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MASTER

RHO-CD-810

PRELIMINARY CRITERIA FOR
SHALLOW-LAND STORAGE/DISPOSAL OF
LOW-LEVEL RADIOACTIVE SOLID WASTE
IN AN ARID ENVIRONMENT

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FORWARD

The burial of low-level radioactive solid waste has been practiced at various Department of Energy (DOE) sites for many years. Such operations have been the subject of recent studies by the former Energy Research and Development Administration (ERDA), United States Geological Survey (USGS), Environmental Protection Agency (EPA), Government Accounting Office (GAO), and several states. The Department of Energy established a steering committee on Development of Shallow Land Burial Technology for the purpose of (1) identifying and planning research and development efforts to solve burial ground problems, (2) developing national/uniform shallow land burial criteria, and (3) serving as an advisory and review group for proposals and programs designed to implement these activities.

One of the activities sponsored by the steering committee and contracted to Rockwell Hanford Operations (Rockwell) was the development of preliminary criteria for shallow land storage/disposal of low-level radioactive solid waste in an arid environment. The preliminary criteria, which addresses the significant parameters in the establishment and operation of a storage/disposal facility for low-level radioactive solid wastes, are the subject of this report and were developed based on inputs from the following sources:

- Literature review of solid waste burial
- Review of the regulations, standards, and codes pertinent to the burial of radioactive wastes
- On-site experience
- Evaluation of existing burial grounds and practices

The preliminary criteria itself was based on a topical outline which was concurred to by the Steering Committee.

In the initial phase of the program, an extensive literature and regulation review was carried out in the field of radioactive waste management. The results were documented in Rockwell Document RHO-CD-467 dated February 2, 1979, "Status Report - Summary of Regulation and Literature Review, Shallow Land Burial Practices for Storage/Disposal of Low-Level Radioactive Solid Waste in an Arid environment." This report was distributed to the Steering Committee at the February 1979 meeting at Tucson, Arizona.

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1.0 GENERAL

1.1 Appearance of Site

1.1.1 Site Planning

A Site Development Plan should be prepared to assure effective utilization of the site and orderly future site development. Site layouts should be developed in accordance with criteria for site development planning contained in DOE Manual Chapter 6203.*

1.1.2 Maintenance

Specifications should be developed for maintenance efforts on structures, grounds, systems and equipment relative to reliability, maintainability, and availability. The level of attention should be based on the importance of the function provided by the structure, system, etc., in providing isolation for the specified time.

1.1.3 Grounds

1.1.3.1 Land Management Plan

A Land Management Plan should be developed that would not only facilitate burial site operations, but would outline the maintenance, conservation, and improvement programs for grounds to increase the value of the land, prevent the waste and destruction of natural resources, protect property, and provide for the welfare of personnel. The plan should be consistent with the Site Development Plan and include the establishment of priorities for all ground development and improvement work.

* As part of the changeover from ERDA to DOE, ERDA Manual Chapters are being replaced by either transitory DOE Interim Management Directives (IMD's) or finalized DOE Order No's. From a consistency standpoint, this document identifies the ERDA/DOE requirements in terms of ERDA Manual Chapter No's. (Identified as DOE Manual Chapter No's.) In developing final criteria for shallow land storage/disposal of low-level radioactive solid waste, the latest DOE requirements should be reviewed and utilized. Note: reference to a DOE (ERDA) Manual Chapter includes its attendant Appendices.

1.1.3.2 Ground Categories and Maintenance Levels

- (1) The degree of maintenance required should be based on the operational status (active or inactive) for the following ground categories: improved, semi-improved and unimproved.
- (2) The degree of maintenance for each ground category and mode (active or inactive) should be governed by the required facility life, operational constraints, and protection of natural resources.

1.1.3.3 Landscape Development

- (1) Landscaping should provide for the creation and maintenance of a setting compatible with the location and type of facilities to be constructed.
- (2) The following landscaping practices and guidelines should be followed:
 - (a) Landscaping should be of an informal, practical design in keeping with the surroundings, and requiring a minimum amount of maintenance.
 - (b) Landscaping should be consciously used as an element in energy conservation design solutions, and recognized for its ability to create a comfortable and pleasing environment.
 - (c) Landscaping should be used for site stabilization during both active and inactive operational phases.

1.1.3.4 Groundskeeping, Control Measures (Stabilization) and Ground Maintenance

(1) Seeding, Fertilization, and Mowing

Grounds should be seeded, fertilized, and mowed, as required, to maintain a satisfactory vegetative cover for the control

of erosion and dust. Care should be taken in the selection of plants to preclude an uptake of radionuclides via the plant roots.

(2) Irrigation

Irrigation should be limited to that essential to establish and support vegetative cover required to prevent dust and erosion problems or prevent the loss of specified turf areas and landscape plantings. The amount of irrigation should be limited to that necessary to meet minimum growth requirements and should be prohibited in the burial grounds if there is a possibility that the irrigation could result in a migration of radionuclides from the storage/disposal modules (trenches).

(3) Plant, Dust, Drainage, and Erosion Control

Weeds, poisonous plants, dust, and drainage should be controlled as needed to facilitate efficient site operations, reduce personnel hazards, and minimize land erosion.

(4) Debris Removal

Debris from construction and maintenance operations such as litter, flora (e.g., tumbleweeds around buildings and fences) should be removed promptly. The debris should be monitored to detect radioactive contamination.

(5) Stored Materials

Stored material and equipment should be properly segregated and/or stacked to enhance site appearance. Buildup of stored items should be precluded by proper disposal at regular intervals.

1.1.4 Roads, Parking Facilities, and Railways

- (1) Roads should be minimized by functional orientation of buildings and by simultaneous development of the site layout in conjunction with the building plan.

- (2) Parking areas should be designed and constructed to facilitate operations.
- (3) Maintenance specifications for roadways, walks, parking facilities, and railway systems (especially roadbeds, crossings, and signals) should be established and enforced to meet operational, safety, and radiological requirements.

1.1.5 Structures

1.1.5.1 Internal Building Service Design (Utilities, etc.)

- (1) Building services should minimize life cycle costs of operation and maintenance. Central locations shorten servicing runs and provide economies in both construction and operation.
- (2) Service line design criteria should specify common conduits (consistent with safety); accessibility for maintenance; and arrangement with minimum concealment.

1.1.5.2 Outside Services Design Considerations

- (1) Service facilities (e.g., water, electrical substations, and communications centers) should adhere to national codes and be located so as to minimize length and size of distribution lines. Hazard factors, thermal energy losses and life cycle costs should be considered. The criteria of DOE Manual Chapter 0270 should be used for telecommunications systems.
- (2) Adequate lighting should be provided to facilitate operations, surveillance, and security after dark. This should include mobile lighting for emergency and/or search activities.

1.1.5.3 Maintenance of Structures

- (1) Buildings and other ground structures should be maintained such that functions are not impaired. Maintenance levels, hence site appearance, will vary depending on the anticipated usage of the particular structure.

- (2) Maintenance programs should specify conditions to be maintained relative to housekeeping. Care should be exercised to preclude an accumulation of debris, excess equipment, parts, etc. in out-of-the-way locations (see 1.1.3.4(4).
- (3) Building custodians should enforce housekeeping practices within the areas of their responsibility and around the building grounds.

1.1.6 Inspections

Periodic site facility inspections should be conducted to (1) measure compliance with facility operational requirements (e.g., radiological and occupational safety), (2) assess conditions which indicate need to revise operational requirements and (3) provide recommendations for revising modes of operation to conserve energy. The frequency and focal points of these inspections should be based on results of feedback on operations and changes in relevant policy.

1.2 Compliance and Appraisals

An effective management system should be established that will formulate and implement the necessary policies and procedures to ensure compliance with applicable regulations, codes, standards, etc. Twelve programs which support safe, effective management and operations should be implemented. These are outlined in 1.2.1 through 1.2.12 below.

1.2.1 Quality Assurance Program

An effective Quality Assurance program should be established that would incorporate the necessary planning and systematic actions to provide adequate assurance that all functions will be performed in a satisfactory manner. The level of quality assurance effort should be commensurate with the importance of the function to be controlled. This would include the establishment of procedures to assure that appropriate codes, regulations, and standards for all

burial site operations are identified and implemented. Quality Assurance requirements should be developed for the following specific site functions in accordance with DOE Manual Chapter 0820 (RDT F2-2 and ANSI N45.2 are other source documents)

- (a) Design and Development
- (b) Procurement
- (c) Manufacturing, Fabrication, and Assembly
- (d) Construction and Installation
- (e) Operation, Maintenance, and Site Modification

1.2.2 Medical Program

Contractor employees should be assured of an adequate occupational medical program. The program should be dedicated to the principle of maintaining and protecting a healthy balance between man's internal environment (physiological/psychological requirements) and his external environment. Impact upon fellow workers, facilities/sites, the public at large, and the general environment should be taken into account as well as the effects of the work environment upon the health and safety of the individual worker. The program should comply with DOE Manual Chapters 0507 and 0528.

