-product material because it is not tailing or waste produced by the extraction or concentration of uranium from ore. Also, being uranium, it is not transuranic waste. Thus, by elimination, depleted uranium would appear to be LLW. Hightower and Trabalka (2000) have concluded that depleted uranium metal and oxides are LLW. The results of their analysis would apply to depleted UF_4.

9.1 COMMERCIAL DISPOSAL FACILITIES

9.1.1 Overview

DOE policy as stated in DOE M 435.1-1, *Radioactive Waste Manual*, Section 1.2.F(4), is that radioactive waste shall be treated, stored, and, in the case of LLW, disposed of at the site where the waste was generated, if practical; or at another DOE facility. However, if DOE capabilities are not practical or not cost effective, an exemption may be approved by the Field Element Manager after consultation with the Office of the Assistant Secretary for Environment, Safety and Health and notice to DOE Headquarters to allow the use of non-DOE facilities if several requirements are met. Among these requirements are documentation that the use of non-DOE facilities would be cost effective and in the best interest of DOE, and that the waste is sufficiently characterized and certified to meet the receiving facility's waste acceptance criteria.

Regulations governing disposal of LLW promulgated by Agreement States must be in accordance with the regulations promulgated by the NRC in 10 CFR Part 61, *Licensing Requirements for Land Disposal of Radioactive Waste*. Part 61 establishes performance objectives, technical requirements, and licensing procedures and criteria for "near-surface" disposal of LLW. Regulation 10 CFR 61.7 explains near-surface disposal involving disposal in the uppermost portion of the earth, (approximately 30 m [98 ft]), although burial deeper than 30 m may also be satisfactory. Near-surface disposal includes engineered facilities built totally or partially above grade, provided they have protective earthen covers. In accordance with the Engineering Analysis Report, a mined-cavity disposal facility is assumed to be 180 m (590 ft) below the surface. This depth would be too far below the surface to be considered near-surface disposal. Therefore, the technical requirements of 10 CFR Part 61 would not apply to a mined cavity, although the performance objectives would. Technical requirements would probably be developed by the licensing agency on a case-specific basis.

A cornerstone of NRC's regulatory system is to ensure stability of the waste and the disposal site once the waste has been emplaced and covered. To reduce migration of radionuclides, access of water to the waste should be minimized. The degree of stability of the waste required depends on how radioactive the waste is, as well as on other factors such as mobility. A lesser degree of stability is required for low activity, low-mobility waste than for high-activity or high-mobility waste. Stability may be inherent in the waste form itself or may be achieved by processing the waste to a stable form or by placing the waste in a disposal container or container that provides stability after disposal [10 CFR 61.56(b)(1)].

The NRC has established four performance objectives:

1. Protection of the general population from releases of radioactivity (10 CFR 61.41) — Concentrations of radioactive material which may be released to the general environment in groundwater, surface water, air, soil, plants, or animals must not result in an annual dose exceeding an equivalent of 25 mrem (0.25 mSv) to the whole body, 75 mrem (0.75 mSv) to the thyroid, and 25 mrem (0.25 mSv) to any other organ of any member of the public. Also reasonable effort should be made to maintain releases in effluents to the general environment as low as is reasonably achievable (ALARA)

2. Protection of individuals from inadvertent intrusion (10 CFR 61.42) — Design, operation, and closure of a land disposal facility must ensure protection of any individual inadvertently intruding into the disposal site and occupying the site or contacting the waste and any time after active institutional controls over the disposal site are removed.

3. Protection of individuals during operations (10 CFR 61.43) — Operations of the facility must be conducted in compliance with the standards for radiation protection set out in 10 CFR Part 20, except for releases of radioactivity in

effluents, which shall be governed by 10 CFR 61.41. Every reasonable effort shall be made to maintain radiation exposures ALARA.

4. Stability of the site after closure (10 CFR 61.44) — A disposal facility must be sited, designed, used, operated, and closed to achieve long-term stability of the disposal site and to eliminate to the extent practicable the need for ongoing active maintenance of the disposal site following closure so that only surveillance, monitoring, or minor custodial care are required.

9.1.2 Technical Requirements

To achieve these performance objectives, the NRC imposes several technical requirements, as discussed below.

9.1.2.1 Waste Classification

The NRC classifies waste suitable for near-surface disposal as Class A, Class B, or Class C on the basis of the concentration of certain long-lived radionuclides and their shorter-lived precursors and on the basis of the concentration of certain shorter-lived radionuclides for which requirements on institutional controls are effective (10 CFR 61.55). Waste with greater concentrations of these radionuclides than Class C waste (greater-than-Class-C waste) is not suitable for near-surface disposal. Waste with the smallest concentration of these radionuclides is Class A waste. The radionuclides of uranium are not used in the NRC classification scheme; therefore, depleted UF_4 would be Class A waste [10 CFR 61.55(a)(6)]. Class A waste need not be segregated if it has structural stability [10 CFR 61.55(a)(2)].

9.1.2.2 Disposal Site Suitability

Regulation 10 CFR 61.50 requires that disposal sites have certain minimum characteristics. These include the following: (1) the site must be capable of characterization; (2) projected population growth and future development should not impair achievement of the performance objectives; (3) the site must avoid natural resources that might be exploited; (4) the site must be well-drained, free of flooding, and not be in a 100-year floodplain, coastal high-hazard area, or wetland; (5) groundwater should not be discharged to the surface within the disposal site; and (6) areas where tectonic processes such as faulting, folding, seismic activity, or vulcanism may occur must be avoided.

9.1.2.3 Disposal Site Design

Regulation 10 CFR 61.51 requires that site design features must be directed toward long-term isolation and avoidance of the need for continuing active maintenance after site closure. These features include covers designed to minimize water infiltration, to direct percolating or surface water away from the disposed waste, and to resist degradation by surface geological processes.

9.1.2.4 Disposal Facility Operation and Closure

Regulation 10 CFR 61.52 addresses land disposal facility operation and site closure. Its requirements include the following: (1) Class A waste must be segregated from other classes of waste if it has not been stabilized; (2) wastes must be emplaced in a manner that maintains disposal container integrity during emplacement, minimizes void spaces between packages, and permits the void spaces to be filled with earth or other materials to reduce future subsidence; and (3) buffer zone must be maintained between any buried waste and the boundary of the disposal site.

9.1.2.5 Waste Characteristics

Any class of LLW must meet certain minimum requirements given in 10 CFR 61.56(a). These are: (1) waste must not be packaged for disposal in cardboard or fiberboard boxes; (2) liquid waste must be solidified or packaged in sufficient absorbent material to absorb twice the volume of the liquid; (3) solid waste containing liquid shall contain as little free-standing and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid content exceed 1% of the volume; (4) waste must not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water; (5) waste must not contain, or be capable of generating, quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste, this does not apply to radioactive gaseous waste packaged in accordance with paragraph 10 CFR 61.56(a)(7); (6) waste must not be pyrophoric — pyrophoric materials contained in waste shall be treated, prepared, and packaged to be nonflammable; (7) waste in a gaseous form must be packaged at a pressure that does not exceed 1.5 atmospheres at 20°C (68°F), total activity must not exceed 100 curies per package; and (8) waste containing hazardous, biological, pathogenic, or infectious material must be treated to reduce to the maximum extent practical the potential hazard from the nonradiological material. Regulation 10 CFR 61.56(b) contains stability requirements to ensure that the waste does not structurally degrade and affect overall stability of the site through slumping, collapse, or other failure of the disposal unit and thereby lead to water infiltration.

9.1.2.6 Analysis

Uranium tetrafluoride is granular, nonvolatile, nonhygroscopic, and only slightly soluble in water. However, it reacts very slowly with moisture at ambient temperatures to form UO_2 and HF, which would enhance the corrosion rate of disposal containers. Uranium tetrafluoride, being granular, does not have inherent stability; therefore, it must be disposed of in a rigid container. To maintain stability, which is compromised by corrosive gas formation, the disposal container used should strongly resist infiltration of moisture. It has been assumed in this analysis that the potential evolution of fluoride ions from chemisorbed HF would be eliminated during the process of converting from UF_6 to UF_4 by heating the depleted UF_4 product. It is also assumed that drum filing would be performed under inert conditions to prevent airborne moisture from being retained in the interior of the disposal containers. The reactivity rate with moisture has been considered to be slow enough for UF_4 to be considered not “reactive” as the term is generally interpreted in the context of waste management (Croff et al. 2000).

9.1.3 Envirocare Radioactive Material License

The Envirocare facility has been issued Radioactive Material License #UT 2300249 by the Utah Department of Environmental Quality, Division of Radiation Control. The current version of the license (Amendment 09) expires October 22, 2003 (Utah Department of Environmental Quality 2000). Envirocare has developed waste acceptance guidelines (Envirocare 1999) that provide waste generators information about the capabilities and requirements of Envirocare’s disposal facility. The current license does not appear to have any provisions in Condition 16 (“Prohibition”) that would prohibit the disposal of depleted UF_4. The only class of LLW allowed to be disposed of by Condition 9C is Class A waste, but depleted UF_4 is Class A waste in the NRC classification system. Condition 8 limits the concentration of depleted uranium to not more than 3.7×10^5 pCi/g (1.4×10^4 Bq/g). It has been assumed that the average isotopic composition of depleted uranium is 0.001% U-234, 0.25% U-235, and 99.75% U-238. This composition yields a specific activity of 4×10^5 pCi/g (1.5×10^4 Bq/g)for depleted uranium. Uranium tetrafluoride is 76% uranium by weight; therefore, its average specific activity is 3×10^5 pCi/g (1.1×10^4 Bq/g), which is below the limit. However, if there were significant variations about the average isotopic composition, it is conceivable that the limit could be exceeded for some containers. Therefore, it would be necessary to carefully characterize the waste before to shipment to the disposal facility.

Condition 9A, which does not apply to DOE waste disposed of at the Envirocare facility, provides that prior to receiving an initial shipment from a generator, the Executive Secretary to the Utah Radiation Control Board shall receive documentation of approval of the waste for export, where this approval would be given by a compact or state, to the extent a state can exercise such approval. The LLWPAA, assigns to the federal government responsibility for providing disposal of LLW generated by DOE. Authority of individual states or interstate compacts under the LLWPAA does not apply to DOE waste.

9.2 DOE DISPOSAL FACILITIES

9.2.1 Overview

DOE is responsible for the LLW it generates under the LLWPAA, and its contractors are subject to DOE orders. The primary applicable order is DOE O 435.1, *Radioactive Waste Management*, which states four general requirements that radioactive waste be managed (1) to protect the public from exposure to radiation from radioactive materials in accordance with DOE 5400.5, *Radiation Protection of the Public and the Environment*; (2) to protect the environment in accordance with DOE 5400.1*, General Environmental Protection Program, DOE 5400.5;* (3) to protect workers in accordance with 10 CFR Part 835, *Occupational Radiation Protection,* and DOE O 440.1A, *Worker Protection Management for DOE Federal and Contractor Employees*; and (4) to comply with applicable federal, state, and local laws and regulations, and with applicable Executive Orders.

DOE O 435.1 also requires that all radioactive waste be managed in accordance with the requirements in DOE M 435.1-1, *Radioactive Waste Management Manual* (the Manual). The Manual requires that certain waste acceptance requirements be imposed by LLW disposal facilities. These requirements are substantially the same as the minimum waste requirements in 10 CFR 61.56(a). DOE does not have a waste classification system applicable to all disposal facilities; rather, it allows for site-specific waste classification systems.

9.2.1.1 Performance Objectives

The Manual establishes performance objectives limiting radiological dose to representative members of the public and release of radon at the boundary of the facility. Radiological dose to representative members of the public shall not exceed 25 mrem (0.25 mSv) in a year total effective dose equivalent (TEDE) from all exposure pathways, excluding the dose from radon and its progeny in air. Dose to representative members of the public via the air pathway shall not exceed 10 mrem (0.10 mSv) in a year TEDE, excluding the dose from radon and its progeny in air. Release of radon shall be less than an average flux of 20 $pCi/m^2/s$ (0.74 $Bq/m^2/s$) at the surface of the disposal facility. Alternatively, a limit of 0.5 pCi/L (0.0185 Bq/L) of air may be applied at the boundary of the facility.

9.2.1.2 Performance Assessment

The Manual requires that a site prepare a performance assessment (PA) for all wastes disposed of after September 1988. The PA is required to include calculations (for a 1,000-year period after closure) of potential doses to representative future members of the public and potential releases from the facility. These calculations are intended to provide a reasonable expectation that the performance objectives will not be exceeded. A PA is used to establish limits on concentrations of radionuclides for disposal. In establishing these limits, a PA should also include inadvertent intruder scenarios. The intruder analyses are required to use performance measures for chronic and acute scenarios, respectively, of 100 mrem (1 mSv) in a year and 500 mrem (5 mSv) TEDE excluding radon in air.

9.2.1.3 Composite Analysis

For the purpose of planning radiation protection activities and future use commitments and to minimize the likelihood that current LLW disposal activities will result in the need for future corrective or remedial actions, a site-specific radiological composite analysis is required. Such an analysis accounts for all sources of radioactive material that may be left at a DOE site and may interact with the LLW disposal facility, contributing to the dose projected to a hypothetical member of the public from existing and future disposal facilities.

9.2.1.4 Site Evaluation and Facility Design

Proposed sites for LLW facilities must be evaluated within the context of environmental and geotechnical characteristics and human activities. As a minimum, it is necessary to demonstrate whether the site is (1) located to accommodate the projected volume of waste to be received; (2) located in a floodplain, tectonically active area, or in the zone of water table fluctuation; and (3) located to achieve long-term stability and to minimize, to the extent practical, the need for active maintenance following final closure. The minimum requirements for the design of a LLW disposal facility include the following: (1) LLW systems and components must be designed to maintain waste confinement; (2) ventilation, if applicable, must be provided through an appropriate filtration system to maintain the release of radioactive material in airborne effluents within applicable requirements; and (3) the contact of waste with water during and after disposal must be minimized to the extent practical.

9.2.2 NTS Waste Acceptance Criteria

Waste disposed of at NTS must meet the requirements, terms, and conditions of the Nevada Test Site Waste Acceptance Criteria (NTSWAC) (DOE 1999). Most of the concerns that must be addressed would not be expected to be issues for disposal of depleted UF_4. For example, the waste is uniform, well characterized, and nontransuranic. However, some conditions may be of concern, as discussed below in Sections 9.2.2.1 through 9.2.2.4.

9.2.2.1 Action Levels for Characterization and Reporting

Section 3.1.2 of the NTSWAC provides for radionuclide concentration limits for disposal. If a limit is exceeded, waste may be acceptable for disposal upon review by DOE's Nevada Operations Office. The limit for U-238 as given in Appendix E of the NTSWAC is 5.9×10^{10} Bq/m^3. The average specific activity of depleted UF_4 is 3.0×10^7 Ci/g or 1.1×10^4 Bq/g or 1.1×10^{10} Bq/te. To be within the limit, the density of depleted UF_4 within the disposal containers must be less than 5.4 te/m^3. However, if there is significant variation in the isotopic composition of depleted uranium, a smaller density would be needed to stay below the limit for some disposal containers. Because UF_4 is taken to have a bulk density of 3.2 te/m^3, the action level for reporting is not exceeded.

9.2.2.2 Particulates

Section 3.1.6 of the NTSWAC provides that fine particulate wastes shall be immobilized so that the waste package contains no more than 1 weight percent of less than 10-µm-diameter particles, or 15 weight percent of less than 200-µm-diameter particles. Waste that is known to be in a fine particulate form, or in a form that can be mechanically or chemically transformed to a particulate during handling and interim storage, must be immobilized. Secure packaging may be used in place of immobilization. Examples of acceptable packaging are overpacking (e.g., a 55-gallon drum inside an 85-gallon drum) and steel boxes. Drums and wooden boxes with sealed 6-mil (minimum) liners will also satisfy this requirement.

9.2.2.3 Stabilization

Section 3.1.8.2 of the NTSWAC requires that chemical stability and compatibility must be demonstrated to ensure that no reactions occur and that significant quantities of harmful gases, vapors, or liquids are not generated. In Section 9.1, it was stated that it has been assumed in this analysis that the potential evolution of fluoride ions from chemisorbed HF would be removed during the process of converting from UF_6 to UF_4 by heating the depleted UF_4 product. It has also been assumed that drum filing would be performed under inert conditions to exclude retention of airborne moisture in the interior of the disposal containers. However, there should be a demonstration of the nonreactive nature of UF_4 as actually produced and packaged in steel drums before shipment to NTS to ensure compliance with this condition and the waste characterization requirements of Section 4.0 of the NTSWAC. It should be noted that, as discussed in Section 1.1, 1,870 te of depleted UF_4 in the form of salts, residues, and dust has been shipped from the DOE FEMP in Ohio to the NTS for disposal. Prior to the shipments, it was demonstrated that this waste met DOT shipping requirements and the NTSWAC.

9.2.2.4 Weight of Disposal Container

Section 3.2.6 requires that the weight of a box not exceed 4,082 kg (9,000 lb) and that the weight of a drum not exceed 544 kg (1,200 lb). With a density of 3.2 g/cm^3, the contents of a 55-drum would weigh 665.5 kg (1,467 lb) if fully loaded, and the contents of a 30-gallon drum would weigh 363 kg (800 lb) if fully loaded. A fully loaded 55-gallon drum would not comply with this weight limitation; a fully loaded 30-gallon drum would comply. This requirement is based on an Occupational Safety Health Administration limit on the loading of hoists (forklifts) currently used at NTS.

10 PRELIMINARY SCHEDULE ESTIMATES

An estimated schedule for the entire life cycle of the depleted UF_4 disposal facility is shown in Figure 10.1.[1] The schedule and rationale presented used here mirror the schedule and rationale in the Engineering Analysis Report.

After a DOE Record of Decision (ROD) has been issued, there would be a period of approximately 1 year for developing management plans, obtaining approvals, and initial budgeting. Next there would be a period of approximately 3 years for developing and testing the form for the depleted UF_4 and for generating baseline design parameters, such as particle size distribution and density. Also included in this period would be computer modeling of the proposed disposal sites. Parallel to these technology verification tasks would be a design task, a safety approval, and NEPA process task. It is estimated that after 5 years, these tasks should be far enough along that a construction application could be submitted. After 2 more years, the final design and final safety analysis would be completed so that construction approval would be granted (at the end of the seventh year).

Licensing and permitting of a disposal facility could potentially add 5 to 10 years to the schedule. In general, the license application is based on site-specific disposal facility design and safety assessments that must demonstrate compliance of the proposed facility with regulatory requirements. Licensing typically involves complex legal and political procedures, intensive technical reviews by the regulatory body, and interaction with the public. A licensing and permitting strategy would be employed to anticipate and avoid needless delay. However, it should be noted that no new commercial repository for low-level wastes has been constructed in the United States since the passage of the Low-Level Radioactive Waste Policy Act of 1980. In eight U.S. states, the site-selection process is in some stage of progress. A total of four sites already have been selected in Nebraska (Central Interstate Compact), North Carolina (Southeast Compact), California (Southwest Compact), and Texas (pending the Texas Compact) and are now in the licensing process.

DOE procurement is another element that would have to be factored into the schedule so that excessive delays would be avoided. Construction would then follow, with an overall schedule of 31 years. However, licensing and permitting remain as the most uncertain stages that could significantly increase schedule. Because a key factor during licensing and permitting currently is public acceptance, disposal facilities in some cases are being colocated at sites where nuclear facilities already exist. The use of an existing wasteform facility or approved disposal facility might shorten the time periods shown in Figure 10.1.