1.2.3 Construction Safety Program

The construction safety program should require contractors and subcontractors to provide safe and healthful working conditions for their employees and to maintain injury, property damage or loss, and environmental risk levels as low as practicable in construction activities. The program should include safety review procedures for each construction project undertaken, including provisions for approval of construction changes from a safety standpoint. The program should comply with:

- DOE Manual Chapters 0505 and 6101
- CFR, Title 29, Part 1926 as applicable.

1.2.4 Occupational Safety and Health Program

An occupational safety and health program should be implemented that will provide contractor employees with safe and healthful working conditions in accordance with the standards prescribed pursuant to the Atomic Energy Act of 1954, as amended, and the Energy Reorganization Act of 1974, which standards shall be at least as effective as those promulgated under the Occupational Safety and Health Act of 1970. The program should comply with DOE Manual Chapters 0506 and 0550.

1.2.5 Nuclear Criticality Safety Program

A nuclear criticality safety program should be instituted such that the processing, handling or storage of fissionable materials is conducted in such a manner that the probability of an accidental chain reaction is very low, and the protection of personnel and property against damaging effects and undue hazards that may arise from a criticality accident is assured. The program should comply with DOE Manual Chapter 0530.

1.2.6 Radiation Protection Program

A radiation protection program should be established to assure that radiation exposure to individuals and population groups is limited to the lowest levels technically and economically practicable. The program should comply with DOE Manual Chapters 0510, 0511, 0524, 0525, and 0545. The Code of Federal Regulations, Title 10, Part 20, should be used as applicable.

1.2.7 Fire Protection Program

A fire protection program should be implemented to assure that fires and related perils will not result in hazardous exposure to the public and employees, unacceptable impairment of programs, or damage to or loss of property beyond a specified amount. The program should comply with DOE Manual Chapter 0552.

1.2.8 Security Program

A security program should be established to safeguard the storage/burial site with appropriate means to protect the public safety, protect classified and/or special nuclear material, and to generally preclude acts of vandalism, theft, diversion, arson, or sabotage. The security program should meet the requirements of DOE Manual Chapters 2401, 2405, and 2406.

1.2.9 Emergency Planning, Preparedness and Response Program

An emergency planning, preparedness and response capability should be developed and maintained to provide for the protection of people, property, and the environment, and to minimize the total damage in emergency situations. The program should comply with DOE Manual Chapter 0601.

1.2.10 Notification, Investigation and Reporting of Occurrences

A program should be initiated to assure that timely notification of occurrences are made to responsible authorities; that all occurrences are investigated; that reports are submitted to responsible individuals; that management take responsive corrective action, and that there be consistency in the treatment of each occurrence. The program should comply with DOE Manual Chapter 0502.

1.2.11 Environmental Monitoring and Reporting

Monitoring and evaluation should be performed on on-site releases, liquid and airborne effluents, and the site environment to assess the levels of radioactivity and non-radioactive pollutants, as appropriate, to determine:

- Compliance with standards and policies, and
- The adequacy and effectiveness of effluent treatment and control, environmental protection and efforts to achieve levels of radioactivity which are as low as practical.

The program should comply with DOE Manual Chapter 0513.

1.2.12 Appraisals

Appraisals should be made of program performance. The objectives of each appraisal should be to:

- Determine that policies are interpreted and implemented correctly.
- Evaluate the effectiveness of the implementation of policies and standards.
- Provide management with timely and reliable information as to performance, including significant achievements and deficiencies.
- Provide management with recommendations, where appropriate, for improvement of programs.
- Provide management with input on changes in public policy which may impact operation.

The program should comply with DOE Manual Chapter 0502 (with Appendix).

2.0 FACILITIES

2.1 Site Selection

Site selection requires thorough investigation and study to assure meeting all program requirements with careful consideration given to safety and economy. The site selection process should comply with DOE Manual Chapter 6202, and should recognize the established lifetime during which the site would operate under administrative control. This lifetime may vary according to the type of waste and site characteristics. The site (facility) design should consider two situations which can add to exposure: chronic and acute releases. Site selection should be based on qualitative and quantitative assessments of site characteristics, integrated with engineered facility features and should include a risk assessment. The following major site parameters should be considered:

2.1.1 Meteorology and Climatology

Meteorology and climatology should be considered as they affect the design, construction and operation of the burial site. The following criteria are suggested in this regard:

- (1) The maximum annual precipitation (based on historic records) should be such that moisture will not penetrate burial cover. Frequency, duration, and intensity of precipitation events should be evaluated to determine likelihood of flash flooding and erosion.
- (2) Allowable surface winds for burial operations should be specified to minimize the chance of ground cover erosion and airborne dispersal of radionuclides.
- (3) Atmospheric conditions in the vicinity of the site should be such that airborne effluents are dispersed within acceptable limits of DOE Manual Chapters 0510 and 0524.

2.1.2 Hydrology

Migration and migration rates for radionuclides in soil are related to surface and subsurface water distribution movement. These migrations effect site selection and site facility engineering requirements. Frequency, duration, and intensity of precipitation and evaporation cycles effect the distribution and movement of surface and subsurface water.

The following criteria apply to site selection activities in support of facilities designs:

- (1) The geologic area under consideration should meet the following definition of "arid":

"Arid - A climate characterized by dryness, variously defined as rainfall, insufficient for plant life or crops without irrigation; less than 10 inches of annual rainfall; or a higher evaporation rate than precipitation rate." (Reference 30)
- (2) The following hydrological criteria should be quantitatively assessed to develop transport data on radionuclides. The sample sizes, collection period, and sample techniques should be commensurate with precision and accuracy requirements for the data.
 - (a) The minimum distance to the nearest surface water streams should be based on likelihood of flooding.
 - (b) The minimum distance from the bottom of a burial trench to the highest level of groundwater table fluctuations should be established based on the radionuclide migration rates in the soil, the migration rates of groundwaters and the half life of radionuclides.
 - (c) The migration rate of groundwater should be such that the time required for leached radionuclides to reach the water table allows for decay to innocuous levels.

- (3) Radioactive waste should have the following chemical properties to retard radionuclide migration:
 - (a) Cation properties (if possible)
 - (b) Low salt concentration
 - (c) Neutral to slightly alkaline pH.
- (4) The minimum distance from the site boundary to any burial trench should be established based on expected radionuclide migration rates.
- (5) The soil should be a composition which permits percolation of water at the determined rate for the specific site. Composition should allow for cation exchange with the radioactive waste.
- (6) Arid or semi-arid areas which are subject to incidences of flooding or overflow from rivers, streams, or lakes within the specified life of the facility should not be considered acceptable locations.
- (7) To preclude radionuclide migration to the biosphere via evapotranspiration, (1) the waste should be buried at an appropriate depth (based on the evapotranspiration characteristics of the particular site), or (2) suitable engineered barriers should be constructed.

2.1.3 Geology

2.1.3.1 Geological stability, stratigraphy, and seismicity are the key factors in determining suitability of a site from a geological standpoint. Where natural conditions are not optimum, facilities design will have to compensate if the site is to be used. The following geological criteria should be assessed:

- (1) The minimum overburden thickness should be determined as a function of the burial depth, vegetation rootings, wind erosion, evapotranspiration, and precipitation.

- (2) The covering over a burial facility should be sloped to promote drainage.
- (3) The existence of a flood plain zone (even if rare), or stream and rivulet channels showing visible water erosion, should be analyzed relative to the use of the location as a burial site.
- (4) The storage/burial site should not be located at or near a seismic source area for macro earthquakes and/or where displacement along a fault or liquefaction of the soil could cause adverse effects upon the site.

2.1.3.2 The geological characterization techniques, methods, number of samples and evaluation techniques should represent accurate and precise processes and instrumentation.

2.1.4 Demography

Demography is an important parameter relative to an unfavorable population shift towards prospective burial sites. The following site criteria are recommended:

- (1) The initial population and density in the vicinity of the site should be low and the site removed from major population centers.
- (2) There should be a lack of existing industry and the site should be unfavorable for future industrial expansion.
- (3) The site should be unsuitable for agriculture.
- (4) The site should be devoid of useful or potentially valuable mineral deposits or other natural resources.
- (5) The site should not be conducive to real estate development.
- (6) There should be an absence of any special environmental attractiveness, such as spectacular scenery, unique flora or fauna, or high recreation potential.
- (7) The regulating agency should monitor the activities of other agencies whose decisions effect demographic characteristics.

2.1.5 Biota

Plant and animal life should be evaluated in terms of their ability to reach and/or concentrate and transport radionuclides to the surface and bring them into contact with man. The following criteria regarding biota is recommended:

2.1.5.1 Flora

- (1) Deep rooting species of plants which can reach the buried waste and assimilate radionuclides should be identified and replaced with shallow rooted types which would have the ability to successfully compete with and exclude the deep rooting species.
- (2) Strips of natural vegetation should be left or returned between modules to serve as windbreaks to reduce wind erosion of the disturbed module (trench) surfaces.
- (3) Where deep rooting species cannot be eliminated, appropriate engineering barriers should be constructed or the burial module constructed deeper than the maximum root penetration.

2.1.5.2 Fauna

- (1) Burrowing mammals, insects, and reptiles should be identified as well as their worst case burrowing and/or tunneling habits.
- (2) To preclude fauna intrusion into the buried radioactive waste, either (a) appropriate engineering barriers should be constructed, or (b) the burials should occur at depths greater than worst case tunneling habits, or (c) a combination of (a) and (b).

2.1.6 Archeological/Historical Sites

Archeological and historical sites should be preserved as outlined in the Code of Federal Regulations, Title 43, Part 3 - Preservation of American Antiquities.

2.2 Engineered Structures

The burial site will contain engineering structures involving design, fabrication, and construction work efforts. The purpose of engineering structures is to augment the isolation capacity of the specific site given a required isolation time. Structures should provide barriers to mitigate or protect against natural phenomena, incursions by animals, plants, microorganisms, unauthorized human entry and accident events. The structures, with maintenance, should function reliably for the specified lifetime of the facility.

2.2.1 Integrating Overall Site Requirements

Proper integration of site needs is necessary in establishing and maintaining an effective operational burial site and should include items such as:

2.2.1.1 Climate, Meteorological and Biota Control

- (1) Barriers to infiltration of rain and surface water such as the following should be considered:
 - (a) Water drainage and/or diversion in the form of structures and/or special backfill and soil configuration.
 - (b) Anti-precipitation shelters or buildings.
 - (c) Artificial barriers such as module covers which absorb or disperse moisture.
 - (d) Artificial barriers which repel burrowing animals.
 - (e) Selective replacement of deep rooting flora which can invade buried waste, assimilate radionuclides and transport them to the biosphere.

2.2.1.2 Seismic, Accident Design

- (1) The following natural phenomena or accidents, given the specified life of the facility, should be considered:

- (a) floods due to unusual precipitation or natural impoundment
 - (b) earthquake
 - (c) volcano
 - (d) geothermal
 - (e) tornadoes, windstorms.
- (2) Accidents involving inadvertant intrusion - air crashes, surface vehicles, meteors, orbiting devices.

2.2.1.3 Protection from Human Intrusion

- (1) Non-war related civilian or military.
- (2) Vehicular - intentional and unintentional.
- (3) Positive physical barriers and signs in appropriate language(s).

2.2.2 Designing for Waste Form

The waste streams, where possible, should be identified and characterized prior to site selection and facility design criteria development. Barriers to contain radioactivity are constrained by retrievability and shielding considerations. In this regard the following criteria are recommended:

2.2.2.1 Waste Characterization

Waste characterization should preceed final site selection and design criteria for engineered facilities. Radiological, physical, chemical, toxicity, pyrophoric, and volume and mass characteristics are constraints to the site and site facilities. Waste characterization would include items such as:

- (1) Transuranic waste (waste containing 10 nCi/gr transuranic materials) should be segregated from other radioactive waste.
- (2) Half lives for radionuclides and fission products to be disposed of by burial should be determined.
- (3) The waste should be compatible with the package design, package facility interface, and required isolation time.

- (4) The following waste characteristics should be assessed to determine material segregation limits:
 - (a) Gas generation from the standpoint of pressure, fire, release, and toxicity.
 - (b) Organic versus non-organic compounds.
 - (c) Combustible versus non-combustible materials.
 - (d) Poisonous, carcinogenic or highly toxic materials or compounds in other than radiological manner.
 - (e) Chemical species and complexants.
- (5) The size and weight of packages should be determined to assess compatibility with:
 - (a) The containment systems
 - (b) Material handling equipment
 - (c) Storage/disposal space envelopes
 - (d) Special environmental conditions such as cooling, non-oxidizing.
 - (e) Retrievability requirement criteria.

2.2.2.2 Barriers to Contain Radioactivity

There are three functional areas relating to barriers which prevent or inhibit the transport of radionuclides to the biosphere:

- Waste package and/or burial containers.
- Burial facility design.
- Waste form (i.e., liquids, gaseous, vitrified, etc.).

Criteria regarding barriers are as follows:

- (1) Waste containers should be suitable for material handling and transportation prior to burial per DOE Manual Chapter 0529.

- (2) Burial facilities should provide the necessary containment to ensure that dispersal of radionuclides occurs only within the specified zone.
- (3) Radioactive wastes, especially liquids, gases, and unstable solids should be converted to stable forms (physically and chemically). The selected forms should:
 - (a) Resist breakdown such that transport of hazardous fractions in air and aqueous media does not occur.
 - (b) Limit potential chemical interactions which would increase radionuclide mobility.

The combination of barriers should function until the radionuclides decay to acceptable levels for release to the environment.

2.2.2.3 Designing for Permanent Disposal

Two areas are important to designing for permanent disposal, namely;

- Burial module design, construction, and backfilling.
- Burial container design and use limitations.

(1) Burial Modules/Subsurface Facilities

- (a) Burial modules/subsurface facilities should adhere to the criteria in 2.1.
- (b) Facility material selections should function to provide positive containment.
- (c) Construction methods should be selected so as to minimize the degradation of the barrier qualities of existing geological structures.
- (d) Backfilling should occur to produce the following conditions:
 - Earth cover on beta-gamma modules to meet ALAP (as low as practical) Specifications and be below the biological migration.

- Prevention of contamination spread.
 - Shielding to meet ALAP Specifications for the site.
 - End-of-day covering of combustibles or wind dispersables if an engineered all-weather facility is not available.
 - TRU modules should require an amount cover based on site selection data from 2.1.
 - Final cover should reduce surface dose rate to ALAP.
- (e) Vegetative or other coverings of filled modules should be accomplished to prevent wind and water erosion, and inhibit biological transport systems. .
- (f) Module covers and backfill should not sink or slump in any way which would disturb or alter any barrier.

(2) Containers

- (a) The following container design parameters should be addressed over the expected service life and conditions.
- Economy of space utilization.
 - Prevention of contamination spreads.
 - Pressure differentials between inside and outside.
 - Module collapse.
 - Thermal effects - external and/or internal.
 - Waste characteristics. .
 - Moisture.
 - Initial and in service inspections and tests.
 - Material corrosion and corrosion rates.
 - Standardization and compatibility with facility and material handling constraints.

- (b) Where a container of hazardous materials could react with the contents of an adjacent container, given an unplanned release, the minimum spacing of earth or earth substitute between adjacent containers should be determined. Failure Mode and Effects Criticality Analysis (FMECA) is a useful technique to determine the minimum spacing.

2.2.2.4 Designing for Retrievable Storage (TRU Waste)

Criteria for retrievable storage should address the following four categories:

- Container design.
- Storage module facility design.
- Administrative controls.
- Expected retrieval period.

2.2.2.5 Container Shielding

- (1) Shielding should be provided for disposal or storage of waste to keep exposure to within ALAP limits for the facility.
- (2) Shielding design should be such that handling, transportation, credible accidents, or storage/disposal methods will not result in loss of shielding.

2.2.2.6 Projected Life Requirements

Service life requirements for non-transuranic waste are different from those for transuranic waste.

(1) Non-Transuranic Waste

- (a) The container should permit secure isolation, from loading through transportation, handling and burial.
- (b) Shielding should be commensurate with ALAP exposure regulations for the facility.

- (c) The container, as part of the radiological containment/isolation barrier should not compromise specified lower limit on migration of radionuclides to groundwater or the biosphere (see 2.1.5, 2.2.2.2, and 7.1).

(2) Transuranic Waste

- (a) The criteria of (1)(a) and (1)(b) above should apply relative to storage.
- (b) The container should retain structural containment and/or shielding integrity through the specified time limit for retrieval, handling, transport, and possible reprocessing or storage.

2.2.3 Compliance with Standards, Codes

Engineering structures should comply with applicable chapters of the DOE Manual, such as those related to environmental, safety and health, construction, and maintenance - to include the referenced specifications, standards and codes contained within the chapters, and also other applicable industry standards. (Reference Section 1.2 this criteria.)

2.2.4 Decontamination and Decommissioning (D&D)

Decontamination and decommissioning considerations should be integrated into the design of engineering structures from a safety and cost effectiveness standpoint.

2.3 Land Use

Optimizing land use value should be a basic objective. Criteria should address the following and take into account both long and short term circumstances:

- Burial site and structure.
- Support facilities and structures.
- Transportation systems.
- Burial ground land use.

2.3.1 Enclosures for Burial Sites and Structures

- (1) Security fences should surround burial sites as required by safeguards.
- (2) Perimeter fencing should be lighted such that movement of persons or larger animals is visible.
- (3) Fence roads should be provided for security patrol purposes.

2.3.2 Support facilities and structures should provide the following:

- (1) Non-radiation related
 - (a) Administrative buildings
 - (b) Waste inventory record keeping facility
 - (c) Operations facility
- (2) Radiation related
 - (a) Change rooms
 - (b) Personnel monitoring installations
 - (c) Decontamination facility
 - (d) Laboratories facilities for sampling and routine analysis.
 - (e) Temporary storage facilities to accomodate large shipments prior to burial.
- (3) Plant protection facilities as required to support fire and security systems as well as any electronic monitoring (surveillance) functions which may be required.