Once the disposal facility is full, or disposal operations are stopped for other reasons, the processes known as “closure” and “post-closure” begins. The closure process includes steps to secure the facility, such as covering or sealing the disposal areas; compiling documents, and

[1] For reader convenience, figures referred to in Section 10 are placed at the end of the section.

performing safety assessments. The licensee and the regulating body would continue to monitor for radioactivity in groundwater, air, soil, and vegetation. Staff from the regulating body would continue to inspect the site and monitor site operator post-closure operations. Several hundreds of years are foreseen for post-closure institutional control, which may include access control, maintenance, site monitoring, record keeping, and corrective actions, if required.

The time periods associated with the post closure (1-10 years), active institutional care (1-100 years), and passive institutional care (101-300 years) are not shown in Figure 10.1, consistent with the Engineering Analysis Report.

The schedule shown in Figure 10.1 is based on experience with actual construction and operations of nonreactor nuclear-type facilities. A "fast track" approach is clearly possible, which would decrease the time to operations. However, for comparison of discounted life-cycle costs and environmental impacts between the various disposal options and chemical forms, the decision was made in this analysis to apply the generic schedule shown in the Engineering Analysis Report for disposal of UO_2 and U_3O_8, as appropriate, for disposal of depleted UF_4. A shorter time to operations would result in higher discounted life-cycle costs and greater annual environmental impacts compared with the other chemical forms considered for disposal.

10.1 WASTEFORM FACILITY

The construction of the wasteform facility would begin in year 8. As roads and rail lines are constructed, the large, but uncomplicated, metal framed buildings of the wasteform facility would be erected, followed by installation and testing of equipment for decontamination and monitoring. It is expected that construction of the adjacent disposal facilities would not interfere with construction and/or operation of the wasteform facility.

10.2 VAULT DISPOSAL FACILITY

As shown in Figure 10.1, construction of the vault disposal facility would begin in year 10 and continue through year 35 (for the new inventory). Sufficient numbers of vaults would be constructed each year to accommodate the next year's anticipated deliveries of depleted UF_4.

Disposal vault construction would include foundation construction and installation of the primary and secondary monitoring systems and data acquisition features, including sensors for monitoring. Initial construction would consist of development and improvement of the site and excavation and preparation of the disposal vaults. Construction of the vault facilities is intended to be a continuous process concurrent with the placement of the depleted UF_4 drums.

Closure activities would take place during the first three years after the facility ceased to accept waste. Closure includes decontamination of the wasteform facility, initial demolition of buildings, site development, closure of the vaults, site remediation, and monitoring of the vault performance and groundwater.

10.3 ENGINEERED TRENCH DISPOSAL FACILITY

As shown in Figure 10.1, construction of the engineered trench disposal facility would begin in year 10 and continue through year 35 (for the new inventory). Waste disposal could potentially occur after 1 month of preliminary excavation without waiting for the entire trench facility to be completed. (It should be noted that this analysis assumes the development of a single engineered trench per year.) This preliminary excavation would begin the continual process of simultaneously excavating and disposing, completing disposal in the first trench within a 12-month period.

Closure activities would be similar to those for the vault disposal facility.

10.4 MINED-CAVITY DISPOSAL FACILITY

Because mined-cavity construction is projected to require 7.5 years, construction activities would begin in year 3 so that the facility would be available to accept waste beginning in year 11 (see Figure 10.2). Facility construction would begin with site preparation, followed by construction of surface facilities (such as the product receiving and shipping warehouse, the ventilation house, and support facilities, including an emergency power generator for subsurface lighting and utilities). Construction of subsurface features (such as the access ramps and disposal drifts) would follow.

Closure activities would include demolition of surface facilities. The access ramps into the mined cavity would be backfilled (the drifts would already have been backfilled) and the area capped and fenced off after demolition.

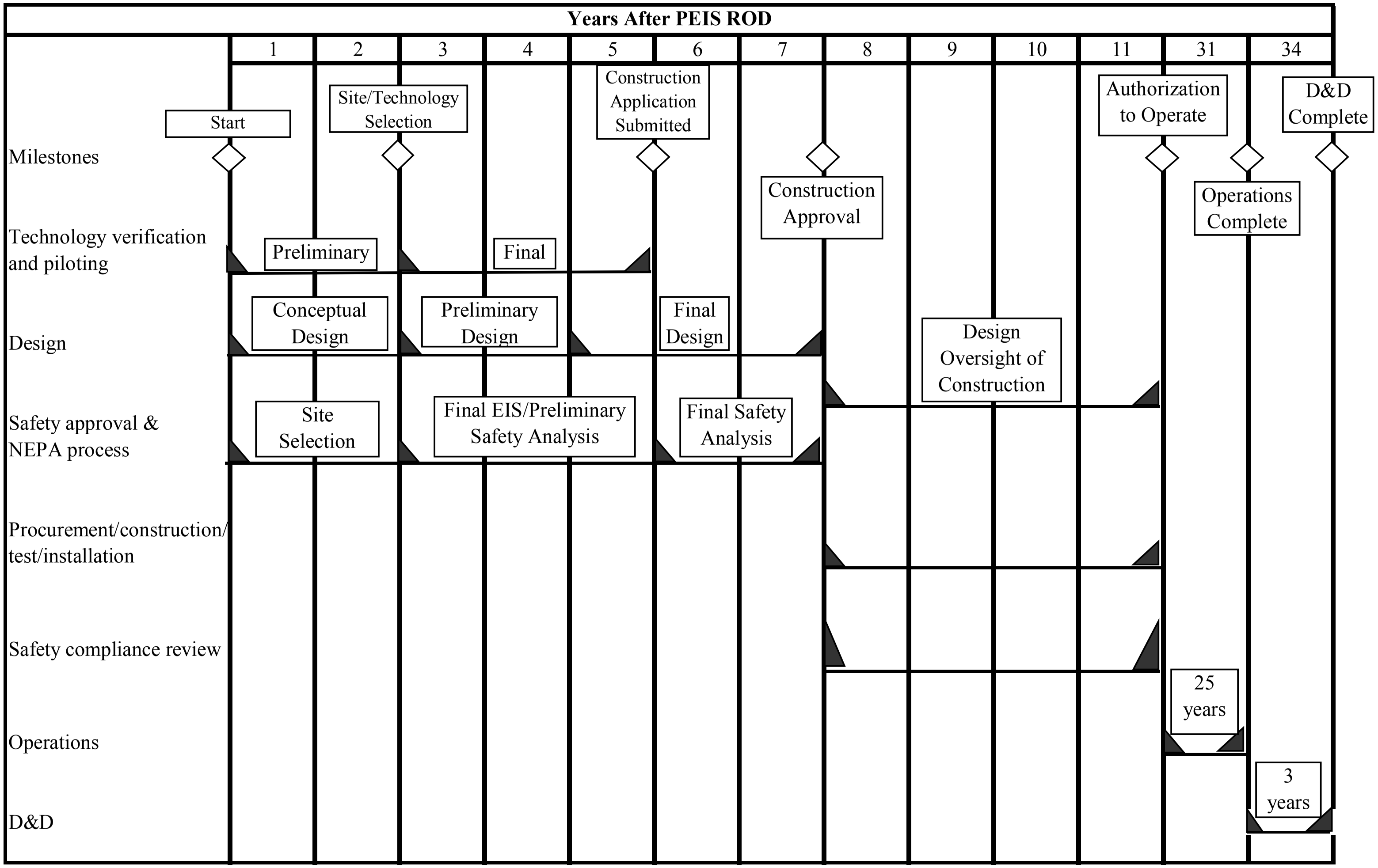

FIGURE 10.1 Estimated Overall Schedule for the Depleted UF_4 Disposal Program, New Inventory, Vault and Engineered Trench Disposal Options

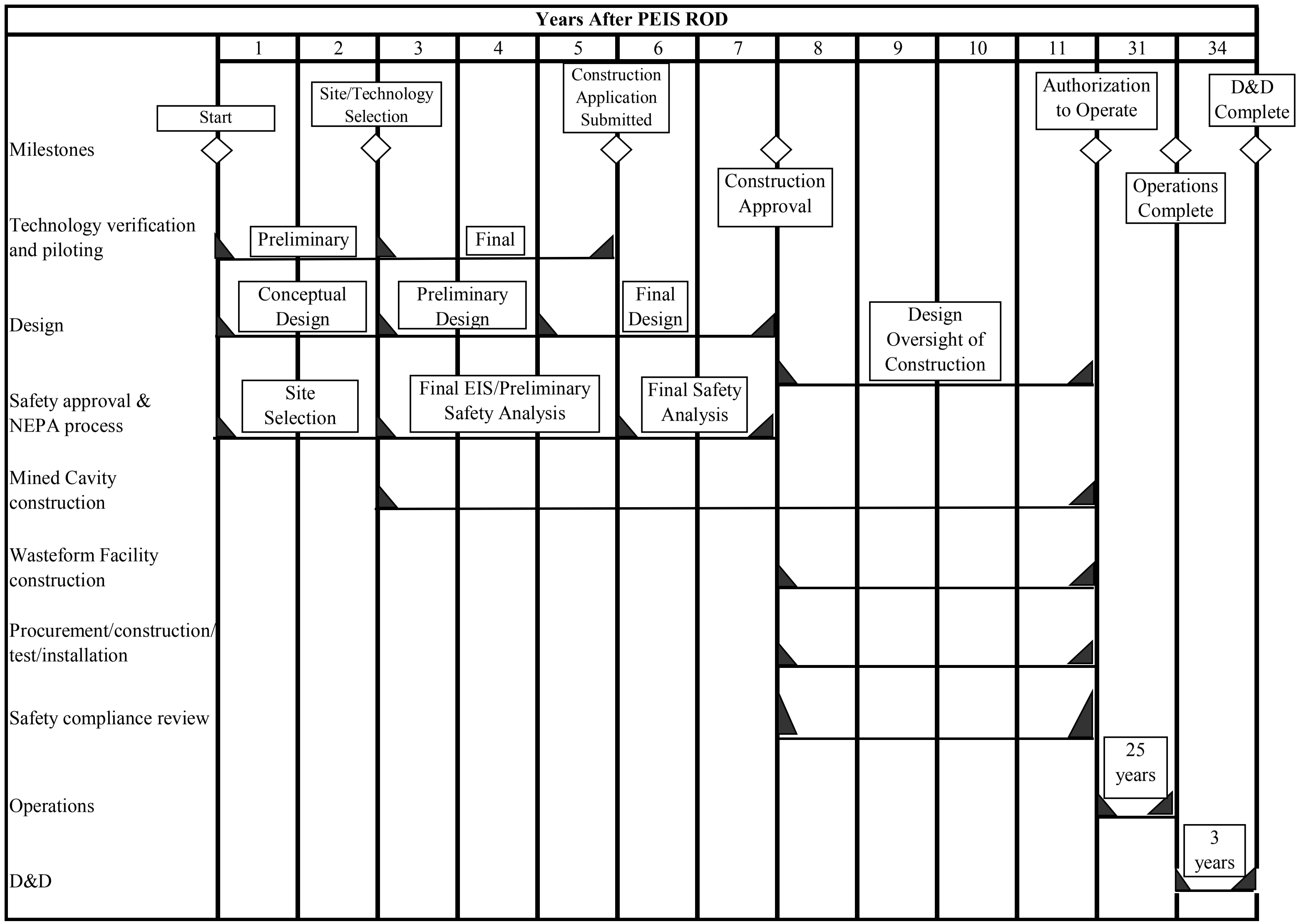

FIGURE 10.2 Estimated Overall Schedule for the Depleted UF_4 Disposal Program, New Inventory, Mined-Cavity Option

11 PARAMETRIC DATA FOR DISPOSAL IN A MINED CAVITY

Three disposal options — (1) engineered trench, (2) belowground vault, and (3) mined cavity — were considered in Sections 1 through 10 of this report. For comparative purposes, and to be consistent with the Engineering Analysis Report, the mined-cavity disposal option has been analyzed for both 30-gallon and 55-gallon drum sizes to develop engineering data in support of the parametric analysis. Details are presented in this section.

Tables 11.1[1] through 11.13 incorporate pertinent factors and parameters into sets of parametric data. Three cases are considered for the amount of depleted uranium disposed of at the disposal facility: the entire original inventory (100% case); half of the original inventory (50% case); and one-quarter of the original inventory (25% case).

Tables 11.1a and 11.1b summarize annual input and output of product for 30-gallon drums and 55-gallon drums, respectively. Tables 11.2a and 11.2b contain land use requirements for the wasteform facility for 30-gallon drums and 55-gallon drums, respectively. Tables 11.3a and 11.3b contain land use requirements for the mined-cavity disposal area for 30-gallon drums and 55-gallon drums, respectively.

Tables 11.4a and 11.4b contain construction resource requirements for the wasteform facility and the mined-cavity disposal area for 30-gallon drums and 55-gallon drums, respectively. Tables 11.5a and 11.5b contain operations resource requirements for the wasteform facility and the mined-cavity disposal area for 30-gallon drums and 55-gallon drums, respectively.

Tables 11.6a and 11.6b contain employment summaries for the wasteform facility and the mined-cavity disposal area for 30-gallon drums and 55-gallon drums, respectively.

Tables 11.7a and 11.7b list construction emissions and wastes for the mined-cavity disposal area for 30-gallon drums and 55-gallon drums, respectively. Tables 11.8a and 11.8b list construction emissions and wastes for the wasteform facility for 30-gallon drums and 55-gallon drums, respectively.

Table 11.9 contains annual emissions and wastes from operation of the mined-cavity disposal facility. Tables 11.10a and 11.10b contain annual emissions and wastes from operation of the wasteform facility for 30-gallon drums and 55-gallon drums, respectively.

Tables 11.11a and 11.11b contain transportation summaries for 30-gallon drums and 55-gallon drums, respectively.

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[1] For reader convenience, tables and figures referred to in Section 11 are placed at the end of the section.

Tables 11.12a, 11.12b, and 11.12c contain estimates of the number of construction workers (FTEs) needed by year for construction of the mined-cavity disposal area for the 100% case, the 50% case, and the 25% case, respectively. Tables 11.13a, 11.13b, and 11.13c contain estimates of the number of construction workers (FTEs) needed by year for construction of the wasteform facility for the 100% case, the 50% case, and the 25% case, respectively. FTEs are rounded to the nearest integer in these tables.

Figures 11.1 and 11.2 display the relative wasteform facility and mined-cavity underground footprint for each parametric case, respectively, for both 30-gallon and 55-gallon drums. Figures 11.3, 11.4, and 11.5 display the underground disposal facility footprint for 100%, 50%, and 25% of the original inventory, respectively.

TABLE 11.1a Annual Input/Output Summary, 30-Gallon Drums

Parameter	Percentage of Original Inventory 100%	50%	25%
Received drums of UF_4 per year	68,650	34,350	17,200
Type of drum	30-gallon	30-gallon	30-gallon
Number of drums per pallet	4	4	4
Width of pallet, m	1.0	1.0	1.0
Required 3-month storage footprint – double tiered pallets, m^3	4,100	2,200	1,200
UF_4 content per drum, te	0.353	0.353	0.353
Uranium content per drum, te	0.276	0.276	0.276
Weight of empty drum, kg	45.4	45.4	45.4

TABLE 11.1b Annual Input/Output Summary, 55-Gallon Drums

Parameter	Percentage of Original Inventory 100%	50%	25%
Received drums of UF_4 per year	37,450	18,750	9,400
Type of drum	55-gallon	55-gallon	55-gallon
Number of drums per pallet	4	4	4
Width of pallet, m	1.22	1.22	1.22
Required 3-month storage footprint – double tiered pallets, m^3	3,100	1,600	1,000
UF_4 content per drum, te	0.644	0.644	0.644
Uranium content per drum, te	0.504	0.504	0.504
Weight of empty drum, kg	34.0	34.0	34.0

TABLE 11.2a Land Use Requirements for Wasteform Facility, 30-Gallon Drums

Parameter	Percentage of Original Inventory 100%	50%	25%
Construction area, ha	1.7	1.1	0.8
Length, m	168	136	115
Width, m	99	80	68
Plant site area, ha	1.7	1.1	0.8
Length, m	168	136	115
Width, m	99	80	68
Total paved area, ha	0.33	0.24	0.19
Total fenced area, ha	1.6	1.0	0.7
Administrative building footprint area, m^2	675	675	675
Product receiving and shipping warehouse footprint area, m^2	4,100	2,200	1,200
Total excavated material, m^3	9,550	5,750	3,750

TABLE 11.2b Land Use Requirements for Wasteform Facility, 55-Gallon Drums

Parameter	Percentage of Original Inventory 100%	50%	25%
Construction area, ha	1.4	0.9	0.7
Length, m	152	124	111
Width, m	89	73	65
Plant site area, ha	1.4	0.9	0.7
Length, m	152	124	111
Width, m	89	73	65
Total paved area, ha	0.28	0.21	0.18
Total fenced area, ha	1.3	0.8	0.6
Administrative building footprint area, m^2	675	675	675
Product receiving and shipping warehouse footprint area, m^2	3,100	1,600	1,000
Total excavated material, m^3	7,550	4,550	3,350

TABLE 11.3a Land Use Requirements for Mined-Cavity Disposal Area, 30-Gallon Drums

Parameter	Percentage of Original Inventory		
	100%	50%	25%
Construction area aboveground (including wasteform facility), ha	236	105	47
Aboveground plant site area (including wasteform facility), ha	236	105	47
Paved area aboveground, ha	12	10	9
Waste ramp area, ha	1.24	1.24	1.24
Length, m	2,065	2,065	2,065
Diameter, m	7	7	7
Height, m	5	5	5
Rock ramp area, ha	1.24	1.24	1.24
Length, m	2,065	2,065	2,065
Diameter, m	7	7	7
Height, m	5	5	5
Perimeter tunnel, ha	3.78	2.70	1.94
Length, m	7,044	7,044	7,044
Diameter, m	7	7	7
Height, m	5	5	5
Depth of shafts, m	180	180	180
Man and material shaft diameter, m	6	6	6
Exhaust shaft #1 diameter, m	6	6	6
Exhaust shaft #2 diameter, m	3	3	3
Exhaust shaft #3 diameter, m	2	2	2
Mined-cavity underground area, ha	247	127	65
Length, m	1,586	1,124	816
Width, m	1,560	1,126	800
Central service tunnel area, ha	1.98	1.41	1.02
Length, m	1,586	1,124	816
Width, m	20	20	20
Height, m	5	5	5
Number of mine drifts	40	28	20
Total emplacement drift length, m	30,515	15,269	7,646
Single drift area, ha	0.44	0.31	0.22
Length, m	763	546	383
Width, m	6.5	6.5	6.5
Height, m	5	5	5
Spacing between drift tunnels, m	32	32	32
Total paved area underground, ha	25.8	15.4	9.8
Total excavated material, m^3	1.22E+06	7.62E+05	5.13E+05

TABLE 11.3b Land Use Requirements for Mined-Cavity Disposal Area, 55-Gallon Drums