2.3.3 Transportation Systems

Transportation systems should meet the following criteria:

- (1) Roads should serve all areas in the burial grounds. Surfacing should be suitable for the specified service requirements.
- (2) Rail access should be provided into burial ground disposal areas.

- (3) Unloading facilities should interface with access system to and within the site as follows:
 - (a) Off-load from rail, air, barge or highway vehicle.
 - (b) Handle largest and heaviest expected containers.
- (4) Site facilities and equipment should be capable of handling and transporting the largest and/or heaviest expected containers.
- (5) Site facilities should include appropriate receiving areas for shipments arriving outside of normal working hours.

2.3.4 Burial Grounds Land Use

- 2.3.4.1 Waste volume per unit burial area should be maximized and involve the following:

- (1) Optimize module or facility depth per unit area
- (2) Maximize number of containers per unit volume space.
- (3) Provide incentives for waste generator to minimize waste volume and radiation level.

- 2.3.4.2 Distances between burial or storage facilities should be minimized by taking the following actions:

- (1) Determine constraints imposed by criticality limits.
- (2) Determine constraints based on location of radionuclide migration fronts.
- (3) Develop policy for assaying various classes of waste to minimize area needs.

2.3.4.3 Module Closure and Stabilization

A comprehensive plan should be prepared for module closure and stabilization (see Section 7).

3.0 TRANSPORTATION

An effective transportation and traffic management system should be established to provide efficient, economical, and safe transportation of radioactive waste; develop new and improved shipping methods and procedures; and promote more efficient utilization of shipment containers.

3.1 Traffic Management

3.1.1 Compliance with Transportation Laws and Regulations

Shipments should be made in compliance with all applicable international, Federal, state, and local regulations.

3.1.2 Administration

The administrative aspects of radioactive waste transportation should follow the guidelines set forth in DOE Manual Chapter 5201.

3.2. Packaging Operations for Transportation

To provide protection of the public health and safety, radioactive materials should be packaged and prepared for shipment in compliance with the requirements of DOE Manual Chapter 0529.

3.3 Transportation Operations

3.3.1 Security

Radioactive waste shipments, classified or unclassified, should be provided with physical protection against theft, pilferage, burglary, hijacking, sabotage, and vandalism as outlined in;

- DOE Manual Chapter 5201, Appendix, Part IV, Paragraph C
- DOE Manual Chapter 2401
- DOE Manual Chapter 2405

3.3.2 Inspection of Vehicles and Packages for Damage and Leakage

Packages of hazardous materials should be inspected promptly upon receipt for damage, evidence of leakage, or noncompliance with regulations to assure that public exposure to contamination will be identified and appropriate action can be taken. The procedures outlined in Paragraph E, Part IV, Appendix to DOE Manual Chapter 5201 should be followed.

3.3.3 Labeling of Hazardous Materials Packages

3.3.3.1 Labels

Labels should be of such quality and applied in such a manner as to assure that they will survive the normal handling and exposure to weather that may be encountered during the transport cycle. Transuranic labels should meet the storage and retrievability life requirements. DOT labeling requirements should also be met.

3.3.3.2 "Empty" Containers

Freight classification for and requirements governing the shipment of "empty" containers, including the use of "EMPTY" labels, should be in accordance with Paragraph G.4, Part IV, Appendix to DOE Manual Chapter 5201. This includes items such as clean, empty casks, internally contaminated casks, and uranium shielded casks.

3.3.4 Radiation Levels - External Surfaces of Vehicles

The maximum permitted radiation levels relative to the external surface of the car or vehicle should be in accordance with DOT regulations (49 CFR 173.393 (j)). Facilities should be available to decontaminate the vehicles to these levels.

3.3.5 Safety

Shipments should be made in a manner which will afford protection of personnel and public health and safety and meet Federal, State, and local regulations, particularly DOT regulations (e.g., CFR Title 49, Parts 171 through 177). The International Atomic Energy

Agency (IAEA) Safety Series No. 6 (Regulations for the Safe Transportation of Radioactive Materials), and Safety Series No. 37 (IAEA Transport Regulations) should be used as a guide, where applicable.

3.3.6 Schedules

Transportation schedules should be arranged and be sufficiently flexible to minimize potential hazards that could arise during the shipment of radioactive waste. For example:

- Shipments should be made where possible during periods of low traffic density to reduce the risk of accidents.
- Alternate routes should be planned in the event of adverse weather conditions or roadway blockage.
- Heavily populated areas and major watersheds should be avoided.
- Estimated Time of Departures (ETD) and Estimated Time of Arrival (ETA) check points should be established.

3.3.7 Personnel Training

Personnel should receive training in the skills required to ensure safe receiving and unloading of radioactive waste. Such training should include:

- Documented review courses on DOT shipping regulations.
- Efficient operation of and safety practices associated with equipment for handling and transporting radioactive waste packages.
- Emergency procedures for credible accident situations.
- Radiation protection training.

3.3.8 Equipment

Only equipment which meet reliability and capacity specifications should be used for loading, transporting, and unloading radioactive waste packages.

3.3.9 Transfers Between Different Modes of Transportation

Adequate and safe interface facilities should be provided for the transfer of radioactive waste packages between different modes of transportation.

3.4 Maintenance of Transportation Equipment

3.4.1 Maintenance of railroad trackage and road pavements should be established to maintain a specified level of performance.

3.4.2 Adequate rail and truck equipment should be provided and maintained (efficiently and economically) to assure:

- Continuity of burial site operations.
- Protection of life and property from credible accidents.

4.0 OPERATIONS AND ADMINISTRATION

4.1 Management

Management of radioactive wastes, including the development of a waste management plan, should meet the requirements of DOE Manual Chapter 0511 with Appendix (Parts I and II), to assure safe long-term management of radioactive waste in such a manner as to minimize the radiation exposure and associated risk to man and his environment.

4.2 Control of Operations

Site operations should be controlled by the development and implementation of effective operating procedures meeting applicable requirements. In this regard the following should be established:

- Mandatory review and approval mechanisms for procedures.
- Review, analysis, and corrective actions for anomalous occurrences.
- A review committee to assess and evaluate operations and operating procedures.
- Procedure departure provisions for unexpected and unplanned deviations.
- Emergency procedures to include 24-hour communications contact.

4.3 Operational Personnel

4.3.1 Operating and Emergency Procedure Training

A formal training program should be established for operating personnel to ensure the safe operation of the burial site. This would include training in both routine (operational) and emergency procedures.

4.3.2 Radiation and Safety Training

4.3.2.1 A formal Radiation and Safety training program should be established for site personnel. The purpose of the program should be to minimize radiation accidents by prevention, rather than in supervision of appropriate remedial measures after an occurrence.

Worker Training and Retraining programs should meet the following criteria:

- (a) Should familiarize the worker with the fundamentals of health physics and radiation exposure.
- (b) Should be modified, as necessary, to reflect changes in practices.
- (c) Should be conducted at sufficient frequencies to ensure worker proficiency.
- (d) Radiation safety training should address the following:
 - Principles of design, operation and plant maintenance, equipment, and experimental apparatus.
 - Potential problem areas from a radiological viewpoint.
 - Basic characteristics of radiation and contamination.
 - Methods (procedures - equipment) for exposure and contamination control.
 - Basic understanding of biological dose and methods of assessment.
 - Emergency procedures and systems.
 - Mask fit and training.
- (e) Equipment and facility instruction should be covered.
- (f) Training programs in operating procedures should be conducted on a scheduled basis.

- 4.3.2.2 Supervisory personnel should have a good understanding of the radiological characteristics and potential safety problem areas associated with their area of responsibility, including all training elements. This would permit a proper assessment of the adequacy of controls in their program area.

4.3.3 Radiation Exposure History

Operations should be conducted in such a manner as to ensure an individual's exposure history does not exceed the limits set forth in DOE Manual Chapter 0524.

4.4 Waste Form Acceptance Criteria

4.4.1. Waste Classifications

The following waste classifications should be recognized and handled accordingly:

4.4.1.1 Nonradioactive Solid Waste

Criteria for definition of nonradioactive solid waste should be based on measurement limits for airborne, smearable/nonsmearable contamination, and specific activity per unit waste material.

4.4.1.2 Radioactive Solid Wastes

Material with detectable radioactivity and/or specific activity greater than the lower limits should be considered radioactive.

4.4.1.3 Transuranic Solid Waste

Transuranic (TRU) solid radioactive waste is defined as containing 10nCi/g or greater of transuranic contamination. This material should be segregated from other waste for retrievability and stored in designated areas. The packages and storage conditions should be such that the packages can be readily retrieved within a 20 year period and transported in an intact contamination-free condition to an offsite repository. These wastes should be segregated into modules, with packages containing combustible materials separated from packages containing noncombustibles.

4.4.2 Contents of Waste Packages

The following acceptance criteria should govern the contents of waste packages.

For waste package contents not described below specific site management approval should be obtained. In this regard acceptance criteria should be based on potential hazards to personnel and the environment.

4.4.2.1 Incompatible Materials

Materials which are incompatible (e.g., those which could react spontaneously and vigorously or possibly explode in combination, such as organics and HNO_3) should not be packaged in the same container. Oxidizing materials should not be packaged with combustible wastes or in combustible containers.

4.4.2.2 Poisonous Materials

Compounds of beryllium, mercury, arsenic, cadmium, selenium, silver, and fluoride including oxides, are poisons. Therefore, solid waste containing these compounds should be packaged per DOT requirements (Title 49 CFR), double contained, sealed, and labeled for each appropriate hazard.

4.4.2.3 Alkali Metals

Alkali metals should be reacted to an inert form. Unreacted alkali metals should not be accepted.

4.4.2.4 Solid Waste to be Dry

Solid radioactive waste should be essentially dry, i.e., no free liquids. Damp waste should be packaged in an inner waterproof container so that the moisture is contained and the integrity of the outer container is not jeopardized during transit, storage, and burial operations.

4.4.2.5 Aqueous Liquids

Liquids in waste for disposal should be mixed with inert absorbent materials to preclude gas generation, spontaneous combustion, or explosion, and also to prevent migration of the liquid if the container is broken.

4.4.2.6 Flammable Liquids, Pyrophorics, Explosives and Acids

Flammable liquids, pyrophorics, explosives, and acids should be prohibited.

4.4.2.7 Smearable Contamination

Waste associated with smearable contamination should be stabilized or contained in the package so the outer surface of the container remains free of smearable contamination during transport and during placement into burial sites.

4.4.2.8 Minimizing Waste

The waste generator/shipper should direct technical and administrative efforts toward a reduction of the gross volume of solid waste generated, and the amount of radioactivity in such waste. Volume reduction technology should be adapted for use with radioactive solid waste whenever practical.

4.4.2.9 Radioactive Contaminated Toxic Waste

The acceptance of hazardous or toxic waste in combination with radioactive waste should require special approvals by the site management. Containers of toxic waste should be labeled as to contents, container inventory and hazard.

4.4.2.10 Organic Liquids

Organic liquids, free or absorbed in unstabilized form, should not be acceptable. Animal carcasses should be considered organic liquids, hence, should not be acceptable unless special provisions are made.

4.4.2.11 Waste Density

Waste density should be such that module (trench) sinking or slumping is minimized.

4.4.2.12 TRU Waste Combustibility

Combustible transuranic solid waste should be segregated, packaged, and stored separately from noncombustible waste. Plastic wrapping for contamination control around noncombustible material should be considered noncombustible.

4.4.2.13 Storage of Gas Generating Solid TRU Waste

Virtually all radioactive wastes, organics such as papers, rags, and plastics, and nonorganics such as cement and water can produce gas through decomposition by radiolysis, pyrolysis, chemical reactions, or bacterial decay. Materials which generate very small amounts of gas over a long period of time, such as cement (when used as a shield) should not be considered gas generators. However, cement mixed with some types of contamination (e.g., alpha) may generate large quantities of gas. Others, such as oxidizing materials, generate significant amounts of gas during their decomposition process that may eventually build up pressure in the containers. The accumulation of certain gases such as H_2 , NO_x , O_2 pose the threat of exploding or corroding away the containers, either of which endangers safety and environment. To minimize such occurrences, the following requirements should apply.

- (1) Decision criteria distinguishing between acceptable and unacceptable categories should be established for known gas generating waste.
- (2) The generator/shipper should present a logical technical analysis to show that the waste is acceptable in (1) above.
- (3) The waste which is in the non-acceptable category may be accepted by site management under special container and packaging conditions.

- (4) The site management should have the option of approving, disapproving, or recommending modifications to the waste package for acceptable disposal.

4.4.3 Criticality Considerations

4.4.3.1 Fissile Material Restrictions

Container size/configuration, should be subjected to criticality analysis given the fissile material to be stored. Storage arrays should be evaluated using criticality analysis techniques to provide operating specifications.

4.4.3.2 Storage of Transuranic Waste

Criticality requirements are identified in Section 6.6.

4.4.3.3 Disposal of Nontransuranic Waste

Uranium, except ^{233}U , should be allowed to be buried in non-transuranic modules. The amount of uranium which may be buried in a single module should be specified. The following is an example from Rockwell Hanford Operations:

<u>Maximum Enrichment</u> <u>Percent ^{235}U</u>	<u>Maximum Amount</u> <u>Kilograms Uranium (total)</u>
0.71	No Limit
1.8	45
2.5	25
5.0	7.8
10.0	3.0
Fully	0.18

Each module or fraction thereof at the end of a day should be covered by the specified amount of earth or earth substitute.

4.4.4 Labeling

Packages accepted for storage or disposal should meet label and identification specifications. This ensures that proper methods of handling, shipping, storage, and disposal will be used. Packages containing transuranic materials should be labeled with a number assigned by the burial site so that the waste can be identified by cross reference to permanent records, and thus assist in future identification for retrieval and handling purposes. Labeling of TRU waste should be such that it can be read a minimum of 20 years later.

4.5 Operational Work Planning

Operations should be conducted to dispose and store radioactive waste in such a manner as to assure that present and future radiation exposures to individuals and population groups will meet ALAP criteria. In order to accomplish this the following work planning objectives should be established:

- Daily, weekly, monthly, yearly, and long term planning.
- Stabilization planning.
- Operational planning for administrative site control.
- Operational planning for unrestricted site use and access (long term).
- Efficient use of personnel.
- Efficient use of facilities.
- Timely handling of radioactive waste by effective planning and scheduling.

4.6 Records and Communications

4.6.1 Site Data Base

A data base of site measurements should be taken and maintained during the pre-operational phase of site development as outlined in Section 7.1.2. This data base should be continued throughout the operational and administrative control phases of site operation.

4.6.2 Historical Records of Waste Disposal Activities

- 4.6.2.1 A coordinate system should be established to use as a basis for placing boundary markers. The system should meet specified accuracy requirements.
- 4.6.2.2 During the operational period of the site, the site operator should establish procedures for placing benchmarks to locate the boundaries of each burial module or facility. Benchmarks should be unaffected by site operation or climatic conditions that are expected to occur during the operational and site administrative control phase.
- 4.6.2.3 The contents, configuration, and coordinates of waste packages should be documented (e.g., chemical, radionuclide, combustible/noncombustible, radioactivity level etc.) and recorded into the site data base.
- 4.6.2.4 During the site operational period, methods should be established for the preservation of inventory records of radionuclides buried, site physical data records, and site surveillance records.
- 4.6.2.5 Records should be kept such that information cannot be lost due to fire or disasters.

4.6.3 Surveillance and Monitoring Records

The surveillance and monitoring data outlined in Section 7 should be documented and maintained.

4.6.4 Routine and Special Reports

- 4.6.4.1 Accurate, current information should be maintained. Due to the large volume of data that will be accumulated during the pre-operational and operating period of the site, automatic data processing methods should be established for maintenance of these records in data base format.
- 4.6.4.2 Methods should be developed to permit rapid compilation of routine reports and capabilities to respond to special requests for site burial or operational information.

4.6.5 Files

The following information should be retained in files:

- All regulations, standards, specifications, etc., governing the establishment and operation of the burial site. All changes or modifications to regulations, standards, specifications, etc. taking place during the operational phase of the site should be retained.
- Correspondence, reports, and data generated during the operational period of the site..
- Personnel records.
- Training records.
- A separate classified records storage file should be established.

4.6.6 Communications

An effective system should be established, with proper documentation, that will permit effective communication within and outside the organization (e.g., customers, media).

4.7 Budgeting and Costs

4.7.1 Funding for Waste Disposal Operations

The cost of waste disposal operations (including post-operational) should be evaluated and the resources funded by the waste generators, taking into account the risks and the process improvements which might be developed during the operational period. The plan and the costs should be reestimated periodically and the corresponding financial arrangements settled during the operational period.

4.7.2 Accounting

- Records should be maintained identifying costs for each specific site activity and each waste type.
- Accrued costs should be maintained for customer billings for each radioactive waste shipment.

4.7.3 Estimating/Forecasting

- Forecasting methods should be established to predict radioactive waste types and volumes for planning and budget purposes.
- Cost estimating methods should be established for site operational purposes (e.g., facility construction, burial operation, shipments, and special waste handling operations).

5.0 WASTE PROCESSING AND PACKAGING

Volume reduction techniques and efficient packaging methods should be utilized to minimize the size of the burial ground, to provide economical and safe handling and disposal of the radioactive waste, and to stabilize the site for long-term environmental control. Waste processing and packaging incentives should be provided to the waste generator to assure meeting these goals as well as meeting the operational, administrative control, and unrestricted site use phases of the burial. These incentives should be written into the waste packaging acceptance criteria.