	Percentage of Original Inventory		
Parameter	100%	50%	25%
Construction area aboveground (including wasteform facility), ha	168	75	34
Aboveground plant site area (including wasteform facility), ha	168	75	34
Paved area aboveground, ha	11	10	9
Waste ramp area, ha	1.24	1.24	1.24
Length, m	2,065	2,065	2,065
Width, m	7	7	7
Height, m	5	5	5
Rock ramp area, ha	1.24	1.24	1.24
Length, m	2,065	2,065	2,065
Width, m	7	7	7
Height, m	5	5	5
Perimeter tunnel, ha	3.28	2.35	1.69
Length, m	5,466	3,916	2,821
Width, m	7	7	7
Height, m	5	5	5
Depth of shafts, m	180	180	180
Man and material shaft diameter, m	6	6	6
Exhaust shaft #1 diameter, m	6	6	6
Exhaust shaft #2 diameter, m	3	3	3
Exhaust shaft #3 diameter, m	2	2	2
Mined-cavity underground area, ha	187	96	50
Length, m	1,355	970	701
Width, m	1,378	988	710
Central service tunnel area, ha	1.69	1.21	0.88
Length, m	1,355	970	701
Width, m	20	20	20
Height, m	5	5	5
Number of mine drifts	34	24	17
Total emplacement drift length, m	22,830	11,415	5,731
Single drift area, ha	0.39	0.27	0.19
Length, m	672	477	338
Width, m	6.5	6.5	6.5
Height, m	5	5	5
Spacing between drift tunnels, m	32	32	32
Total paved area underground, ha	20.6	12.6	8.4
Total excavated material, m^3	9.91E+05	6.39E+05	4.44E+05

TABLE 11.4a Construction Resources, 30-Gallon Drums

Resource	Percentage of Original Inventory 100%	50%	25%
Wasteform Facility			
Water, ML	3.3	2.2	1.6
Concrete, redi-mix, m^3	5,591	3,149	1,941
Steel, te	349	200	122
Excavated material, m^3	9,550	5,750	3,750
Electricity, MW-h	480	346	276
Masonry brick, m^2	573	573	573
Diesel fuel, L	99,000	52,000	32,000
Mined-Cavity Disposal Area			
Water, ML	16.7	11.1	7.9
Concrete, redi-mix, m^3	9.90E+04	6.50E+04	4.50E+04
Steel, te	3,890	2,540	1,770
Electricity, GW-h	5,760	3,820	2,710
Diesel fuel, L	7.16E+05	4.48E+05	3.02E+05
Excavated material, m^3	1.22E+06	7.62E+05	5.13E+05

TABLE 11.4b Construction Resources, 55-Gallon Drums

Resource	Percentage of Original Inventory 100%	50%	25%
Wasteform Facility			
Water, ML	2.7	1.8	1.5
Concrete, redi-mix, m^3	4,286	2,416	1,708
Steel, te	271	153	106
Excavated material, m^3	7,550	4,550	3,350
Electricity, MW-h	410	304	262
Masonry brick, m^2	573	573	573
Diesel Fuel, L	70,000	40,000	28,000
Mined-Cavity Disposal Area			
Water, ML	14.0	9.5	6.9
Concrete, redi-mix, m^3	8.20E+04	5.50E+04	3.90E+04
Steel, te	3,230	2,160	1,550
Electricity, GW-h	4,810	3,280	2,380
Diesel fuel, L	5.83E+05	3.76E+05	2.61E+05
Excavated material, m^3	9.90E+05	6.39E+05	4.44E+05

TABLE 11.5a Operations Resources, 30-Gallon Drums

Resource	Percentage of Original Inventory 100%	50%	25%
Wasteform Facility			
Water, ML	12	8.5	6.2
Natural gas, therms (1E+05 Btu)	2,830	1,710	1,120
Electricity, MW-h	13,400	9,800	7,500
Diesel fuel, L	11,100	8,900	7,400
Mined-Cavity Disposal Area			
Water, ML	61.8	44.7	32.3
Electricity, GW-h	1.66E+05	1.18E+05	8.32E+04
Diesel fuel, L	1.86E+05	1.18E+05	7.46E+04

TABLE 11.5b Operations Resources, 55-Gallon Drums

Resource	Percentage of Original Inventory 100%	50%	25%
Wasteform Facility			
Water, ML	10	7.2	5.7
Natural gas, therms (1E+05 Btu)	2,240	1,350	1,000
Electricity, MW-h	11,600	8,400	6,900
Diesel fuel, L	10,000	8,100	7,100
Mined-Cavity Disposal Area			
Water, ML	46.5	33.6	24.3
Electricity, GW-h	1.23E+05	8.68E+04	6.16E+04
Diesel fuel, L	1.25E+05	7.88E+04	5.00E+04

TABLE 11.6a Employment, 30-Gallon Drums

Stage	Percentage of Original Inventory 100%	50%	25%
Wasteform Facility			
Construction (total person-years)	280	140	82
Operating (annual)	41	29	21
Mined-Cavity Disposal Area			
Construction (total person-years)	3,800	2,900	2,200
Operating (annual)	30	20	14

TABLE 11.6b Employment, 55-Gallon Drums

Stage	Percentage of Original Inventory		
	100%	50%	25%
Wasteform Facility			
Construction (total person-years)	200	100	72
Operating (annual)	35	26	20
Mined-Cavity Disposal Area			
Construction (total person-years)	3,400	2,600	2,000
Operating (annual)	25	17	12

TABLE 11.7a Construction Emissions and Wastes, Mined-Cavity Disposal Facility, 30-Gallon Drums

Material	Percentage of Original Inventory		
	100%	50%	25%
Emissions			
CO, te/yr	1.51	0.945	0.637
NMHC, te/yr	0.530	0.332	0.224
NO_x, te/yr	7.00	4.38	2.95
SO_2, te/yr	0.462	0.289	0.195
PM_{10}, te/yr	636	282	126
Methane, te/yr	4.34E-02	2.72E-02	1.83E-02
Wastes			
Hazardous solids, m^3	200	153	116
Hazardous liquids, m^3	406	309	234
Concrete, m^3	1.98E+03	1,300	900
Steel, te	19.5	12.7	8.9
Other solid waste, m^3	1.60E+04	1.04E+04	7.26E+03
Sanitary liquids, m^3	5.80E+04	4.40E+04	3.40E+04
Other liquids, m^3	2.60E+04	2.00E+04	1.50E+04

TABLE 11.7b Construction Emissions and Wastes, Mined-Cavity Disposal Facility, 55-Gallon Drums

	Percentage of Original Inventory		
Material	100%	50%	25%
Emissions			
CO, te/yr	1.23	0.793	0.550
NMHC, te/yr	0.432	0.278	0.193
NO_x, te/yr	5.70	3.60	2.55
SO_2, te/yr	0.38	0.242	0.168
PM_{10}, te/yr	452	201	90.7
Methane, te/yr	3.53E-02	2.28E-02	1.58E-02
Wastes			
Hazardous solids, m^3	179	137	106
Hazardous liquids, m^3	363	278	213
Concrete, m^3	1.64E+03	1.11E+03	780
Steel, te	16.2	10.8	7.8
Other solid waste, m^3	1.31E+04	8.80E+03	6.24E+03
Sanitary liquids, m^3	5.20E+04	4.00E+04	3.10E+04
Other liquids, m^3	2.30E+04	1.80E+04	1.40E+04

TABLE 11.8a Construction Emissions and Wastes, Wasteform Facility, 30-Gallon Drums

	Percentage of Original Inventory		
Material	100%	50%	25%
Emissions			
CO, te/yr	0.712	0.411	0.253
NMHC, te/yr	0.250	0.144	0.089
NO_x, te/yr	3.30	1.91	1.17
SO_2, te/yr	0.218	0.126	0.077
PM_{10}, te/yr	17.9	11.7	8.45
Methane, te/yr	2.05E-02	1.18E-02	7.27E-03
Wastes			
Hazardous solids, m^3	14.8	7.40	4.30
Hazardous liquids, m^3	29.9	14.9	8.8
Concrete, m^3	110	60	40
Steel, te	1.7	1.0	0.6
Other solid waste, m^3	890	500	310
Sanitary liquids, m^3	4.30E+03	2.10E+03	1.30E+03
Other liquids, m^3	1.90E+03	9.50E+02	5.60E+02

TABLE 11.8b Construction Emissions and Wastes, Wasteform Facility, 55-Gallon Drums

	Percentage of Original Inventory		
Material	100%	50%	25%
Emissions			
CO, te/yr	0.554	0.316	0.221
NMHC, te/yr	0.194	0.111	0.078
NO_x, te/yr	2.57	1.47	1.03
SO_2, te/yr	0.169	0.097	0.068
PM_{10}, te/yr	14.6	9.75	7.80
Methane, te/yr	1.59E-02	9.09E-03	6.36E-03
Wastes			
Hazardous solids, m^3	10.6	5.30	3.80
Hazardous liquids, m^3	21.3	10.7	7.70
Concrete, m^3	90	50	30
Steel, te	1.4	0.8	0.5
Other solid waste, m^3	690	390	270
Sanitary liquids, m^3	3.10E+03	1.50E+03	1.10E+03
Other liquids, m^3	1.40E+03	68	49

TABLE 11.9 Operations Emissions and Wastes, Mined-Cavity Disposal Facility

	Percentage of Original Inventory		
Material	100%	50%	25%
For 30-Gallon Drums			
SO_2, te/yr	4.5E-02	2.8E-02	1.8E-02
NO_x, te/yr	0.68	0.43	0.27
Hydrocarbons, te/yr	5.6E-02	3.5E-02	2.2E-02
CO, te/yr	0.15	9.2E-02	5.8E-02
PM_{10}, te/yr	4.8E-02	3.0E-02	1.9E-02
For 55-Gallon Drums			
SO_2, te/yr	3.0E-02	1.9E-02	1.2E-02
NO_x, te/yr	0.46	0.29	0.18
Hydrocarbons, te/yr	3.7E-02	2.4E-02	1.5E-02
CO, te/yr	9.7E-02	6.2E-02	3.9E-02
PM_{10}, te/yr	3.2E-02	2.0E-02	1.3E-02

TABLE 11.10a Annual Emissions and Wastes, Wasteform Facility, 30-Gallon Drums

Material	Percentage of Original Inventory 100%	50%	25%
Emissions			
SO_2, te/yr	2.7E-03	2.1E-03	1.8E-03
NO_x, te/yr	4.1E-02	3.3E-02	2.7E-02
Hydrocarbons, te/yr	3.3E-03	2.7E-03	2.2E-03
CO, te/yr	8.9E-03	7.1E-03	5.9E-03
PM_{10}, te/yr	2.9E-03	2.3E-03	1.9E-03
Wastes			
Spent HEPA filters, noncombustible, compactable, LLW, m^3	23.8	23.8	23.8
Damaged drums, surface contaminated metal LLW, m^3	7.8	3.9	2.0
Other LLW, combustible solid LLW, m^3/yr	47.6	23.8	7.9
Inorganic solutions, liquid LLMW, m^3/yr	0.26	0.17	0.11
Nonhazardous (sanitary) wastes, m^3/yr	986	701	510
Nonhazardous (other) wastes, m^3/yr	78	55	40
Recyclable wastes, m^3/yr	31	22	16

TABLE 11.10b Annual Emissions and Wastes, Wasteform Facility, 55-Gallon Drums

Material	Percentage of Original Inventory 100%	50%	25%
Emissions			
SO_2, te/yr	2.4E-03	1.9E-03	1.7E-03
NO_x, te/yr	3.7E-02	3.0E-02	2.6E-02
Hydrocarbons, te/yr	3.0E-03	2.4E-03	2.1E-03
CO, te/yr	8.0E-03	6.4E-03	5.6E-03
PM_{10}, te/yr	2.6E-03	2.1E-03	1.8E-03
Wastes			
Spent HEPA filters, noncombustible, compactable, LLW, m^3	23.8	23.8	23.8
Damaged drums, surface contaminated metal LLW, m^3	7.8	3.9	2.0
Other LLW, combustible solid LLW, m^3/yr	26.2	9.6	1.6
Inorganic solutions, liquid LLMW, m^3/yr	0.18	0.12	0.08
Nonhazardous (sanitary) wastes, m^3/yr	859	637	478
Nonhazardous (other) wastes, m^3/yr	68	50	38
Recyclable wastes, m^3/yr	27	20	15

TABLE 11.11a Transportation Summary, 30-Gallon Drums

Item	Percentage of Original Inventory 100%	50%	25%
Received at Disposal Facility			
Pallets/yr	17,170	8,587	4,294
Pallets/shipment (rail)	132	132	132
Pallets/shipment (truck)	12	12	12
Shipments/yr (rail)	131	66	33
Shipments/yr (truck)	1,431	716	359
Internal Site Shipment to Disposal Area			
Pallets/yr	17,170	8,587	4,294
Pallets/shipment (truck)	12	12	12
Shipments/yr (truck)	1,431	716	359

TABLE 11.11b Transportation Summary, 55-Gallon Drums

Item	Percentage of Original Inventory 100%	50%	25%
Received at Disposal Facility			
Pallets/yr	9,362	4,687	2,344
Pallets/shipment (rail)	76	76	76
Pallets/shipment (truck)	7	7	7
Shipments/yr (rail)	124	62	31
Shipments/yr (truck)	1,338	670	336
Internal Site Shipment to Disposal Area			
Pallets/yr	9,362	4,687	2,344
Pallets/shipment (truck)	7	7	7
Shipments/yr (truck)	1,338	670	336

TABLE 11.12a Number of Construction Workers (FTEs) Needed by Year for Mined-Cavity Disposal Facility, 100% Case

Employees	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Total
For 30-Gallon Drums									
Total craft workers	111	287	456	583	697	697	473	171	3,474
Construction management and support staff	16	33	51	51	63	63	33	16	326
Subtotal	127	320	507	633	760	760	507	187	3,800
For 55-Gallon Drums									
Total craft workers	99	256	408	521	623	623	424	153	3,109
Construction management and support staff	14	30	45	45	57	57	30	14	291
Subtotal	113	286	453	567	680	680	453	167	3,400

TABLE 11.12b Number of Construction Workers (FTEs) Needed by Year for Mined-Cavity Disposal Facility, 50% Case

Employees	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Total
For 30-Gallon Drums									
Total craft workers	85	219	348	445	532	532	361	131	2,651
Construction management and support staff	12	25	39	39	48	48	25	12	249
Subtotal	97	244	387	483	580	580	387	143	2,900
For 55-Gallon Drums									
Total craft workers	76	196	312	399	477	477	324	117	2,377
Construction management and support staff	11	23	35	35	43	43	23	11	223
Subtotal	87	219	347	433	520	520	347	128	2,600

TABLE 11.12c Number of Construction Workers (FTEs) Needed by Year for Mined-Cavity Disposal Facility, 25% Case

Employees	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Total
For 30-Gallon Drums									
Total craft workers	64	166	264	337	403	403	274	99	2011
Construction management and support staff	9	19	29	29	37	37	19	9	189
Subtotal	73	185	293	367	440	440	293	108	2,200
For 55-Gallon Drums									
Total craft workers	58	151	240	307	367	367	249	90	1,829
Construction management and support staff	8	17	27	27	33	33	17	8	171
Subtotal	67	168	267	333	400	400	267	98	2,000

TABLE 11.13a Number of Construction Workers (FTEs) Needed by Year for the Wasteform Facility, 100% Case

	30-Gallon Disposal Containers				55-Gallon Disposal Containers			
Employees	Year 1	Year 2	Year 3	Subtotal	Year 1	Year 2	Year 3	Subtotal
Total Craft Workers	67	89	89	245	46	62	62	169
Construction management and support staff	7	15	22	45	5	10	15	31
Total	74	104	112	290	51	72	77	200

TABLE 11.13b Number of Construction Workers (FTEs) Needed by Year for the Wasteform Facility, 50% Case

	30-Gallon Disposal Containers				55-Gallon Disposal Containers			
Employees	Year 1	Year 2	Year 3	Subtotal	Year 1	Year 2	Year 3	Subtotal
Total craft workers	32	43	43	118	23	31	31	85
Construction management and support staff	4	7	11	22	3	5	8	15
Total	36	50	54	140	26	36	39	100

TABLE 11.13c Number of Construction Workers (FTEs) Needed by Year for the Wasteform Facility, 25% Case

	30-Gallon Disposal Containers				55-Gallon Disposal Containers			
Employees	Year 1	Year 2	Year 3	Subtotal	Year 1	Year 2	Year 3	Subtotal
Total Craft Workers	19	25	25	69	17	22	22	61
Construction management and support staff	2	4	6	13	2	4	6	11
Total	21	29	32	82	18	26	28	72

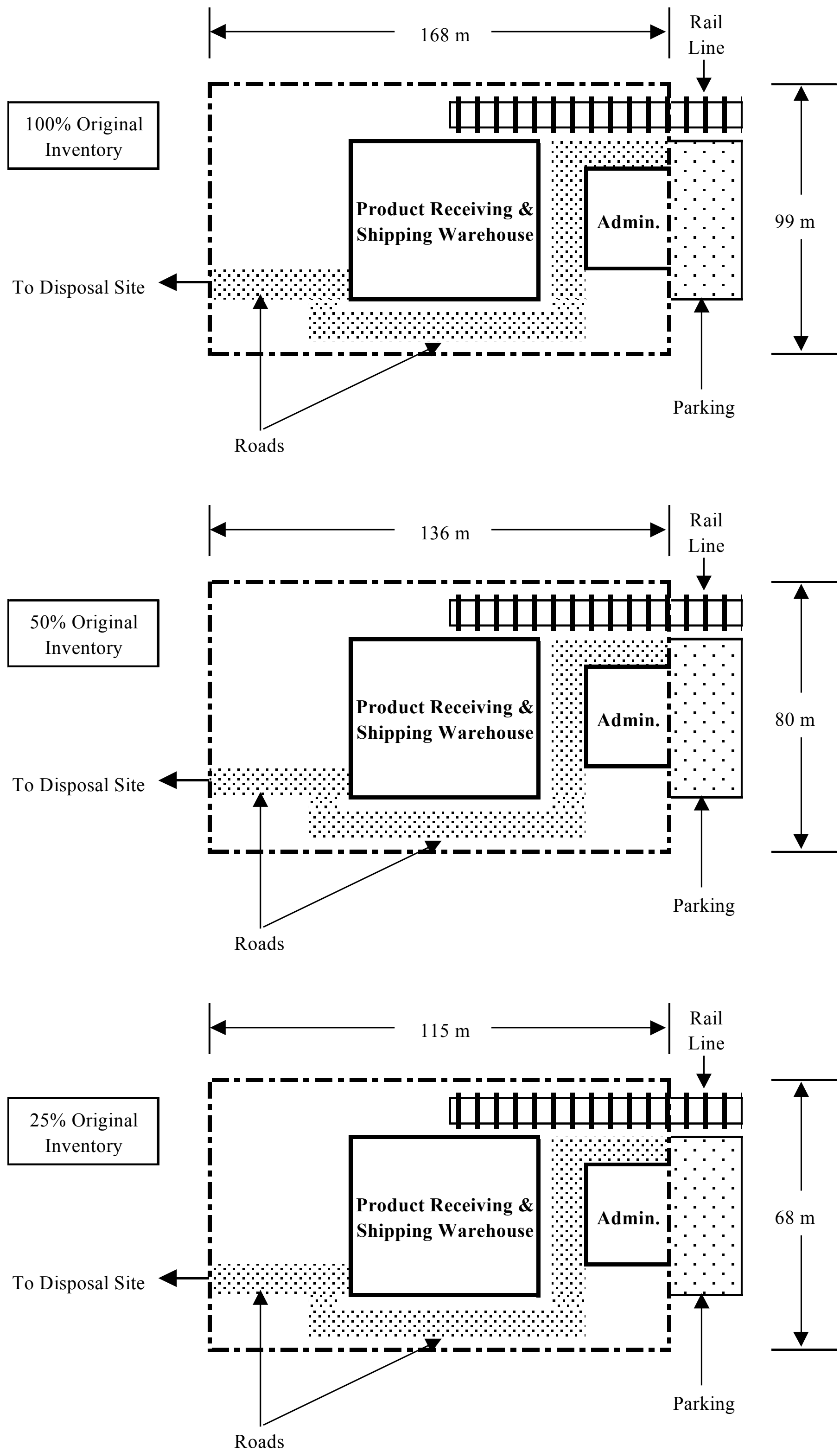

FIGURE 11.1a Wasteform Facility Footprint for 100%, 50%, and 25% of Original Inventory, 30-Gallon Drums (*not to scale*)

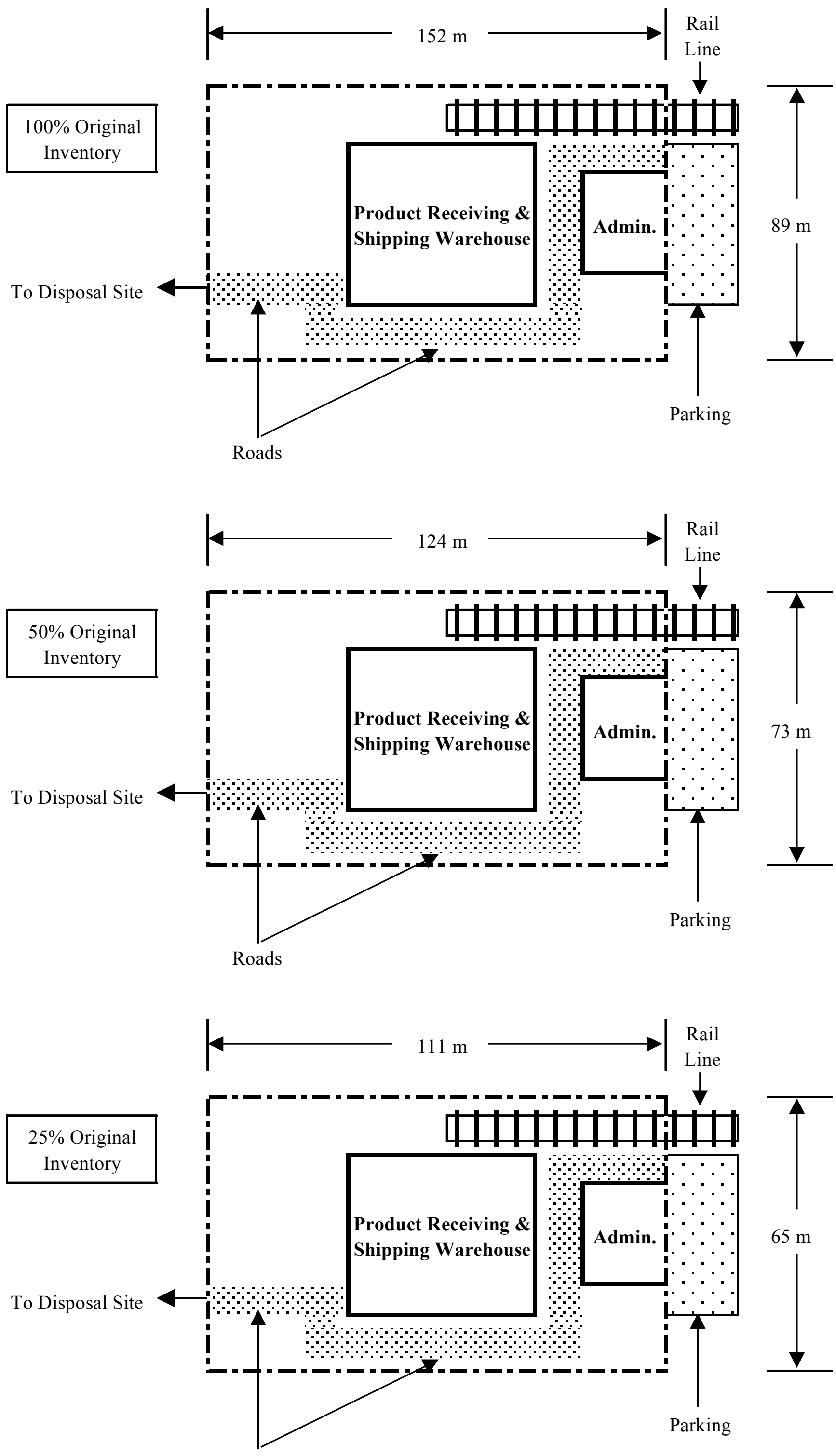

FIGURE 11.1b Wasteform Facility Footprint for 100%, 50%, and 25% of Original Inventory, 55-Gallon Drums (*not to scale*)

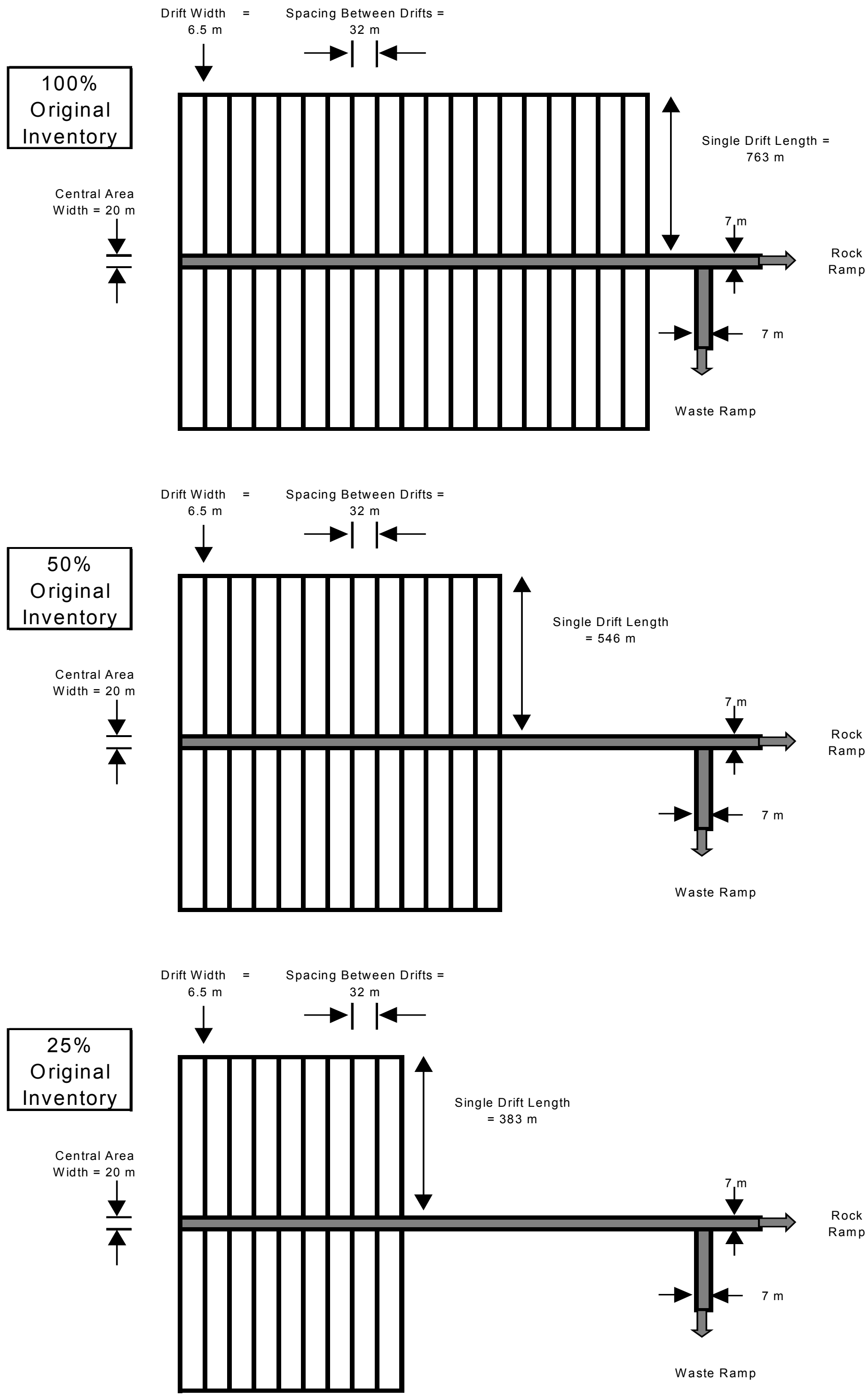

FIGURE 11.2a Mined-Cavity Underground Footprint for 100%, 50%, and 25% of Original Inventory, 30-Gallon Drums (not to scale)

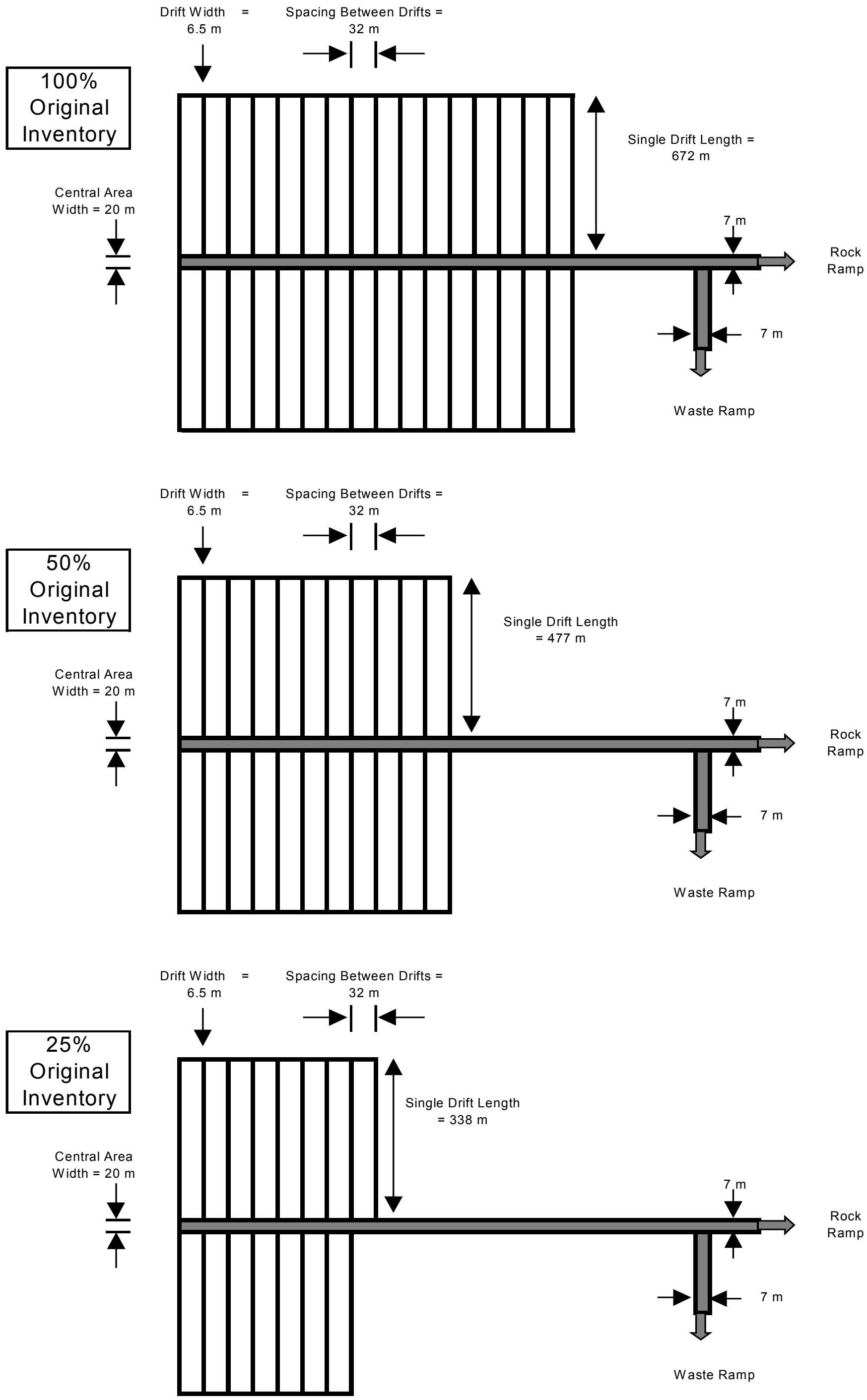

FIGURE 11.2b Mined-Cavity Underground Footprint for 100%, 50%, and 25% of Original Inventory, 55-Gallon Drums (*not to scale*)

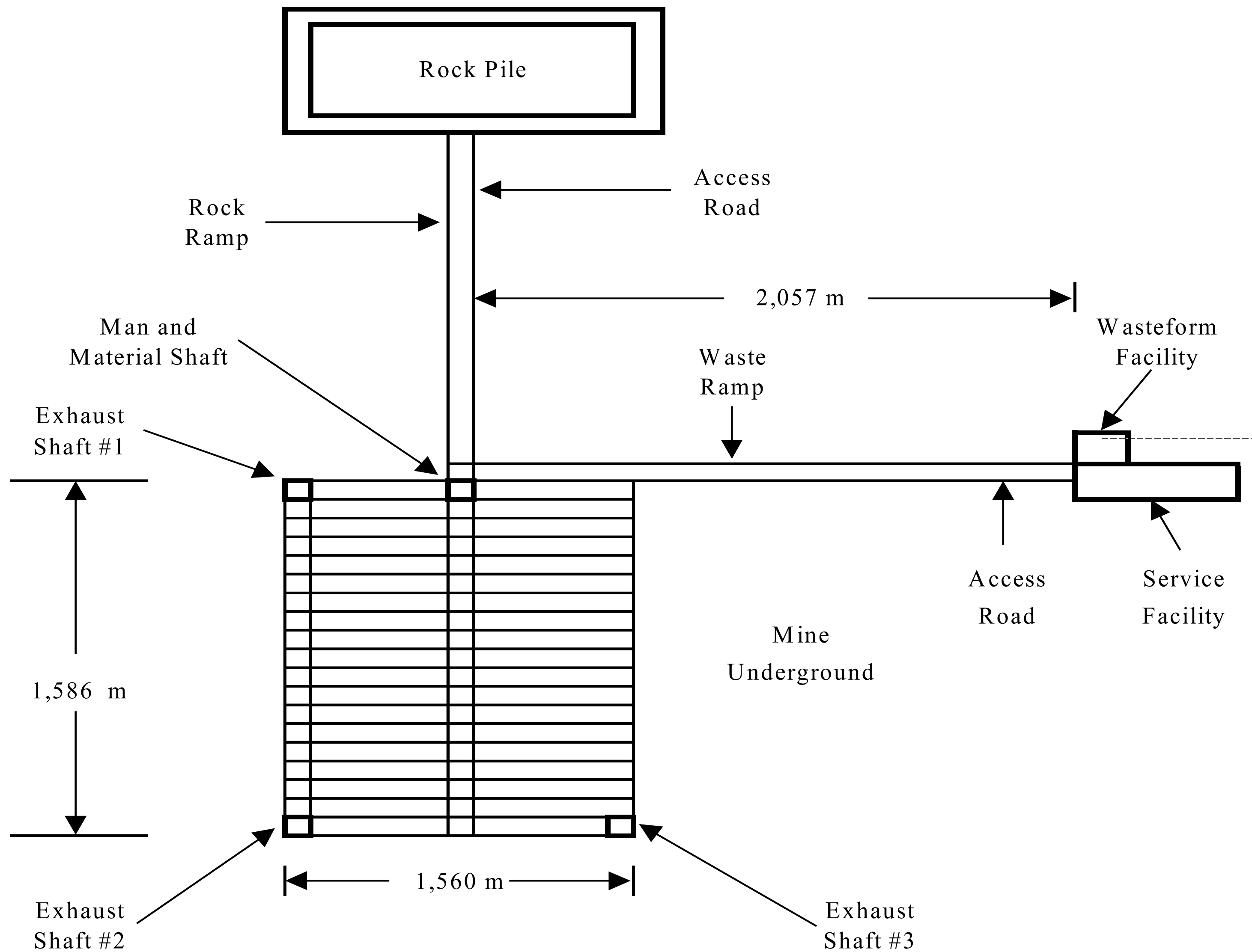

FIGURE 11.3a Mined-Cavity Disposal Facility Footprint at 100% of Original Inventory, 30-Gallon Drums (*not to scale*)

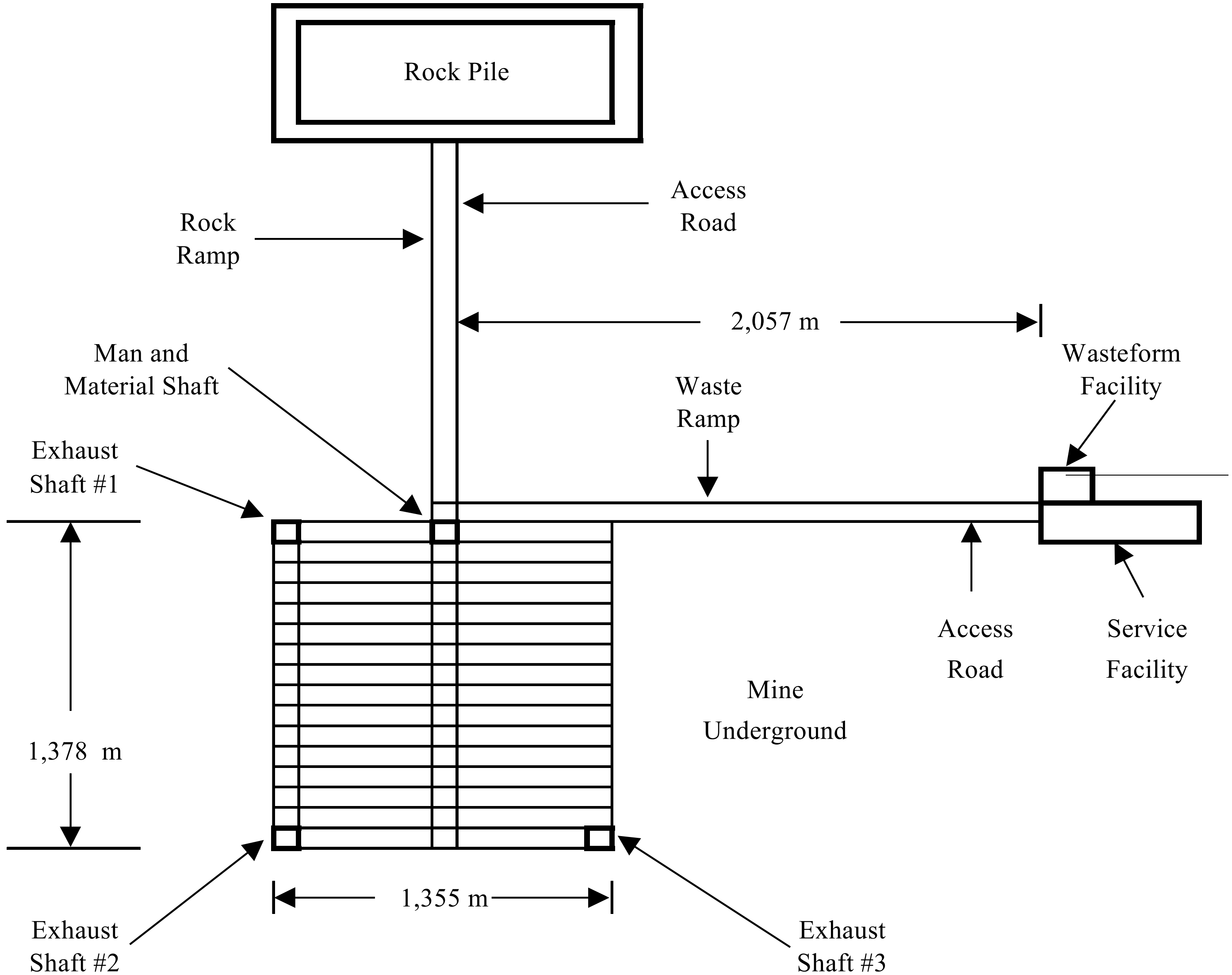

FIGURE 11.3b Mined-Cavity Disposal Facility Footprint at 100% of Original Inventory, 55-Gallon Drums (*not to scale*)