Waste processing and packaging operations are within the purview of the waste generator/shipper and not the responsibility of the storage/burial site. On this basis the criteria regarding waste processing and packaging are presented in Appendix A for information only.

6.0 RETRIEVABLE STORAGE

6.1 General

In accordance with the requirements of DOE Manual Chapter 0511, wastes containing greater than 10 nanocuries per gram* of transuranic material (i.e., transuranium alpha emitting radionuclides with a half-life greater than 100 years, including uranium 233 and daughter products), should be stored such that the packages can be readily retrieved free of surface contamination within 20 years after burial.

6.2 Waste Identification and Segregation

6.2.1 Waste Assay

Waste should be identified by content and quantity of radionuclides to determine whether they meet the 10 nCi/g criteria. Methods which are available include:

- (1) Determination by Non-Destructive Assay (NDA) - Waste packages are "counted" or measured.
- (2) Source - Waste from areas known to contain TRU radionuclides can be considered potentially contaminated and therefore placed in TRU storage.

6.2.2 Waste Segregation

Waste requiring retrievable storage should be segregated at the source of generation and isolated from waste to be buried. Non-combustible waste should be segregated from combustible wastes.

* The 10 nanocuries per gram figure should be at the 95% confidence level.

6.3 Facilities and Containment

- 6.3.1 Storage conditions and facilities should be made compatible with radiological, chemical, and physical characteristics of wastes.
- 6.3.2 Engineered structures should be designed to provide containment, maintain structural integrity, and be readily retrievable in an intact, contamination free condition within a 20 year period after burial.
- 6.3.3 Structures should provide protection of packages from both deterioration and destruction.
- 6.3.4 Transuranic burial modules should be covered with the specified soil overburden or suitable engineered structures constructed.
- 6.3.5 Modules of transuranic waste should be separated by the specified amount of earth or earth substitute.
- 6.3.6 Containers in a storage mode should be inspected periodically for deterioration and especially prior to closure.

6.4 Packages and Containers

- 6.4.1 All TRU waste should be packaged, suitably labeled, and stored such that (a) intact, contamination free retrieval and onsite transportation of the waste can be readily implemented in a practical manner within 20 years after burial and (b) packages of combustible waste can be retrieved separately from packages of non-combustible waste.
- 6.4.2 Packages should be of a standard form compatible with existing equipment to promote ease of storage and retrievability.
- 6.4.3 Packages should be provided with containment barriers, where needed.
- 6.4.4 Prior to placement, storage containers should be inspected for punctures, dents, scratches on paint, loose lids, corrosion, proper identification, and seals. Discrepancies should be corrected.

- 6.4.5 Packages containing TRU waste should not be accepted if surface dose rates exceed specified limits. Packages exceeding these limits should require special advance site management approval.

6.5 Labeling

- 6.5.1 Packaging labels and records should identify the type of waste, waste form, qualitative and quantitative radionuclide assay, waste location, and content.
- 6.5.2 Labels should be standardized to maximize the consistency of the recorded information.
- 6.5.3 Labels should survive the expected 20 year storage lifetime of the container.

6.6 Criticality

The following limits should be used as a guide to maintain criticality safety for storage of solid fissile material wastes.

6.6.1 Transuranic Caisson (Underground Vault) Storage

The quantity of fissile material in each waste package container added to the caisson should not exceed the specified limits derived from caisson design and critical mass criteria.

6.6.2 Transuranic Asphalt Pad Storage and Dry Waste Module Storage

- (1) Individual containers should have standard dimensions. Commonly used containers are 55-gallon DOT Specification 17-H metal drums. The accepted fissile limit in a 55-gallon drum (at Hanford and other government sites) is 200 grams total mass of plutonium, ^{233}Pa , ^{233}U , and ^{235}U (where ^{235}U is associated with any uranium enrichment above natural).

- (2) The amount of hydrogenous material, i.e., polyethylene, should be limited in each package in accordance with criticality considerations.
- (3) The containers should be stacked and stored such that maximum space utilization is accomplished.

6.6.3 Transuranic Contaminated Industrial Equipment and Special Waste Module Storage

- (1) The containers used should have standard dimensions for maximum utilization of the storage space.
- (2) Any hydrogenous material, other than that associated with the piece of waste equipment, should be physically segregated from the wastes.
- (3) The containers should be limited as to the maximum quantity of fissile material which they may contain based on criticality considerations. In addition, the quantity of fissile material in the wastes, other than the equipment pieces, should be limited for each container.
- (4) Any containers with a quantity of fissile material greater than the specified limit should be spaced a certain distance apart when stored to ensure criticality prevention. Some means should be provided to ensure this correct spacing.

7.0 MONITORING, SURVEILLANCE, AND MAINTENANCE

The major goals of a low-level solid waste burial operation should be to contain the waste until it decays to an innocuous level, to guarantee that the radioactive waste is under control at all times, and to guarantee that if contaminants migrate from the site, their movements can be predicted so that necessary corrective actions can be taken. To achieve the above goals an effective burial site Monitoring, Surveillance, and Maintenance Program should be established to consist of the following operational phases:

- Pre-Operational Phase
- Operational Phase
- Administrative Control Phase
- Site Maintenance and Surveillance

7.1 Pre-Operational Phase

7.1.1 An Environmental Radioactivity Baseline Should First be Established in the Region of the Burial Site.

Background information should be obtained during the site selection phase and would provide base data for comparison with subsequent data gathered during the site monitoring program. Insufficient information on these important characteristics could result in an ineffective system to detect radionuclide migration.

7.1.2 The Minimum Pre-Operational (Baseline) Surveillance Program to be Undertaken Should be as Follows:

- (1) Natural background radiation should be established for the area to be used for disposal, the buffer zone, and the area outside the buffer zone prior to the use of the disposal site.
- (2) Gamma radiation dose measurements from meteorological and/or hydrogeological sources.

- (3) In-situ quantitative gamma spectrometric measurements. The spectra should be analyzed to apportion the total gamma dose rate among the contributing radionuclides.
- (4) Air samples for gross beta and gamma isotopic (monthly composite).
- (5) Periodic gamma isotopic analysis of samples of water, and biota per site specification. Particular attention should be given to critical pathways and sampling for seasonal variations.
- (6) Baseline data should be obtained on alpha emitters such as: ^{226}Ra , ^{238}Pu , ^{239}Pu , and ^{232}Th .

7.1.3 Design for Monitoring and Surveillance Functions

(1) Monitoring Network

The type, density, and sampling frequency of the monitoring network should be compatible with the site. The network should detect radionuclide migration in any direction and from any location, particularly in the local biosphere.

(2) Modeling

A predictive mass-transport model should be developed to assist in network decisions and correlate to data base information. Adequate hydrogeological investigations should be performed to provide a valid data base.

(3) Monitoring Stations and Sampling Frequency

(a) Primary migration and transport pathways to the biosphere, illustrated in Figure 7.1; are:

- Disentment by normal or catastrophic erosional process.
- Released radioactive gases transporting through the unsaturated zone.

ARID SITE TRANSPORT FROM
SHALLOW LAND BURIAL SITES

FIGURE 7.1

- Released radionuclides in aqueous solution migrating upward or downward.
- Plant uptake and burrowing animals.

Monitoring stations should be located along each migration and transport pathway.

- (b) The types of monitoring and sampling should be that outlined in Table 7.1. Frequency should be determined from site characteristics, but in no case should exceed an annual sample.

(4) Design of Equipment

Monitoring apparatus should be designed to require minimum maintenance and, whenever practicable, be designed to function for the duration of the administrative control phase without replacement. Equipment costs should be weighed against the consequences of failure and the impact of breakdown.

7.2 Operational Phase

7.2.1 Site Surveillance Performance

The site operator should establish that the site is performing as predicted and that no unexpected release of radionuclides has occurred. Changes in critical baseline parameters should be evaluated to determine if the criteria should be modified, performance expectations changed, or a combination of both.

7.2.2 Surveillance for Unexpected Occurrences

An augmented site surveillance effort should be conducted in the event of unexpected occurrences when the occurrences are suspected of being detrimental to the storage/burial site.

7.2.3 Monitoring Interpretation

Data collected from the monitoring systems should be reviewed, integrated, and evaluated by a specifically assigned knowledgeable individual or organization.

TABLE 7.1

PROPOSED ENVIRONMENTAL MONITORING AND SAMPLING
FOR DOE
ARID SOLID LAND BURIAL SITES

<u>SAMPLE MEDIA</u>	<u>SAMPLE TYPE LOCATION</u>
Water	<ol style="list-style-type: none">1. Deep wells to groundwater placed in and around the burial site as determined by site characterization.2. Offsite perimeter springs, streams, and rivers.3. Onsite surface runoff following each runoff event.
Air	<ol style="list-style-type: none">1. Air samples continuously at selected locations of the burial ground, and at the site perimeter.2. Operational air sampling within the site during handling of high radioactivity shipments.
Soils	<ol style="list-style-type: none">1. Dry-well total gamma scintillation analysis or gamma energy analysis either through or adjacent to trenches.
Vegetation	<ol style="list-style-type: none">1. One composite sample from each trench cover. The appearance of plant life generally uncommon to the area or a change in existing vegetation could be indicative of possible soil chemistry changes caused by assimilation of migrating radioactive contamination.
Other	<ol style="list-style-type: none">1. Onsite rodents.2. Perimeter coyotes and fish.