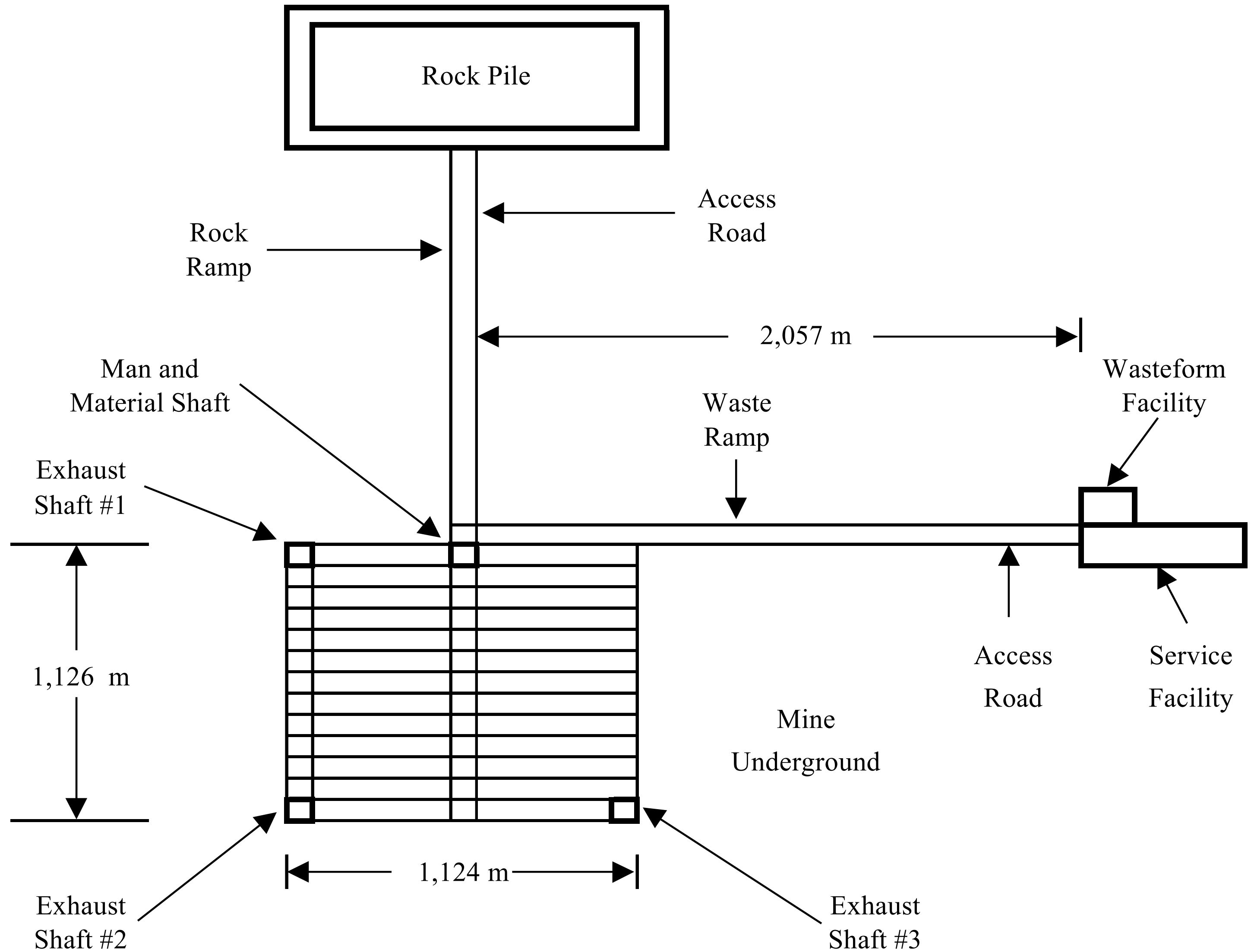

FIGURE 11.4a Mined-Cavity Disposal Facility Footprint at 50% of Original Inventory, 30-Gallon Drums (*not to scale*)

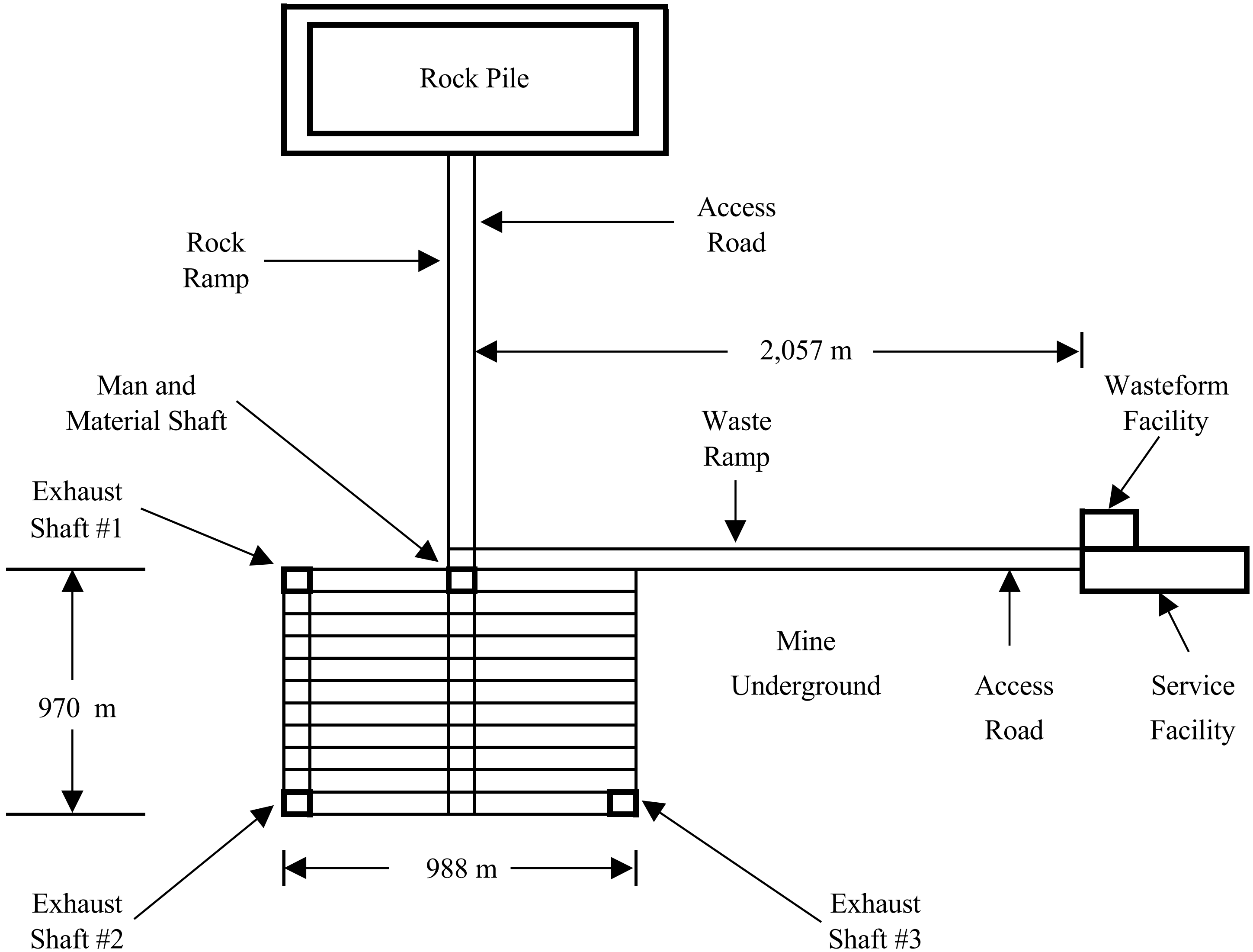

FIGURE 11.4b Mined-Cavity Disposal Facility Footprint at 50% of Original Inventory, 55-Gallon Drums (*not to scale*)

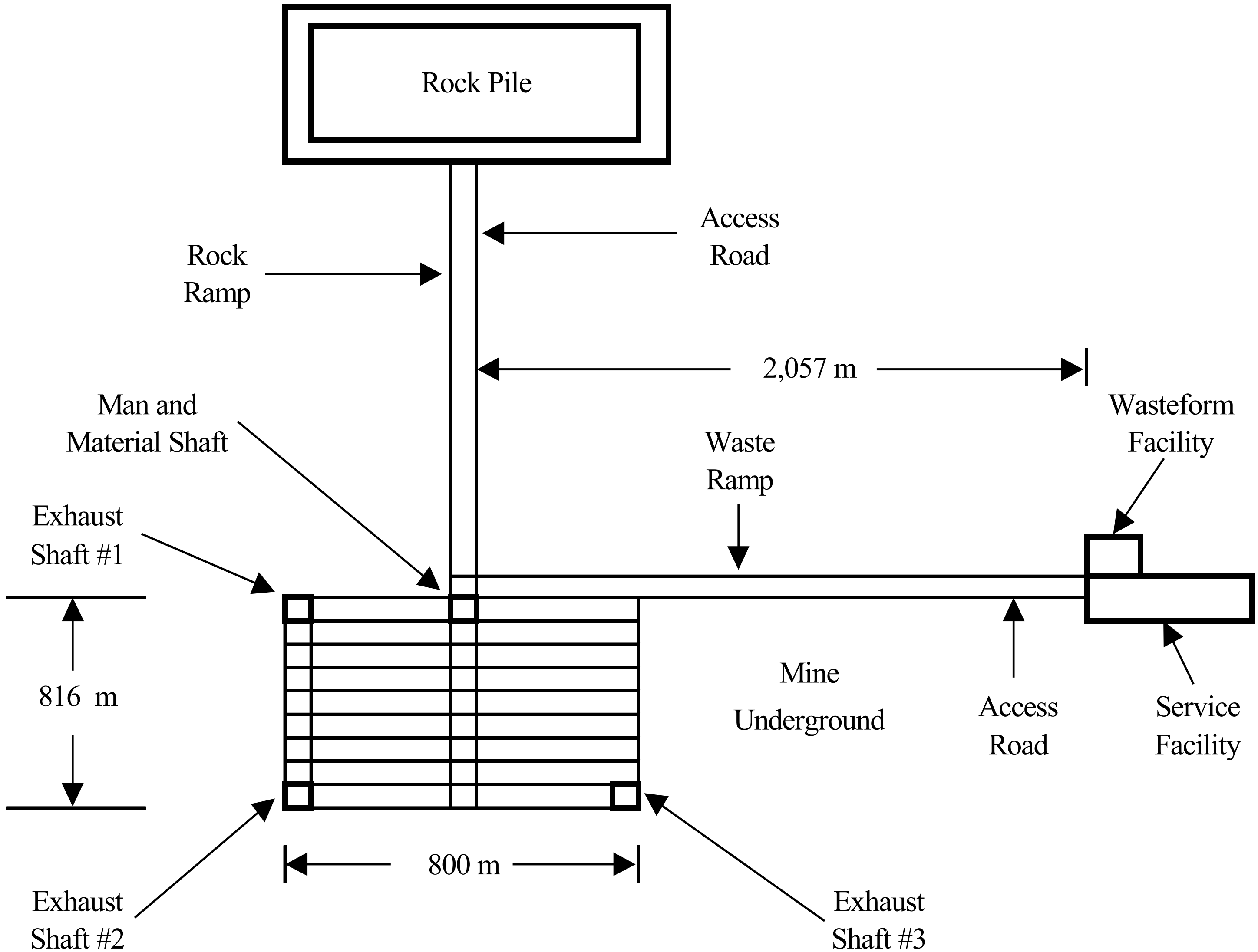

FIGURE 11.5a Mined-Cavity Disposal Facility Footprint at 25% of Original Inventory, 30-Gallon Drums (*not to scale*)

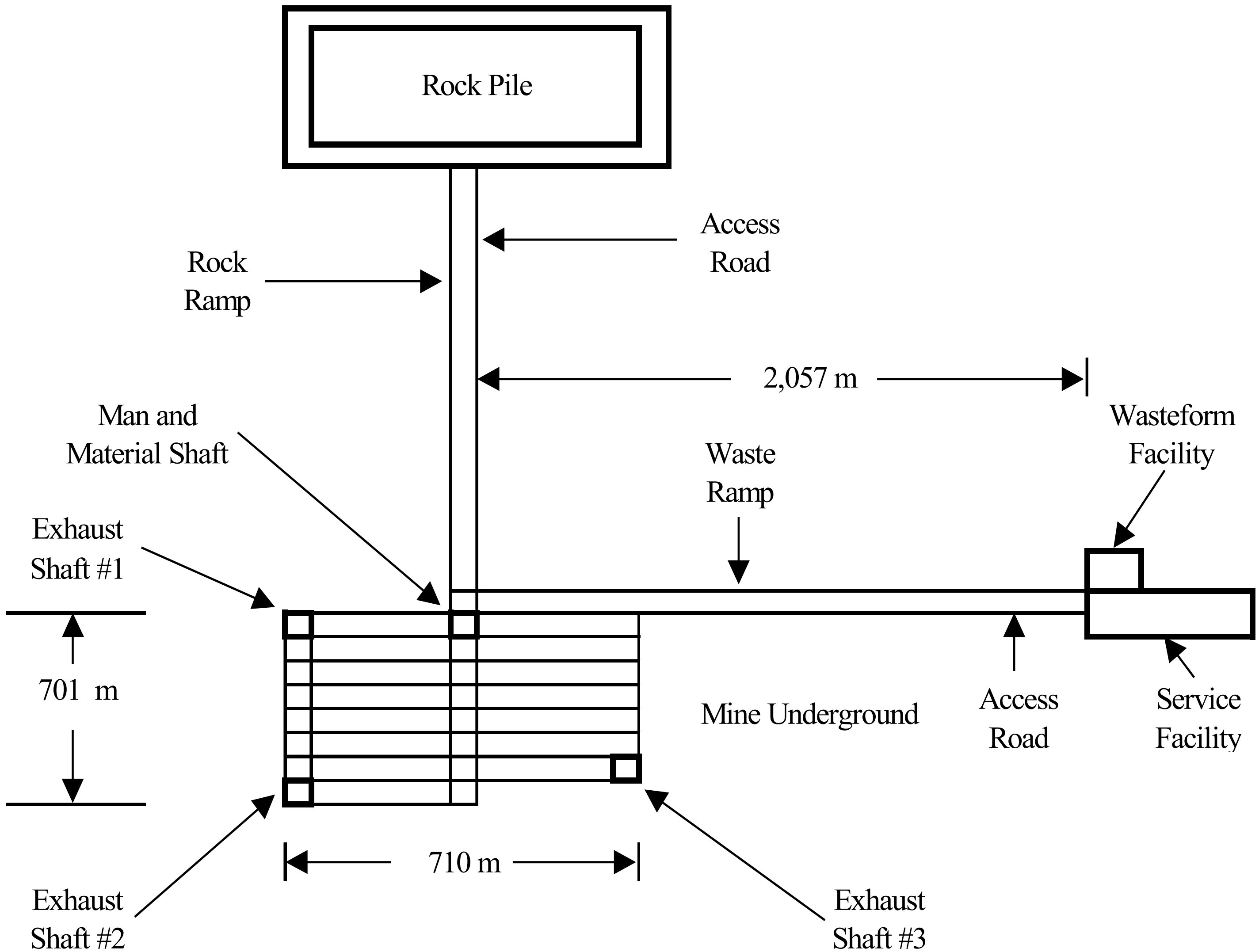

FIGURE 11.5b Mined-Cavity Disposal Facility Footprint at 25% of Original Inventory, 55-Gallon Drums (*not to scale*)

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APPENDIX A:

PRELIMINARY EQUIPMENT LIST

TABLE A.1 Preliminary Equipment List for the Administration Building

Item/Description	Number
HVAC system	1
Office PC/LAN system	30 / 1
Office furnishing	30
Conference furnishing	1
Lunchroom furnishing	1
Storage shelving system, 1,600 lb-cap per shelf, 6 ft wide × 24 in. deep	1
Site telephone system	1
Portal monitor	1
Transformer	1
Emergency lighting system	1
Security door, remote operation	1
Security gate, remote operation	1
Area monitoring system, video	1

TABLE A.2 Preliminary Equipment List for the Product Receiving and Shipping Warehouse

Item/Description	Number
Overhead bridge crane, 15 te	2
HVAC	2
HEPA	2
Dilute acid spray/rinse/drying system	1
Monitoring station equipment	1
Decontamination equipment	2
Office furniture	1
Personal computers	2
Deck plate, size to forklift and load	6
Forklift truck, diesel	1
Receiving inspection station, complete	1
Transformer	1
Emergency lighting system	1
Prime mover for rail car and semitrailer use	2

TABLE A.3 Preliminary Equipment List for the Engineered Trench Disposal Facility

Item/Description	Number
Tractor trailers, drum transport	10
Emplacement cranes, 10,000-lb capacity	4
Forklift trucks, 5-te capacity	12
Vibratory compactor, 4,536-kg capacity	4
Front-end loaders, 3.5-yd^3 capacity	4
Pick up trucks	20
Sump pumps	40
Monitoring pipes	60
0.6-m French drain	1

TABLE A.4 Preliminary Equipment List for the Vault Disposal Facility

Item/Description	Number
Emplacement cranes, 10,000-lb capacity	5
Front-end loaders, 3.5-yd^3 capacity	5
Pick up trucks	16
Tractor trailers, drum transport	5
Forklift trucks, 5-te capacity	10
Vibratory compactor, 4,536-kg capacity	5
Sump pump	76

TABLE A.5 Preliminary Equipment List for the Mined-Cavity Disposal Facility

Item/Description	Number
Emplacement (Subsurface) Area	
Sump pump, 2,000 gpm @ 1,000 ft head	1
Straddle carrier, electric, 10-ton	6
Radiation monitor station	4
Emergency power supply	4
Positive (force) fan, 200,000 cfm	2
Negative (exhaust) fan, 200,000 cfm	2
Surface Support Area	
Recovery/service vehicles	5
Forklift trucks, 5-te	50
Elevator, 20-ton	2
Radiation monitor station	2
Fire sensors/alarm	1 set
Scales	4

APPENDIX B:

RADIATION EXPOSURE AND MANPOWER DISTRIBUTION ESTIMATING DATA, ORIGINAL AND NEW INVENTORIES

TABLE B.1 Vault Disposal Facility: Operational Activities, Original Inventory – 30-Gallon Drums

Activity	Number of Workers per Station	Time per Operation (h)	Operations per Year	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Unload/inspect arriving pallet	2	0.25	17,163	1	0.9	Steel	0.24	8,581
Transfer pallet to warehouse storage	2	0.2	17,163	1	1.8	Steel	0.24	6,865
Transport pallet to transport bay	2	0.2	17,163	1	1.8	Steel	0.24	6,865
Load pallet on transport to disposal area	2	0.05	17,163	1	0.9	Steel	0.24	1,716
Decontaminate full drum exterior (0.1% of drums)	1	0.5	69	4	1.8	Steel	0.24	35
Warehouse storage surveillance	2	8	520	2	0.9	Steel	0.24	8,320
Building management	1	8	260	2	3.0	Steel	0.24	2,080
Security	1	2	1,095	2	4.6	Steel	0.24	2,190
Administration Building								
Building operations	12	8	260	2	49	Steel	0.24	24,960
Security	2	8	1,095	2	49	Steel	0.24	17,520
Disposal Area – Vault								
Transport pallets to vault	1	1	1,430	3	1.8	Steel	0.24	1,430
Unload pallet from transport at vault	2	0.2	17,163	1	0.9	Steel	0.24	6,865
Transfer drum to disposal position	2	0.25	68,650	4	1.8	Steel	0.24	34,325
Vault fill-in with gravel and compact (by level)	4	40	113	5	1.8	Steel	0.24	18,007
Cement cover vault	12	160	3.80	5	3.0	Steel	0.24	7,296
Earth fill on cement cover	8	80	3.80	5	6.1	Steel	0.24	2,432
Disposal area surveillance	1	8	520	5	3.0	Steel	0.24	4,160
Disposal management	4	8	520	5	6.1	Steel	0.24	16,640
Security	1	2	1,095	5	15	Steel	0.24	2,190
Subtotal								172,477
Number of full-time equivalents								82.9

[a] Source codes:
1 = Single pallet with four UF_4 drums.
2 = Three months storage of UF_4 drums in receiving warehouse.
3 = 30-gallon drums: 12 pallets; 55-gallon drums: 7 pallets.
4 = Single UF_4 drum.
5 = Cumulative inventory of a single disposal vault.

[b] Materials do not include walls between operating areas.

TABLE B.2 Vault Disposal Facility: Maintenance Activities, Original Inventory – 30-Gallon Drums

Equipment	Number of Workers per Station	Hours per Component per Year	Number of Components	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Overhead crane	2	52	1	1	3.0	Steel	0.24	104
HVAC	2	520	1	1	3.0	Steel	0.24	1,040
HEPA	2	26	2	1	6.1	Steel	0.24	104
Dilute acid spray/rinse/drying system	1	52	1	1	18.3	Steel	0.24	52
Monitoring station equipment	1	26	4	1	0.9	Steel	0.24	104
Decontamination equipment	2	520	1	1	49	Steel	0.24	1,040
Administration Building								
HVAC	2	520	1	1	3.0	Steel	0.24	1,040
Disposal Area – Vault								
Sump pump	1	26	76	2	3.0	Steel	0.24	1,976
Vault monitoring equipment	1	26	76	2	6.1	Steel	0.24	1,976
Subtotal								7,436
Number of full-time equivalents								3.6

[a] Source codes:
1 = Three months storage of UF_4 drums in receiving warehouse.
2 = Cumulative inventory of a single disposal vault.

[b] Materials do not include walls between operating areas.

TABLE B.3 Engineered Trench Disposal Facility: Operational Activities, Original Inventory – 30-Gallon Drums

Activity	Number of Workers per Station	Time per Operation (h)	Operations per Year	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Unload/inspect arriving pallet	2	0.25	17,163	1	0.9	Steel	0.24	8,581
Transfer pallet to warehouse storage	2	0.2	17,163	1	1.8	Steel	0.24	6,865
Transport pallet to transport bay	2	0.2	17,163	1	1.8	Steel	0.24	6,865
Load pallet on transport to disposal area	2	0.05	17,163	1	0.9	Steel	0.24	1,716
Decontaminate full drum exterior (0.1% of drums)	1	0.5	69	4	1.8	Steel	0.24	35
Warehouse storage surveillance	2	8	520	2	0.9	Steel	0.24	8,320
Building management	1	8	260	2	3.0	Steel	0.24	2,080
Security	1	2	1,095	2	4.6	Steel	0.24	2,190
Administration Building								
Building operations	12	8	260	2	49	Steel	0.24	24,960
Security	2	8	1,095	2	49	Steel	0.24	17,520
Disposal Area - Trench								
Transport pallets to trench	1	1	1,430	3	1.8	Steel	0.24	1,430
Unload pallet from transport at trench	2	0.2	17,163	1	0.9	Steel	0.24	6,865
Transfer pallet to disposal position	2	0.25	17,163	1	1.8	Steel	0.24	8,581
Trench fill-in (by level)	7.5	8	260	5	0.9	Steel	0.24	15,600
Trench fill-in (closure)	8	160	1	5	1.8	Steel	0.24	1,280
Disposal area surveillance	1	8	520	5	3.0	Steel	0.24	4,160
Disposal management	2	8	260	5	6.1	Steel	0.24	4,160
Security	1	2	1,095	5	15	Steel	0.24	2,190
Subtotal								123,398
Number of full-time equivalents								59.3

[a] Source codes:
1 = Single pallet with four UF_4 drums.
2 = Three months storage of UF_4 drums in receiving warehouse.
3 = 30-gallon drums: 12 pallets; 55-gallon drums: 7 pallets.
4 = Single UF_4 drum.
5 = Cumulative inventory of a single disposal trench.

[b] Materials do not include walls between operating areas.

TABLE B.4 Engineered Trench Disposal Facility: Maintenance Activities, Original Inventory – 30-Gallon Drums

Equipment	Number of Workers per Station	Hours per Component per Year	Number of Components	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Overhead crane	2	52	1	1	3.0	Steel	0.24	104
HVAC	2	520	1	1	3.0	Steel	0.24	1,040
HEPA	2	26	2	1	6.1	Steel	0.24	104
Dilute acid spray/rinse/drying system	1	52	1	1	18	Steel	0.24	52
Monitoring station equipment	1	26	4	1	0.9	Steel	0.24	104
Decontamination equipment	2	520	1	1	49	Steel	0.24	1,040
Administration Building								
HVAC	2	520	1	1	3.0	Steel	0.24	1,040
Disposal Area – Trench								
Sump pump	1	26	20	2	3.0	Steel	0.24	520
Monitoring equipment	1	26	20	2	6.1	Steel	0.24	520
Subtotal								4,524
Number of full-time equivalents								2.2

[a] Source codes:
1 = Three months storage of UF_4 drums in receiving warehouse.
2 = Cumulative inventory of a single disposal trench.

[b] Materials do not include walls between operating areas.

TABLE B.5 Mined-Cavity Disposal Facility: Operational Activities, Original Inventory – 30-Gallon Drums

Activity	Number of Workers per Station	Time per Operation (h)	Operations per Year	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Unload/inspect arriving pallet	2	0.25	17,163	1	0.9	Steel	0.24	8,581
Transfer pallet to warehouse storage	2	0.2	17,163	1	1.8	Steel	0.24	6,865
Transport pallet to transport bay	2	0.2	17,163	1	1.8	Steel	0.24	6,865
Load pallet on transport to disposal area	2	0.05	17,163	1	0.9	Steel	0.24	1,716
Decontaminate full drum exterior (0.1% of drums)	1	0.5	69	4	1.8	Steel	0.24	35
Warehouse storage surveillance	2	8	520	2	0.9	Steel	0.24	8,320
Building management	1	8	260	2	3.0	Steel	0.24	2,080
Security	1	2	1,095	2	4.6	Steel	0.24	2,190
Administration Building								
Building operations	12	8	260	2	49	Steel	0.24	24,960
Security	2	8	1,095	2	49	Steel	0.24	17,520
Support Facilities								
Ventilation operations	2	8	730	2	18	Steel	0.24	11,680
Security	2	2	1,095	2	244	Steel	0.24	4,380
Disposal Area – Mined Cavity								
Transport pallets to mine	1	1	1,430	3	1.8	Steel	0.24	1,430
Unload pallet from transport at mine	2	0.2	17,163	1	0.9	Steel	0.24	6,865
Load pallets onto mine transport	2	0.2	17,163	1	0.9	Steel	0.24	6,865
Transport pallets into mine	1	2	1,430	3	1.8	Steel	0.24	2,860
Unload pallet to disposal position	2	0.25	17,163	5	1.8	Steel	0.24	8,581
Disposal area surveillance	2	8	520	5	3.0	Steel	0.24	8,320
Disposal management	2	8	520	5	6.1	Steel	0.24	8,320
Security	1	2	1,095	5	15	Steel	0.24	2,190
Subtotal								140,624
Number of full-time equivalents								67.6

[a] Source codes:
1 = Single pallet with four UF_4 drums.
2 = Three months storage of UF_4 drums in receiving warehouse.
3 = 30-gallon drums: 12 pallets; 55-gallon drums: 7 pallets.
4 = Single UF_4 drum.
5 = Cumulative inventory of a single mine drift.

[b] Materials do not include walls between operating areas.

TABLE B.6 Mined-Cavity Disposal Facility: Maintenance Activities, Original Inventory – 30-Gallon Drums

Equipment	Number of Workers per Station	Hours per Component per Year	Number of Components	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Overhead crane	2	52	1	1	3.0	Steel	0.24	104
HVAC	2	520	1	1	3.0	Steel	0.24	1,040
HEPA	2	26	2	1	6.1	Steel	0.24	104
Dilute acid spray/rinse/drying system	1	52	1	1	18	Steel	0.24	52
Monitoring station equipment	1	26	4	1	0.9	Steel	0.24	104
Decontamination equipment	2	520	1	1	49	Steel	0.24	1,040
Administration Building								
HVAC	2	520	1	1	3.0	Steel	0.24	1,040
Support Facilities								
HVAC	2	520	2	1	49	Steel	0.24	2,080
Disposal Area – Mined Cavity								
Sump pump	2	52	8	2	3.0	Steel	0.24	832
Force fan	2	52	2	2	6.1	Steel	0.24	208
Exhaust fan	2	52	2	2	6.1	Steel	0.24	208
Mine elevator	2	104	2	2	305	Steel	0.24	416
Subtotal								7,228
Number of full-time equivalents								3.5

[a] Source codes:

1 = Three months storage of UF_4 drums in receiving warehouse.

2 = Cumulative inventory of a single mine drift.

[b] Materials do not include walls between operating areas.

TABLE B.7 Vault Disposal Facility: Operational Activities, Original Inventory – 55-Gallon Drums

Activity	Number of Workers per Station	Time per Operation (h)	Operations per Year	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Unload/inspect arriving pallet	2	0.25	9,363	1	0.9	Steel	0.13	4,681
Transfer pallet to warehouse storage	2	0.2	9,363	1	1.8	Steel	0.13	3,745
Transport pallet to transport bay	2	0.2	9,363	1	1.8	Steel	0.13	3,745
Load pallet on transport to disposal area	2	0.05	9,363	1	0.9	Steel	0.13	936
Decontaminate full drum exterior (0.1% of drums)	1	0.5	38	4	1.8	Steel	0.13	19
Warehouse storage surveillance	2	8	520	2	0.9	Steel	0.13	8,320
Building management	1	8	260	2	3.0	Steel	0.13	2,080
Security	1	2	1,095	2	4.6	Steel	0.13	2,190
Administration Building								
Building operations	12	8	260	2	49	Steel	0.13	24,960
Security	2	8	1,095	2	49	Steel	0.13	17,520
Disposal Area - Vault								
Transport pallets to vault	1	1	1,338	3	1.8	Steel	0.13	1,338
Unload pallet from transport at vault	2	0.2	9,363	1	0.9	Steel	0.13	3,745
Transfer drum to disposal position	2	0.25	37,450	4	1.8	Steel	0.13	18,725
Vault fill-in with gravel and compact (by level)	4	40	83	5	1.8	Steel	0.13	13,316
Cement cover vault	12	160	4.20	5	3.0	Steel	0.13	8,064
Earth fill on cement cover	8	80	4.20	5	6.1	Steel	0.13	2,688
Disposal area surveillance	1	8	520	5	3.0	Steel	0.13	4,160
Disposal management	4	8	520	5	6.1	Steel	0.13	16,640
Security	1	2	1,095	5	15	Steel	0.13	2,190
Subtotal								139,062
Number of full-time equivalents								66.9

[a] Source codes:
1 = Single pallet with four UF_4 drums.
2 = Three months storage of UF_4 drums in receiving warehouse.
3 = 30-gallon drums: 12 pallets; 55-gallon drums: 7 pallets.
4 = Single UF_4 drum.
5 = Cumulative inventory of a single disposal vault.

[b] Materials do not include walls between operating areas.

TABLE B.8 Vault Disposal Facility: Maintenance Activities, Original Inventory – 55-Gallon Drums

Equipment	Number of Workers per Station	Hours per Component per Year	Number of Components	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Overhead crane	2	52	1	1	3.0	Steel	0.13	104
HVAC	2	520	1	1	3.0	Steel	0.13	1,040
HEPA	2	26	2	1	6.1	Steel	0.13	104
Dilute acid spray/rinse/drying system	1	52	1	1	18.3	Steel	0.13	52
Monitoring station equipment	1	26	4	1	0.9	Steel	0.13	104
Decontamination equipment	2	520	1	1	49	Steel	0.13	1,040
Administration Building								
HVAC	2	520	1	1	3.0	Steel	0.13	1,040
Disposal Area – Vault								
Sump pump	1	26	84	2	3.0	Steel	0.13	2,184
Vault monitoring equipment	1	26	84	2	6.1	Steel	0.13	2,184
Subtotal								7,852
Number of full-time equivalents								3.8

[a] Source codes:
1 = Three months storage of UF_4 drums in receiving warehouse.
2 = Cumulative inventory of a single disposal vault.

[b] Materials do not include walls between operating areas.

TABLE B.9 Engineered Trench Disposal Facility: Operational Activities, Original Inventory – 55-Gallon Drums

Activity	Number of Workers per Station	Time per Operation (h)	Operations per Year	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Unload/inspect arriving pallet	2	0.25	9,363	1	0.9	Steel	0.13	4,681
Transfer pallet to warehouse storage	2	0.2	9,363	1	1.8	Steel	0.13	3,745
Transport pallet to transport bay	2	0.2	9,363	1	1.8	Steel	0.13	3,745
Load pallet on transport to disposal area	2	0.05	9,363	1	0.9	Steel	0.13	936
Decontaminate full drum exterior (0.1% of drums)	1	0.5	38	4	1.8	Steel	0.13	19
Warehouse storage surveillance	2	8	520	2	0.9	Steel	0.13	8,320
Building management	1	8	260	2	3.0	Steel	0.13	2,080
Security	1	2	1,095	2	4.6	Steel	0.13	2,190
Administration Building								
Building operations	12	8	260	2	49	Steel	0.13	24,960
Security	2	8	1,095	2	49	Steel	0.13	17,520
Disposal Area - Trench								
Transport pallets to trench	1	1	1,338	3	1.8	Steel	0.13	1,338
Unload pallet from transport at trench	2	0.2	9,363	1	0.9	Steel	0.13	3,745
Transfer pallet to disposal position	2	0.25	9,363	1	1.8	Steel	0.13	4,681
Trench fill-in (by level)	6.2	8	260	5	0.9	Steel	0.13	12,896
Trench fill-in (closure)	8	160	1	5	1.8	Steel	0.13	1,280
Disposal area surveillance	1	8	520	5	3.0	Steel	0.13	4,160
Disposal management	2	8	260	5	6.1	Steel	0.13	4,160
Security	1	2	1,095	5	15	Steel	0.13	2,190
Subtotal								102,646
Number of full-time equivalents								49.3

[a] Source codes:
1 = Single pallet with four UF_4 drums.
2 = Three months storage of UF_4 drums in receiving warehouse.
3 = 30-gallon drums: 12 pallets; 55-gallon drums: 7 pallets.
4 = Single UF_4 drum.
5 = Cumulative inventory of a single disposal trench.

[b] Materials do not include walls between operating areas.

TABLE B.10 Engineered Trench Disposal Facility: Maintenance Activities, Original Inventory – 55-Gallon Drums

Equipment	Number of Workers per Station	Hours per Component per Year	Number of Components	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Overhead crane	2	52	1	1	3.0	Steel	0.13	104
HVAC	2	520	1	1	3.0	Steel	0.13	1,040
HEPA	2	26	2	1	6.1	Steel	0.13	104
Dilute acid spray/rinse/drying system	1	52	1	1	18	Steel	0.13	52
Monitoring station equipment	1	26	4	1	0.9	Steel	0.13	104
Decontamination equipment	2	520	1	1	49	Steel	0.13	1,040
Administration Building								
HVAC	2	520	1	1	3.0	Steel	0.13	1,040
Disposal Area – Trench								
Sump pump	1	26	20	2	3.0	Steel	0.13	520
Monitoring equipment	1	26	20	2	6.1	Steel	0.13	520
Subtotal								4,524
Number of full-time equivalents								2.2

[a] Source Codes:
1 = Three months storage of UF_4 drums in receiving warehouse.
2 = Cumulative inventory of a single disposal trench.

[b] Materials do not include walls between operating areas.

TABLE B.11 Mined-Cavity Disposal Facility: Operational Activities, Original Inventory – 55-Gallon Drums

Activity	Number of Workers per Station	Time per Operation (h)	Operations per Year	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving And Shipping Warehouse								
Unload/inspect arriving pallet	2	0.25	9,363	1	0.9	Steel	0.13	4,681
Transfer pallet to warehouse storage	2	0.2	9,363	1	1.8	Steel	0.13	3,745
Transport pallet to transport bay	2	0.2	9,363	1	1.8	Steel	0.13	3,745
Load pallet on transport to disposal area	2	0.05	9,363	1	0.9	Steel	0.13	936
Decontaminate full drum exterior (0.1% of drums)	1	0.5	38	4	1.8	Steel	0.13	19
Warehouse storage surveillance	2	8	520	2	0.9	Steel	0.13	8,320
Building management	1	8	260	2	3.0	Steel	0.13	2,080
Security	1	2	1,095	2	4.6	Steel	0.13	2,190
Administration Building								
Building operations	12	8	260	2	49	Steel	0.13	24,960
Security	2	8	1,095	2	49	Steel	0.13	17,520
Support Facilities								
Ventilation operations	2	8	730	2	18	Steel	0.13	11,680
Security	2	2	1,095	2	244	Steel	0.13	4,380
Disposal Area – Mined Cavity								
Transport pallets to mine	1	1	1,338	3	1.8	Steel	0.13	1,338
Unload pallet from transport at mine	2	0.2	9,363	1	0.9	Steel	0.13	3,745
Load pallets onto mine transport	2	0.2	9,363	1	0.9	Steel	0.13	3,745
Transport pallets into mine	1	2	1,338	3	1.8	Steel	0.13	2,675
Unload pallet to disposal position	2	0.25	9,363	5	1.8	Steel	0.13	4,681
Disposal area surveillance	2	8	520	5	3.0	Steel	0.13	8,320
Disposal management	2	8	520	5	6.1	Steel	0.13	8,320
Security	1	2	1,095	5	15	Steel	0.13	2,190
Subtotal								119,270
Number of full-time equivalents								57.3

[a] Source codes:
1 = Single pallet with four UF_4 drums.
2 = Three months storage of UF_4 drums in receiving warehouse.
3 = 30-gallon drums: 12 pallets; 55-gallon drums: 7 pallets.
4 = Single UF_4 drum.
5 = Cumulative inventory of a single mine drift.