7.2.4 Surveillance for Acceptable Burial Design

During the period the site is operational, the site operator should demonstrate, using a sufficient number of completed modules, that the procedures employed for module stabilization and water management during the administrative control phase will be adequate to perform their intended purpose. If deterioration occurs, the site operator should determine its causes, propose a modified design and demonstrate its adequacy. If the modified design results in higher costs, the plan for financing of administrative control care, and the burial fee should be modified accordingly.

7.3 Administrative Control Phase

7.3.1 Administrative Control Plan

7.3.1.1 General Considerations

Development of a clear, comprehensive plan and procedures for administrative control after the site has terminated active operation should be considered essential. Such a plan should take into account the following points.

- (1) It should include procedures for stabilization and closure of the facility under both normal and emergency conditions during both operational and administrative control phases.
- (2) It should be prepared and approved by the appropriate authorities before the site is allowed to begin operations.
- (3) It should cover all aspects of the burial site and disposal system.
- (4) A multi-disciplinary team of geologists, hydrologists, ecologists, engineers, and health physicists should develop the administrative control plan.

- (5) It should provide for the commitment of the necessary resources and effort for as long as the wastes in the site remain hazardous.
- (6) Periodic review of the entire plan should be considered mandatory both in the operational and administrative control phases.

7.3.1.2 Conditions for Closing and Discontinuing of Control

- (1) The conditions which would require the site to be closed should be specified, and should include closure when;
 - (a) Authorized burial space is filled.
 - (b) Total site activity limit is reached.
 - (c) A significant release of activity indicates that a basic non-correctable error has been made in the design of the burial system or in the environmental assessment of the site.
 - (d) A serious accident or natural disaster alters conditions at the site.
- (2) The time when stabilization and closure activities are to begin should be specified.
- (3) Certain sites may not require surveillance or restricted access after a few tens or hundreds of years because the wastes buried therein will have decayed to innocuous levels. Procedures and tests for determining when a site is no longer hazardous from radioactivity or chemical toxicity should be specified.

7.3.1.3 Definition of Responsibilities

Responsibilities and duration of involvement should be specified for those organizations or groups which participate in closing down the site and in administrative control and long-term surveillance.

7.3.1.4 Plan for Long-Term Care and Surveillance

Detailed plans should be prepared for stabilization of the burial site after routine operations have ceased. Every effort should be made to prepare the site into as maintenance-free condition as possible based on type of radionuclides, waste form, site conditions, and existing public policy.

7.3.1.5 Plan for Non-Routine Closure

The possibility that the site could be closed because of non-routine conditions such as an accident, unexpected hydro-geological conditions or extreme meteorological event should be anticipated and planned for, possibly through fault-tree or other appropriate analyses.

7.3.1.6 Records

Up-to-date records should be maintained of the site data base, waste volumes, activity levels, and types of radionuclides, location and content. Retention of duplicate records at an alternate location should be considered.

7.3.1.7 Control of Access

An access control plan should be prepared to address access by people, vehicles, and wildlife.

7.3.1.8 Risk Assessment

A risk assessment should be conducted to evaluate long-term environmental impact of the administrative control phase. It should be of similar intensity and scope as the initial risk assessment undertaken during the site selection process. Data gathered during site use should be used to refine original estimates.

7.3.1.9 Financial Arrangement

A plan for financing administrative control activities and control of the burial site should be made and should provide for

routine maintenance, patrol, surveillance activities, etc. Special provisions should be made for emergency corrective actions, which might greatly exceed anticipated routine costs.

7.3.2 Administrative Control Surveillance

7.3.2.1 Design of Administrative Control Surveillance Program

A surveillance program should be established that identifies the agency responsible for institutional control and the duration of control during the administrative control phase. Surveillance and monitoring data obtained during the operational period should be used as a basis for modifying or refining the program.

7.3.2.2 Action Levels

The administrative control plan should contain action levels with a specific action plan and responsible personnel for each. Operational data should be used in this regard.

7.3.2.3 Maintenance and Testing

The administrative control surveillance program should contain a program of preventive maintenance and periodic testing of sampling and monitoring equipment.

7.3.3 Reuse of the Site

- (1) Reuse should be contingent on the following:
 - (a) The radioactivity decaying to innocuous levels.
 - (b) The proposed use being such that toxic/hazardous materials will not be disinterred or isolation barriers compromised (or any combination thereof).
- (2) Reuse should not be considered which in any way poses the possibility that mankind will be exposed to radiation, or hazardous or toxic materials.

7.4 Maintenance

The general aspects of site facility maintenance are covered in 1.1 Appearance of Site. Specific items associated with site maintenance should include the following:

- (1) Surface depressions due to subsidence or erosion.
- (2) Vegetation control over the burial modules.
- (3) Module covers (e.g., asphalt, gravel, etc.)
- (4) Monitoring and surveillance equipment.
- (5) Equipment for handling and transporting radioactive waste.

8.0 SECURITY

The site should be safeguarded with appropriate means to protect the public safety, protect classified and/or special nuclear material, and to generally preclude acts of vandalism, theft, diversion, arson, or sabotage. The safeguards program should meet the intent of DOE Manual Chapters 2401, 2405, and 2406. Although individual areas of the site may vary in the degree of protection required (e.g., special nuclear material vs low-level mixed fission product waste), an overall high quality safeguard system should be instituted.

8.1 Program Planning

The following factors should be taken into consideration relative to the type and degree of physical protection provided for the site.

- (1) The importance of the facility to the overall program of the DOE taking into consideration the availability of alternate facilities in the case of an emergency.
- (2) The vulnerability of vital equipment or material to sabotage or theft.
- (3) The location, size, and arrangement of the facility and number of personnel involved.
- (4) The need for integrating security measures with facility operations.
- (5) The probable duration of operations.
- (6) The probability of expansion, curtailment, or other significant change in operations.
- (7) The relative efficiency and economy of alternate security methods to assure the most effective and economical use of manpower consistent with security requirements.

8.2 Site Security - Operational Phase

8.2.1 Classified and Special Nuclear Material

Specific physical protection measures for classified or unclassified special nuclear material should meet the applicable requirements of DOE Manual Chapter 2401 or 2405.

8.2.2 Basic Security Measures

In addition to meeting the requirements of DOE Manual Chapter 2406, the following basic site security measures should be instituted.

8.2.2.1 Physical Barriers

Clearly defined physical barriers such as fences should be used to, (1) deny or impede unauthorized access to the site, (2) facilitate effective use of guards, and (3) direct the flow of personnel and vehicular traffic through designated areas.

8.2.2.2 Locks and Keys

Key locks in doors should be resistant to picking and jimmying and combination locks to manipulation. Padlocks should be of sturdy construction, designed for outdoor use, and resistant to opening by picking, rapping, forcing, or the use of shims or similar techniques. Positive control and accountability of keys should be considered essential.

8.2.2.3 Personnel Identification System

- (1) A security pass or badge system should be used within the confines of the burial site to assure that only authorized personnel enter and leave the site.
- (2) The pass or badge should be always worn conspicuously (by employees and escorted or unescorted visitors) unless prohibited by health or safety regulations. If visitors cannot wear passes or badges they should be escorted at all times.
- (3) Records should be maintained showing the disposition of all passes and badges.

- (4) A record of lost passes and badges should be kept and personnel controlling access to the site should be notified to prevent their misuse.
- (5) Stocks of inserts and unissued passes and badges should be stored in a manner assuring their protection against loss, theft, or unauthorized use.
- (6) Security passes and badges should be recovered from terminating employees. Passes and badges issued to visitors should be recovered at the conclusion of each visit.
- (7) Security passes and badges issued to permanent employees should be replaced by a new issuance having different background design or color, with new photographs, periodically or when a certain percentage of the number currently in use have been lost, whichever occurs first.
- (8) If a significant change in facial appearance takes place (e.g. beard), a pass or badge with a new photograph should be issued.

8.2.2.4 Access Controls

- (1) Access to the burial site during working hours should be controlled by guards, watchmen, receptionists, or by employees who have specifically designated responsibility for assuring that only persons with proper authorization are admitted. When unoccupied, site facilities should be locked with DOE approved locking devices and/or other suitable means.
- (2) Site entrances should be equipped with doors, gates, rails or other movable barriers which will direct and control the movement of personnel.
- (3) A visitor log or similar record should be maintained to show the name, organization, and citizenship status of each uncleared visitor, person visited, and time in and out of the area.

- (4) A visitor without appropriate access authorization should be escorted at all times while within the security area by a guard, the person being visited, or another employee assigned for that purpose.