[b] Materials do not include walls between operating areas.

TABLE B.12 Mined-Cavity Disposal Facility: Maintenance Activities, Original Inventory – 55-Gallon Drums

Equipment	Number of Workers per Station	Hours per Component per Year	Number of Components	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving And Shipping Warehouse								
Overhead crane	2	52	1	1	3.0	Steel	0.13	104
HVAC	2	520	1	1	3.0	Steel	0.13	1,040
HEPA	2	26	2	1	6.1	Steel	0.13	104
Dilute acid spray/rinse/drying system	1	52	1	1	18	Steel	0.13	52
Monitoring station equipment	1	26	4	1	0.9	Steel	0.13	104
Decontamination equipment	2	520	1	1	49	Steel	0.13	1,040
Administration Building								
HVAC	2	520	1	1	3.0	Steel	0.13	1,040
Support Facilities								
HVAC	2	520	2	1	49	Steel	0.13	2,080
Disposal Area – Mined Cavity								
Sump pump	2	52	8	2	3.0	Steel	0.13	832
Force fan	2	52	2	2	6.1	Steel	0.13	208
Exhaust fan	2	52	2	2	6.1	Steel	0.13	208
Mine elevator	2	104	2	2	305	Steel	0.13	416
Subtotal								7,228
Number of full-time equivalents								3.5

[a] Source codes:
1 = Three months storage of UF_4 drums in receiving warehouse.
2 = Cumulative inventory of a single mine drift.

[b] Materials do not include walls between operating areas.

TABLE B.13 Vault Disposal Facility: Operational Activities, New Inventory – 30-Gallon Drums

Activity	Number of Workers per station	Time per Operation (h)	Operations per Year	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving And Shipping Warehouse								
Unload/inspect arriving pallet	2	0.25	17,290	1	0.9	Steel	0.24	8,645
Transfer pallet to warehouse storage	2	0.2	17,290	1	1.8	Steel	0.24	6,916
Transport pallet to transport bay	2	0.2	17,290	1	1.8	Steel	0.24	6,916
Load pallet on transport to disposal area	2	0.05	17,290	1	0.9	Steel	0.24	1,729
Decontaminate full drum exterior (0.1% of drums)	1	0.5	70	4	1.8	Steel	0.24	35
Warehouse storage surveillance	2	8	520	2	0.9	Steel	0.24	8,320
Building management	1	8	260	2	3.0	Steel	0.24	2,080
Security	1	2	1,095	2	4.6	Steel	0.24	2,190
Administration Building								
Building operations	12	8	260	2	49	Steel	0.24	24,960
Security	2	8	1,095	2	49	Steel	0.24	17,520
Disposal Area - Vault								
Transport pallets to vault	1	1	1,441	3	1.8	Steel	0.24	1,441
Unload pallet from transport at vault	2	0.2	17,290	1	0.9	Steel	0.24	6,916
Transfer drum to disposal position	2	0.25	69,160	4	1.8	Steel	0.24	34,580
Vault fill-in with gravel and compact (by level)	4	40	113	5	1.8	Steel	0.24	18,140
Cement cover vault	12	160	3.80	5	3.0	Steel	0.24	7,296
Earth fill on cement cover	8	80	3.80	5	6.1	Steel	0.24	2,432
Disposal area surveillance	1	8	520	5	3.0	Steel	0.24	4,160
Disposal management	4	8	520	5	6.1	Steel	0.24	16,640
Security	1	2	1,095	5	15	Steel	0.24	2,190
Subtotal								173,106
Number of full-time equivalents								83.2

[a] Source codes:
1 = Single pallet with four UF_4 drums.
2 = Three months storage of UF_4 drums in receiving warehouse.
3 = 30-gallon drums: 12 pallets; 55-gallon drums: 7 pallets.
4 = Single UF_4 drum.
5 = Cumulative inventory of a single disposal vault.

[b] Materials do not include walls between operating areas.

TABLE B.14 Vault Disposal Facility: Maintenance Activities, New Inventory – 30-Gallon Drums

Equipment	Number of Workers per Station	Hours per Component per Year	Number of Components	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving And Shipping Warehouse								
Overhead crane	2	52	1	1	3.0	Steel	0.24	104
HVAC	2	520	1	1	3.0	Steel	0.24	1,040
HEPA	2	26	2	1	6.1	Steel	0.24	104
Dilute acid spray/rinse/drying system	1	52	1	1	18.3	Steel	0.24	52
Monitoring station equipment	1	26	4	1	0.9	Steel	0.24	104
Decontamination equipment	2	520	1	1	49	Steel	0.24	1,040
Administration Building								
HVAC	2	520	1	1	3.0	Steel	0.24	1,040
Disposal Area – Vault								
Sump pump	1	26	76	2	3.0	Steel	0.24	1,976
Vault monitoring equipment	1	26	76	2	6.1	Steel	0.24	1,976
Subtotal								7,436
Number of full-time equivalents								3.6

[a] Source codes:

1 = Three months storage of UF_4 drums in receiving warehouse.

2 = Cumulative inventory of a single disposal vault.

[b] Materials do not include walls between operating areas.

TABLE B.15 Engineered Trench Disposal Facility: Operational Activities, New Inventory – 30-Gallon Drums

Activity	Number of Workers per Station	Time per Operation (h)	Operations per Year	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Unload/inspect arriving pallet	2	0.25	17,290	1	0.9	Steel	0.24	8,645
Transfer pallet to warehouse storage	2	0.2	17,290	1	1.8	Steel	0.24	6,916
Transport pallet to transport bay	2	0.2	17,290	1	1.8	Steel	0.24	6,916
Load pallet on transport to disposal area	2	0.05	17,290	1	0.9	Steel	0.24	1,729
Decontaminate full drum exterior (0.1% of drums)	1	0.5	70	4	1.8	Steel	0.24	35
Warehouse storage surveillance	2	8	520	2	0.9	Steel	0.24	8,320
Building management	1	8	260	2	3.0	Steel	0.24	2,080
Security	1	2	1,095	2	4.6	Steel	0.24	2,190
Administration Building								
Building operations	12	8	260	2	49	Steel	0.24	24,960
Security	2	8	1,095	2	49	Steel	0.24	17,520
Disposal Area - Trench								
Transport pallets to trench	1	1	1,441	3	1.8	Steel	0.24	1,441
Unload pallet from transport at trench	2	0.2	17,290	1	0.9	Steel	0.24	6,916
Transfer pallet to disposal position	2	0.25	17,290	1	1.8	Steel	0.24	8,645
Trench fill-in (by level)	7.6	8	260	5	0.9	Steel	0.24	15,808
Trench fill-in (closure)	8	160	1	5	1.8	Steel	0.24	1,280
Disposal area surveillance	1	8	520	5	3.0	Steel	0.24	4,160
Disposal management	2	8	260	5	6.1	Steel	0.24	4,160
Security	1	2	1,095	5	15	Steel	0.24	2,190
Subtotal								123,911
Number of full-time equivalents								59.6

[a] Source codes:
1 = Single pallet with four UF_4 drums.
2 = Three months storage of UF_4 drums in receiving warehouse.
3 = 30-gallon drums: 12 pallets; 55-gallon drums: 7 pallets.
4 = Single UF_4 drum.
5 = Cumulative inventory of a single disposal trench.

[b] Materials do not include walls between operating areas.

TABLE B.16 Engineered Trench Disposal Facility: Maintenance Activities, New Inventory – 30-Gallon Drums

Equipment	Number of Workers per Station	Hours per Component per Year	Number of Components	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Overhead crane	2	52	1	1	3.0	Steel	0.24	104
HVAC	2	520	1	1	3.0	Steel	0.24	1,040
HEPA	2	26	2	1	6.1	Steel	0.24	104
Dilute acid spray/rinse/drying system	1	52	1	1	18	Steel	0.24	52
Monitoring station equipment	1	26	4	1	0.9	Steel	0.24	104
Decontamination equipment	2	520	1	1	49	Steel	0.24	1,040
Administration Building								
HVAC	2	520	1	1	3.0	Steel	0.24	1,040
Disposal Area – Trench								
Sump pump	1	26	20	2	3.0	Steel	0.24	520
Monitoring equipment	1	26	20	2	6.1	Steel	0.24	520
Subtotal								4,524
Number of full-time equivalents								2.2

[a] Source codes:

1 = Three months storage of UF_4 drums in receiving warehouse.

2 = Cumulative inventory of a single disposal trench.

[b] Materials do not include walls between operating areas.

TABLE B.17 Mined-Cavity Disposal Facility: Operational Activities, New Inventory – 30-Gallon Drums

Activity	Number of Workers per Station	Time per Operation (h)	Operations per Year	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving And Shipping Warehouse								
Unload/inspect arriving pallet	2	0.25	17,290	1	0.9	Steel	0.24	8,645
Transfer pallet to warehouse storage	2	0.2	17,290	1	1.8	Steel	0.24	6,916
Transport pallet to transport bay	2	0.2	17,290	1	1.8	Steel	0.24	6,916
Load pallet on transport to disposal area	2	0.05	17,290	1	0.9	Steel	0.24	1,729
Decontaminate full drum exterior (0.1% of drums)	1	0.5	70	4	1.8	Steel	0.24	35
Warehouse storage surveillance	2	8	520	2	0.9	Steel	0.24	8,320
Building management	1	8	260	2	3.0	Steel	0.24	2,080
Security	1	2	1,095	2	4.6	Steel	0.24	2,190
Administration Building								
Building operations	12	8	260	2	49	Steel	0.24	24,960
Security	2	8	1,095	2	49	Steel	0.24	17,520
Support Facilities								
Ventilation operations	2	8	730	2	18	Steel	0.24	11,680
Security	2	2	1,095	2	244	Steel	0.24	4,380
Disposal Area – Mined Cavity								
Transport pallets to mine	1	1	1,441	3	1.8	Steel	0.24	1,441
Unload pallet from transport at mine	2	0.2	17,290	1	0.9	Steel	0.24	6,916
Load pallets onto mine transport	2	0.2	17,290	1	0.9	Steel	0.24	6,916
Transport pallets into mine	1	2	1,441	3	1.8	Steel	0.24	2,882
Unload pallet to disposal position	2	0.25	17,290	5	1.8	Steel	0.24	8,645
Disposal area surveillance	2	8	520	5	3.0	Steel	0.24	8,320
Disposal management	2	8	520	5	6.1	Steel	0.24	8,320
Security	1	2	1,095	5	15	Steel	0.24	2,190
Subtotal								141,001
Number of full-time equivalents								67.8

[a] Source codes:
1 = Single pallet with four UF_4 drums.
2 = Three months storage of UF_4 drums in receiving warehouse.
3 = 30-gallon drums: 12 pallets; 55-gallon drums: 7 pallets.
4 = Single UF_4 drum.
5 = Cumulative inventory of a single mine drift.

[b] Materials do not include walls between operating areas.

TABLE B.18 Mined-Cavity Disposal Facility: Maintenance Activities, New Inventory – 30-Gallon Drums

Equipment	Number of Workers per Station	Hours per Component per Year	Number of Components	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Overhead crane	2	52	1	1	3.0	Steel	0.24	104
HVAC	2	520	1	1	3.0	Steel	0.24	1,040
HEPA	2	26	2	1	6.1	Steel	0.24	104
Dilute acid spray/rinse/drying system	1	52	1	1	18	Steel	0.24	52
Monitoring station equipment	1	26	4	1	0.9	Steel	0.24	104
Decontamination equipment	2	520	1	1	49	Steel	0.24	1,040
Administration Building								
HVAC	2	520	1	1	3.0	Steel	0.24	1,040
Support Facilities								
HVAC	2	520	2	1	49	Steel	0.24	2,080
Disposal Area – Mined Cavity								
Sump pump	2	52	8	2	3.0	Steel	0.24	832
Force fan	2	52	2	2	6.1	Steel	0.24	208
Exhaust fan	2	52	2	2	6.1	Steel	0.24	208
Mine elevator	2	104	2	2	305	Steel	0.24	416
Subtotal								7,228
Number of full-time equivalents								3.5

[a] Source codes:
1 = Three months storage of UF_4 drums in receiving warehouse.
2 = Cumulative inventory of a single mine drift.

[b] Materials do not include walls between operating areas.

TABLE B.19 Vault Disposal Facility: Operational Activities, New Inventory – 55 Gallon Drums

Activity	Number of Workers per Station	Time per Operation (h)	Operations per Year	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving And Shipping Warehouse								
Unload/inspect arriving pallet	2	0.25	9,430	1	0.9	Steel	0.13	4,715
Transfer pallet to warehouse storage	2	0.2	9,430	1	1.8	Steel	0.13	3,772
Transport pallet to transport bay	2	0.2	9,430	1	1.8	Steel	0.13	3,772
Load pallet on transport to disposal area	2	0.05	9,430	1	0.9	Steel	0.13	943
Decontaminate full drum exterior (0.1% of drums)	1	0.5	38	4	1.8	Steel	0.13	19
Warehouse storage surveillance	2	8	520	2	0.9	Steel	0.13	8,320
Building management	1	8	260	2	3.0	Steel	0.13	2,080
Security	1	2	1,095	2	4.6	Steel	0.13	2,190
Administration Building								
Building operations	12	8	260	2	49	Steel	0.13	24,960
Security	2	8	1,095	2	49	Steel	0.13	17,520
Disposal Area - Vault								
Transport pallets to vault	1	1	1,347	3	1.8	Steel	0.13	1,347
Unload pallet from transport at vault	2	0.2	9,430	1	0.9	Steel	0.13	3,772
Transfer drum to disposal position	2	0.25	37,720	4	1.8	Steel	0.13	18,860
Vault fill-in with gravel and compact (by level)	4	40	84	5	1.8	Steel	0.13	13,412
Cement cover vault	12	160	4.20	5	3.0	Steel	0.13	8,064
Earth fill on cement cover	8	80	4.20	5	6.1	Steel	0.13	2,688
Disposal area surveillance	1	8	520	5	3.0	Steel	0.13	4,160
Disposal management	4	8	520	5	6.1	Steel	0.13	16,640
Security	1	2	1,095	5	15	Steel	0.13	2,190
Subtotal								139,424
Number of full-time equivalents								67.0

[a] Source codes:
1 = Single pallet with four UF_4 drums.
2 = Three months storage of UF_4 drums in receiving warehouse.
3 = 30-gallon drums: 12 pallets; 55-gallon drums: 7 pallets.
4 = Single UF_4 drum.
5 = Cumulative inventory of a single disposal vault.

[b] Materials do not include walls between operating areas.

TABLE B.20 Vault Disposal Facility: Maintenance Activities, New Inventory

Equipment	Number of Workers per Station	Hours per Component per Year	Number of Components	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving And Shipping Warehouse								
Overhead crane	2	52	1	1	3.0	Steel	0.13	104
HVAC	2	520	1	1	3.0	Steel	0.13	1,040
HEPA	2	26	2	1	6.1	Steel	0.13	104
Dilute acid spray/rinse/drying system	1	52	1	1	18.3	Steel	0.13	52
Monitoring station equipment	1	26	4	1	0.9	Steel	0.13	104
Decontamination equipment	2	520	1	1	49	Steel	0.13	1,040
Administration Building								
HVAC	2	520	1	1	3.0	Steel	0.13	1,040
Disposal Area – Vault								
Sump pump	1	26	84	2	3.0	Steel	0.13	2,184
Vault monitoring equipment	1	26	84	2	6.1	Steel	0.13	2,184
Subtotal								7,852
Number of full-time equivalents								3.8

[a] Source codes:

1 = Three months storage of UF_4 drums in receiving warehouse.

2 = Cumulative inventory of a single disposal vault.

[b] Materials do not include walls between operating areas.

TABLE B.21 Engineered Trench Disposal Facility: Operational Activities, New Inventory

Activity	Number of Workers per Station	Time per Operation (h)	Operations per Year	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving And Shipping Warehouse								
Unload/inspect arriving pallet	2	0.25	9,430	1	0.9	Steel	0.13	4,715
Transfer pallet to warehouse storage	2	0.2	9,430	1	1.8	Steel	0.13	3,772
Transport pallet to transport bay	2	0.2	9,430	1	1.8	Steel	0.13	3,772
Load pallet on transport to disposal area	2	0.05	9,430	1	0.9	Steel	0.13	943
Decontaminate full drum exterior (0.1% of drums)	1	0.5	38	4	1.8	Steel	0.13	19
Warehouse storage surveillance	2	8	520	2	0.9	Steel	0.13	8,320
Building management	1	8	260	2	3.0	Steel	0.13	2,080
Security	1	2	1,095	2	4.6	Steel	0.13	2,190
Administration Building								
Building operations	12	8	260	2	49	Steel	0.13	24,960
Security	2	8	1,095	2	49	Steel	0.13	17,520
Disposal Area - Trench								
Transport pallets to trench	1	1	1,347	3	1.8	Steel	0.13	1,347
Unload pallet from transport at trench	2	0.2	9,430	1	0.9	Steel	0.13	3,772
Transfer pallet to disposal position	2	0.25	9,430	1	1.8	Steel	0.13	4,715
Trench fill-in (by level)	6.2	8	260	5	0.9	Steel	0.13	12,896
Trench fill-in (closure)	8	160	1	5	1.8	Steel	0.13	1,280
Disposal area surveillance	1	8	520	5	3.0	Steel	0.13	4,160
Disposal management	2	8	260	5	6.1	Steel	0.13	4,160
Security	1	2	1,095	5	15	Steel	0.13	2,190
Subtotal								102,811
Number of full-time equivalents								49.4

[a] Source codes:
1 = Single pallet with four UF_4 drums.
2 = Three months storage of UF_4 drums in receiving warehouse.
3 = 30-gallon drums: 12 pallets; 55-gallon drums: 7 pallets.
4 = Single UF_4 drum.
5 = Cumulative inventory of a single disposal trench.

[b] Materials do not include walls between operating areas.

TABLE B.22 Engineered Trench Disposal Facility: Maintenance Activities, New Inventory

Equipment	Number of Workers per Station	Hours per Component per Year	Number of Components	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving And Shipping Warehouse								
Overhead crane	2	52	1	1	3.0	Steel	0.13	104
HVAC	2	520	1	1	3.0	Steel	0.13	1,040
HEPA	2	26	2	1	6.1	Steel	0.13	104
Dilute acid spray/rinse/drying system	1	52	1	1	18	Steel	0.13	52
Monitoring station equipment	1	26	4	1	0.9	Steel	0.13	104
Decontamination equipment	2	520	1	1	49	Steel	0.13	1,040
Administration Building								
HVAC	2	520	1	1	3.0	Steel	0.13	1,040
Disposal Area – Trench								
Sump pump	1	26	20	2	3.0	Steel	0.13	520
Monitoring equipment	1	26	20	2	6.1	Steel	0.13	520
Subtotal								4,524
Number of full-time equivalents								2.2

[a] Source codes:

1 = Three months storage of UF_4 drums in receiving warehouse.

2 = Cumulative inventory of a single disposal trench.

[b] Materials do not include walls between operating areas.

TABLE B.23 Mined-Cavity Disposal Facility: Operational Activities, New Inventory

Activity	Number of Workers per Station	Time per Operation (h)	Operations per Year	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Unload/inspect arriving pallet	2	0.25	9,430	1	0.9	Steel	0.13	4,715
Transfer pallet to warehouse storage	2	0.2	9,430	1	1.8	Steel	0.13	3,772
Transport pallet to transport bay	2	0.2	9,430	1	1.8	Steel	0.13	3,772
Load pallet on transport to disposal area	2	0.05	9,430	1	0.9	Steel	0.13	943
Decontaminate full drum exterior (0.1% of drums)	1	0.5	38	4	1.8	Steel	0.13	19
Warehouse storage surveillance	2	8	520	2	0.9	Steel	0.13	8,320
Building management	1	8	260	2	3.0	Steel	0.13	2,080
Security	1	2	1,095	2	4.6	Steel	0.13	2,190
Administration Building								
Building operations	12	8	260	2	49	Steel	0.13	24,960
Security	2	8	1,095	2	49	Steel	0.13	17,520
Support Facilities								
Ventilation operations	2	8	730	2	18	Steel	0.13	11,680
Security	2	2	1,095	2	244	Steel	0.13	4,380
Disposal Area – Mined Cavity								
Transport pallets to mine	1	1	1,347	3	1.8	Steel	0.13	1,347
Unload pallet from transport at mine	2	0.2	9,430	1	0.9	Steel	0.13	3,772
Load pallets onto mine transport	2	0.2	9,430	1	0.9	Steel	0.13	3,772
Transport pallets into mine	1	2	1,347	3	1.8	Steel	0.13	2,694
Unload pallet to disposal position	2	0.25	9,430	5	1.8	Steel	0.13	4,715
Disposal area surveillance	2	8	520	5	3.0	Steel	0.13	8,320
Disposal management	2	8	520	5	6.1	Steel	0.13	8,320
Security	1	2	1,095	5	15	Steel	0.13	2,190
Subtotal								119,481
Number of full-time equivalents								57.4

[a] Source codes:
1 = Single pallet with four UF_4 drums.
2 = Three months storage of UF_4 drums in receiving warehouse.
3 = 30-gallon drums: 12 pallets; 55-gallon drums: 7 pallets.
4 = Single UF_4 drum.
5 = Cumulative inventory of a single mine drift.

[b] Materials do not include walls between operating areas.

TABLE B.24 Mined-Cavity Disposal Facility: Maintenance Activities, New Inventory

Equipment	Number of Workers per Station	Hours per Component per Year	Number of Components	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving And Shipping Warehouse								
Overhead crane	2	52	1	1	3.0	Steel	0.13	104
HVAC	2	520	1	1	3.0	Steel	0.13	1,040
HEPA	2	26	2	1	6.1	Steel	0.13	104
Dilute acid spray/rinse/drying system	1	52	1	1	18	Steel	0.13	52
Monitoring station equipment	1	26	4	1	0.9	Steel	0.13	104
Decontamination equipment	2	520	1	1	49	Steel	0.13	1,040
Administration Building								
HVAC	2	520	1	1	3.0	Steel	0.13	1,040
Support Facilities								
HVAC	2	520	2	1	49	Steel	0.13	2,080
Disposal Area – Mined Cavity								
Sump pump	2	52	8	2	3.0	Steel	0.13	832
Force fan	2	52	2	2	6.1	Steel	0.13	208
Exhaust fan	2	52	2	2	6.1	Steel	0.13	208
Mine elevator	2	104	2	2	305	Steel	0.13	416
Subtotal								7,228
Number of full-time equivalents								3.5

[a] Source codes:

1 = Three months storage of UF_4 drums in receiving warehouse.

2 = Cumulative inventory of a single mine drift.

[b] Materials do not include walls between operating areas.

APPENDIX C:

RADIATION EXPOSURE AND MANPOWER DISTRIBUTION ESTIMATING DATA, 25% AND 50% CASES

TABLE C.1 Mined-Cavity Disposal Facility: Operational Activities, 50% of Original Inventory — 30-Gallon Drums

Activity	Number of Workers per Station	Time per Operation (h)	Operations per Year	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Unload/inspect arriving pallet	2	0.25	8,588	1	0.9	Steel	0.24	4,294
Transfer pallet to warehouse storage	2	0.2	8,588	1	1.8	Steel	0.24	3,435
Transport pallet to transport bay	2	0.2	8,588	1	1.8	Steel	0.24	3,435
Load pallet on transport to disposal area	2	0.05	8,588	1	0.9	Steel	0.24	859
Decontaminate full drum exterior (0.1% of drums)	1	0.5	35	4	1.8	Steel	0.24	18
Warehouse storage surveillance	2	8	520	2	0.9	Steel	0.24	8,320
Building management	1	8	260	2	3.0	Steel	0.24	2,080
Security	1	2	1,095	2	4.6	Steel	0.24	2,190
Administration Building								
Building operations	6	8	260	2	49	Steel	0.24	12,480
Security	2	8	1,095	2	49	Steel	0.24	17,520
Support Facilities								
Ventilation operations	2	8	730	2	18	Steel	0.24	11,680
Security	2	2	1,095	2	244	Steel	0.24	4,380
Disposal Area – Mined Cavity								
Transport pallets to mine	1	1	716	3	1.8	Steel	0.24	716
Unload pallet from transport at mine	2	0.2	8,588	1	0.9	Steel	0.24	3,435
Load pallets onto mine transport	2	0.2	8,588	1	0.9	Steel	0.24	3,435
Transport pallets into mine	1	2	716	3	1.8	Steel	0.24	1,431
Unload pallet to disposal position	2	0.25	8,588	5	1.8	Steel	0.24	4,294
Disposal area surveillance	1	8	520	5	3.0	Steel	0.24	4,160
Disposal management	1	8	520	5	6.1	Steel	0.24	4,160
Security	1	2	1,095	5	15	Steel	0.24	2,190
Subtotal								94,511
Number of full-time equivalents								45.4

[a] Source codes:
1 = Single pallet with four UF_4 drums.
2 = Three months storage of UF_4 drums in receiving warehouse.
3 = 30-gallon drums: 12 pallets; 55-gallon drums: 7 pallets.
4 = Single UF_4 drum.
5 = Cumulative inventory of a single mine drift.

[b] Materials do not include walls between operating areas.

TABLE C.2 Mined-Cavity Disposal Facility: Maintenance Activities, 50% of Original Inventory — 30-Gallon Drums

Equipment	Number of Workers per Station	Hours per Component per Year	Number of Components	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Overhead crane	2	52	1	1	3.0	Steel	0.24	104
HVAC	2	520	1	1	3.0	Steel	0.24	1,040
HEPA	2	26	2	1	6.1	Steel	0.24	104
Dilute acid spray/rinse/drying system	1	52	1	1	18	Steel	0.24	52
Monitoring station equipment	1	26	4	1	0.9	Steel	0.24	104
Decontamination equipment	2	520	1	1	49	Steel	0.24	1,040
Administration Building								
HVAC	2	520	1	1	3.0	Steel	0.24	1,040
Support Facilities								
HVAC	2	520	2	1	49	Steel	0.24	2,080
Disposal Area – Mined Cavity								
Sump pump	2	52	8	2	3.0	Steel	0.24	832
Force fan	2	52	2	2	6.1	Steel	0.24	208
Exhaust fan	2	52	2	2	6.1	Steel	0.24	208
Mine elevator	2	104	2	2	305	Steel	0.24	416
Subtotal								7,228
Number of full-time equivalents								3.5

[a] Source codes:
1 = Three months storage of UF_4 drums in receiving warehouse.
2 = Cumulative inventory of a single mine drift.

[b] Materials do not include walls between operating areas.

TABLE C.3 Mined-Cavity Disposal Facility: Operational Activities, 50% of Original Inventory — 55-Gallon Drums

Activity	Number of Workers per Station	Time per Operation (h)	Operations per Year	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Unload/inspect arriving pallet	2	0.25	4,688	1	0.9	Steel	0.13	2,344
Transfer pallet to warehouse storage	2	0.2	4,688	1	1.8	Steel	0.13	1,875
Transport pallet to transport bay	2	0.2	4,688	1	1.8	Steel	0.13	1,875
Load pallet on transport to disposal area	2	0.05	4,688	1	0.9	Steel	0.13	469
Decontaminate full drum exterior (0.1% of drums)	1	0.5	19	4	1.8	Steel	0.13	10
Warehouse storage surveillance	2	8	520	2	0.9	Steel	0.13	8,320
Building management	1	8	260	2	3.0	Steel	0.13	2,080
Security	1	2	1,095	2	4.6	Steel	0.13	2,190
Administration Building								
Building operations	6	8	260	2	49	Steel	0.13	12,480
Security	2	8	1,095	2	49	Steel	0.13	17,520
Support Facilities								
Ventilation operations	2	8	730	2	18	Steel	0.13	11,680
Security	2	2	1,095	2	244	Steel	0.13	4,380
Disposal Area – Mined Cavity								
Transport pallets to mine	1	1	670	3	1.8	Steel	0.13	670
Unload pallet from transport at mine	2	0.2	4,688	1	0.9	Steel	0.13	1,875
Load pallets onto mine transport	2	0.2	4,688	1	0.9	Steel	0.13	1,875
Transport pallets into mine	1	2	670	3	1.8	Steel	0.13	1,339
Unload pallet to disposal position	2	0.25	4,688	5	1.8	Steel	0.13	2,344
Disposal area surveillance	1	8	520	5	3.0	Steel	0.13	4,160
Disposal management	1	8	520	5	6.1	Steel	0.13	4,160
Security	1	2	1,095	5	15	Steel	0.13	2,190
Subtotal								83,835
Number of full-time equivalents								40.3

[a] Source codes:
1 = Single pallet with four UF_4 drums.
2 = Three months storage of UF_4 drums in receiving warehouse.
3 = 30-gallon drums: 12 pallets; 55-gallon drums: 7 pallets.
4 = Single UF_4 drum.
5 = Cumulative inventory of a single mine drift.

[b] Materials do not include walls between operating areas.

TABLE C.4 Mined-Cavity Disposal Facility: Maintenance Activities, 50% of Original Inventory — 55-Gallon Drums

Equipment	Number of Workers per Station	Hours per Component per Year	Number of Components	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Overhead crane	2	52	1	1	3.0	Steel	0.13	104
HVAC	2	520	1	1	3.0	Steel	0.13	1,040
HEPA	2	26	2	1	6.1	Steel	0.13	104
Dilute acid spray/rinse/drying system	1	52	1	1	18	Steel	0.13	52
Monitoring station equipment	1	26	4	1	0.9	Steel	0.13	104
Decontamination equipment	2	520	1	1	49	Steel	0.13	1,040
Administration Building								
HVAC	2	520	1	1	3.0	Steel	0.13	1,040
Support Facilities								
HVAC	2	520	2	1	49	Steel	0.13	2,080
Disposal Area – Mined Cavity								
Sump pump	2	52	8	2	3.0	Steel	0.13	832
Force fan	2	52	2	2	6.1	Steel	0.13	208
Exhaust fan	2	52	2	2	6.1	Steel	0.13	208
Mine elevator	2	104	2	2	305	Steel	0.13	416
Subtotal								7,228
Number of full-time equivalents								3.5

[a] Source codes:

1 = Three months storage of UF_4 drums in receiving warehouse.

2 = Cumulative inventory of a single mine drift.

[b] Materials do not include walls between operating areas.

TABLE C.5 Mined-Cavity Disposal Facility: Operational Activities, 25% of Original Inventory — 30-Gallon Drums

Activity	Number of Workers per Station	Time per Operation (h)	Operations per Year	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Unload/inspect arriving pallet	2	0.25	4,300	1	0.9	Steel	0.24	2,150
Transfer pallet to warehouse storage	2	0.2	4,300	1	1.8	Steel	0.24	1,720
Transport pallet to transport bay	2	0.2	4,300	1	1.8	Steel	0.24	1,720
Load pallet on transport to disposal area	2	0.05	4,300	1	0.9	Steel	0.24	430
Decontaminate full drum exterior (0.1% of drums)	1	0.5	18	4	1.8	Steel	0.24	9
Warehouse storage surveillance	1	8	520	2	0.9	Steel	0.24	4,160
Building management	1	8	260	2	3.0	Steel	0.24	2,080
Security	1	2	1,095	2	4.6	Steel	0.24	2,190
Administration Building								
Building operations	3	8	260	2	49	Steel	0.24	6,240
Security	2	8	1,095	2	49	Steel	0.24	17,520
Support Facilities								
Ventilation operations	2	8	730	2	18	Steel	0.24	11,680
Security	1	2	1,095	2	244	Steel	0.24	2,190
Disposal Area – Mined Cavity								
Transport pallets to mine	1	1	358	3	1.8	Steel	0.24	358
Unload pallet from transport at mine	2	0.2	4,300	1	0.9	Steel	0.24	1,720
Load pallets onto mine transport	2	0.2	4,300	1	0.9	Steel	0.24	1,720
Transport pallets into mine	1	2	358	3	1.8	Steel	0.24	717
Unload pallet to disposal position	2	0.25	4,300	5	1.8	Steel	0.24	2,150
Disposal area surveillance	0.5	8	520	5	3.0	Steel	0.24	2,080
Disposal management	0.5	8	520	5	6.1	Steel	0.24	2,080
Security	1	2	1,095	5	15	Steel	0.24	2,190
Subtotal								65,104
Number of full-time equivalents								31.3

[a] Source codes:
1 = Single pallet with four UF_4 drums.
2 = Three months storage of UF_4 drums in receiving warehouse.
3 = 30-gallon drums: 12 pallets; 55-gallon drums: 7 pallets.
4 = Single UF_4 drum.
5 = Cumulative inventory of a single mine drift.

[b] Materials do not include walls between operating areas.

TABLE C.6 Mined-Cavity Disposal Facility: Maintenance Activities, 25% of Original Inventory — 30-Gallon Drums

Equipment	Number of Workers per Station	Hours per Component per Year	Number of Components	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Overhead crane	2	52	1	1	3.0	Steel	0.24	104
HVAC	2	520	1	1	3.0	Steel	0.24	1,040
HEPA	2	26	2	1	6.1	Steel	0.24	104
Dilute acid spray/rinse/drying system	1	52	1	1	18	Steel	0.24	52
Monitoring station equipment	1	26	4	1	0.9	Steel	0.24	104
Decontamination equipment	2	520	1	1	49	Steel	0.24	1,040
Administration Building								
HVAC	2	520	1	1	3.0	Steel	0.24	1,040
Support Facilities								
HVAC	2	520	2	1	49	Steel	0.24	2,080
Disposal Area – Mined Cavity								
Sump pump	2	52	8	2	3.0	Steel	0.24	832
Force fan	2	52	2	2	6.1	Steel	0.24	208
Exhaust fan	2	52	2	2	6.1	Steel	0.24	208
Mine elevator	2	104	2	2	305	Steel	0.24	416
Subtotal								7,228
Number of full-time equivalents								3.5

[a] Source codes:
1 = Three months storage of UF_4 drums in receiving warehouse.
2 = Cumulative inventory of a single mine drift.

[b] Materials do not include walls between operating areas.

TABLE C.7 Mined-Cavity Disposal Facility: Operational Activities, 25% of Original Inventory — 55-Gallon Drums

Activity	Number of Workers per Station	Time per Operation (h)	Operations per Year	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours per Year
Product Receiving and Shipping Warehouse								
Unload/inspect arriving pallet	2	0.25	2,350	1	0.9	Steel	0.13	1,175
Transfer pallet to warehouse storage	2	0.2	2,350	1	1.8	Steel	0.13	940
Transport pallet to transport bay	2	0.2	2,350	1	1.8	Steel	0.13	940
Load pallet on transport to disposal area	2	0.05	2,350	1	0.9	Steel	0.13	235
Decontaminate full drum exterior (0.1% of drums)	1	0.5	10	4	1.8	Steel	0.13	5
Warehouse storage surveillance	1	8	520	2	0.9	Steel	0.13	4,160
Building management	1	8	260	2	3.0	Steel	0.13	2,080
Security	1	2	1,095	2	4.6	Steel	0.13	2,190
Administration Building								
Building operations	3	8	260	2	49	Steel	0.13	6,240
Security	2	8	1,095	2	49	Steel	0.13	17,520
Support Facilities								
Ventilation operations	2	8	730	2	18	Steel	0.13	11,680
Security	1	2	1,095	2	244	Steel	0.13	2,190
Disposal Area - Mined Cavity								
Transport pallets to mine	1	1	336	3	1.8	Steel	0.13	336
Unload pallet from transport at mine	2	0.2	2,350	1	0.9	Steel	0.13	940
Load pallets onto mine transport	2	0.2	2,350	1	0.9	Steel	0.13	940
Transport pallets into mine	1	2	336	3	1.8	Steel	0.13	671
Unload pallet to disposal position	2	0.25	2,350	5	1.8	Steel	0.13	1,175
Disposal area surveillance	0.5	8	520	5	3.0	Steel	0.13	2,080
Disposal management	0.5	8	520	5	6.1	Steel	0.13	2,080
Security	1	2	1,095	5	15	Steel	0.13	2,190
Subtotal								59,767
Number of full-time equivalents								28.7

[a] Source codes:
1 = Single pallet with four UF_4 drums.
2 = Three months storage of UF_4 drums in receiving warehouse.
3 = 30-gallon drums: 12 pallets; 55-gallon drums: 7 pallets.
4 = Single UF_4 drum.
5 = Cumulative inventory of a single mine drift.

[b] Materials do not include walls between operating areas.

TABLE C.8 Mined-Cavity Disposal Facility: Maintenance Activities, 25% of Original Inventory — 55-Gallon Drums

Equipment	Number of Workers Per Station	Hours per Component Per Year	Number of Components	Source[a]	Distance (m)	Material[b]	Thickness (cm)	Person-Hours Per Year
Product Receiving and Shipping Warehouse								
Overhead crane	2	52	1	1	3.0	Steel	0.13	104
HVAC	2	520	1	1	3.0	Steel	0.13	1,040
HEPA	2	26	2	1	6.1	Steel	0.13	104
Dilute acid spray/rinse/drying system	1	52	1	1	18	Steel	0.13	52
Monitoring station equipment	1	26	4	1	0.9	Steel	0.13	104
Decontamination equipment	2	520	1	1	49	Steel	0.13	1,040
Administration Building								
HVAC	2	520	1	1	3.0	Steel	0.13	1,040
Support Facilities								
HVAC	2	520	2	1	49	Steel	0.13	2,080
Disposal Area – Mined Cavity								
Sump pump	2	52	8	2	3.0	Steel	0.13	832
Force fan	2	52	2	2	6.1	Steel	0.13	208
Exhaust fan	2	52	2	2	6.1	Steel	0.13	208
Mine elevator	2	104	2	2	305	Steel	0.13	416
Subtotal								7,228
Number of full-time equivalents								3.5

[a] Source codes:

1 = Three months storage of UF_4 drums in receiving warehouse.
2 = Cumulative inventory of a single mine drift.

[b] Materials do not include walls between operating areas.