8.2.2.5 Examination of Packages and Briefcases

- (1) The following articles should be restricted from the site without proper authorization.
 - Firearms, explosives, or incendiary devices.
 - Other items capable of causing property damage or personal injury.
- (2) All vehicles, packages, briefcases, and other containers should be subject to search upon entering and leaving the burial site to reasonably assure that they do not contain government property which is being removed without proper authorization.
- (3) Signs identifying the requirements of (1) and (2) above should be posted at site entrances and other conspicuous locations to provide reasonable notice to persons about to enter the site.

8.2.2.6 Intrusion Detection

(1) Protection Alarms

The utilization of protection alarms should be based on the security requirements of each particular area.

Protection alarms should be used to, (1) increase guard efficiency and reduce guard force costs, and (2) supplement or replace other physical security measures.

(a) Types of Alarm Systems

The following alarm systems should be employed:

- A central station alarm system in which alarm signals are transmitted to a headquarters location where alarm monitors are constantly attended.
- A local alarm system which employs a loud, audible signaling device in the immediate vicinity of the protected area and located such that the signal would be immediately detected by personnel designated to take necessary protective action.

(b) Central Station Operation

Operational requirements should be as follows:

- Response Time - Protective or other designated personnel should arrive at the area or object under alarm protection within a designated time from the time the alarm signal is received at the central station.
- Tests - Alarm equipment and circuits should be tested on some appropriate basis by actual intrusion of the alarmed area. Tests should be conducted at least semiannually to determine the response time by plant guard personnel.
- Inspection - Alarm equipment and circuits should be thoroughly inspected by qualified service personnel at least annually to assure continuing operability.
- Maintenance - The alarm equipment and circuits should be maintained continuously by qualified service personnel.
- Records - Protective personnel should record each nonscheduled alarm, showing the date and time the signal was received, the time protective or other

responsible personnel arrived at the alarmed area, action taken, and the cause of the alarm if known or probable cause if not definitely established.

(c) Reports

A report of each non-scheduled alarm should be furnished to the facility security officer immediately if unauthorized intrusion is involved.

(d) Power Sources

- Primary power for protective alarm systems should be furnished from public utility, battery, or other self-generated source. When a public utility power source is used, an auxiliary (emergency) source should be required for the protective alarm system.
- Auxiliary (emergency) power for protective alarm systems should be supplied by batteries or motor driven generators. Switchover to the auxiliary power should be automatic upon failure of the primary power source and a signal should be activated in the monitor to indicate this switchover.

Batteries, when used, should be either dry cell or rechargeable. If rechargeable, the batteries should be kept fully charged or subject to automatic recharging whenever the voltage drops a certain percentage below normal. If dry cell, they should be replaced with fresh ones whenever the voltage drops a certain percentage below the rated voltage. A signal should be activated in the monitor to indicate when this condition exists.

Auxiliary (emergency) power sources should be capable of maintaining full operation of the alarm system for not less than 24 hours. Such power

sources should contain a switching capability to facilitate operational testing.

- Ventilation. The power supply, other than public utility, should be sufficiently vented to preclude deterioration of any of its components as a result of operation under high temperatures.

(2) Protective Lighting

- (a) Protective lighting should be used as a part of the site security system.
- (b) Lamps in which light is produced directly or indirectly by the use of gas, such as sodium vapor lamps, are highly efficient and economical in operation and their use in protective lighting systems should be encouraged. However, it should be recognized that a relight period of approximately 3 minutes following any power interruption is required for gas lamps.
- (c) Facilities having protective lighting should have emergency lighting capability.
- (d) Adequate illumination should be provided to detect intruders, reveal unauthorized persons, and, at pedestrian and vehicular entrances, to examine credentials and inspect vehicles.
- (e) Light glare should be kept to a minimum in those situations when it would impede effective operations of protective personnel, interfere with rail, highway, or navigable water traffic, or be objectionable to occupants of adjacent properties.

- (f) Perimeter light sources should be so located that illumination is directed, whenever possible, outward and with relative darkness existing along patrol routes and at fixed guard posts other than pedestrian and vehicular entrances.

8.2.2.7 Protective Personnel

- (1) If the burial site contains classified material or unclassified special nuclear material, security measures should meet the requirements of DOE Manual Chapters 2401 or 2405 respectively.
- (2) In the event the burial site does not contain classified or special nuclear material, protection should be provided by guards or watchmen, as follows:
 - (a) Guards or watchmen should meet the standards specified in DOE Manual Chapter 2401.
 - (b) Guards or watchmen should perform the following duties:
 - Enforce regulations concerning trespass exclusive of prohibited articles, and personnel identification.
 - Observe and patrol designated perimeters, areas, and structures.
 - Prevent persons or vehicles from gaining unauthorized access to the site.
 - Perform escort duties as necessary.
 - Respond to protective alarm signals or other indication of suspicious activity.
 - Act as necessary in the event of situations affecting the security of the facility, including fires, industrial accidents, internal disorders, and attempts to commit espionage, sabotage, or other criminal acts.

- Protect property against unauthorized access, theft, or intentional damage.
 - Report to supervisors all incidents or unusual circumstances affecting the security of the area at the time of occurrence or as soon thereafter as possible.
- (c) Guards or watchmen should conduct patrols of the site at irregular intervals, but not less frequently than once every four (4) hours during non-working hours.
- (3) Communications for Protective Personnel
- (a) An effective communications system should be implemented for protective personnel utilizing both normal telephone service and two-way radio communication which would provide both onsite and offsite communications.
 - (b) The protective communications system should be tested on a periodic basis to assure proper operating conditions.

8.2.2.8 Posting Against Trespassing

"No Trespassing" signs should be posted pursuant to Section 229 of the Atomic Energy Act of 1954, as amended, and 10 CFR Part 160. Posting should be accomplished according to the requirements of DOE Manual Chapter 2401.

8.2.2.9 Emergency Plans

Each Burial site should adopt a site protection emergency plan. Elements of an effective emergency plan are contained in the Appendix to DOE Manual Chapter 2406.

8.3 Site Security - Administrative Control Phase

Detailed plans should be prepared for security of the burial site during the administrative control phase and should be integrated into the monitoring, surveillance, and maintenance planning discussed in Section 7. The condition of the burial site during the administrative control phase should be such that only minimal security measures would be necessary during the period required for the radioactive wastes to decay to innocuous levels.

REFERENCES

<u>Section</u>	<u>Reference(s)</u>
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1.1	<ol style="list-style-type: none"> DOE Manual Chapter 5401 (with RL Appendix), "Maintenance of Property." DOE Manual Chapter 6301 (with Appendix), "Facilities General Design Criteria." DOE Manual Chapter 6203, "Site Development and Facility Utilization Planning."
1.2	<ol style="list-style-type: none"> DOE Manual Chapter 0820 (with RL Appendices), "Quality Assurance." DOE Manual Chapter 0507, "Federal Employee Safety and Health Program." DOE Manual Chapter 0528 (with Appendix), "Contractor Occupational Medical Program." DOE Manual Chapter 0505 (with Appendix), "Construction Safety Program." RL Appendix to DOE Manual Chapter 6101, "Management of Construction Projects." CFR, Title 29, Part 1926, "Safety and Health Regulations for Construction." DOE Manual Chapter 0530, "Nuclear Criticality Safety." DOE Manual Chapter 0510, "Prevention Control, and Abatement of Air and Water Pollution." DOE Manual Chapter 0511, "Radioactive Waste Management." DOE Manual Chapter 0524, "Standards for Radiation Protection." DOE Manual Chapter 0525, "Occupational Radiation Exposure Information." DOE Manual Chapter 0545, "Nuclear Accident Dosimetry Program."

REFERENCES

<u>Section</u>	<u>Reference(s) - Continued</u>
	16. CFR, Title 10, Part 20, "Standards for Protection Against Radiation."
	17. DOE Manual Chapter 0552, "Fire Protection."
	18. DOE Manual Chapter 0601, "Emergency Planning, Preparedness, and Response Program."
	19. DOE Manual Chapter 0502 (with Appendix), Notification Investigation, and Reporting of Occurrences."
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2.0 Facilities	21. A. E. Peckham and W. G. Becter, "Considerations for Selection and Operations of Radioactive Waste Burial Sites," March 1962.
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	27. ONWI - 38 (Draft) "Criteria for Geologic Disposal of Nuclear Wastes: Part 1. System and Package Performance Criteria: prepared by the Office of Nuclear Waste Isolation, Criteria Developers Group (Working Committee) dated March 30, 1979.

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	32. "Guidelines for Construction and Use of Solid Waste Disposal Facilities," LASL.
	33. DOE Manual Chapter 6202, "Site Selection."
	34. DOE Manual Chapter 0524, "Standards for Radiation Protection."
	35. DOE Manual Chapter 0511, "Radioactive Waste Management."
3.0 Transportation	36. IAEA Safety Series #6, "Regulations for the Safe Transport of Radioactive Materials."
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	38. 49 CFR, "Transportation Regulations."
	39. DOE Manual Chapter 5201 (with Appendix), "Transportation of Property."
	40. DOE Manual Chapter 5401 (with RL Appendices), "Maintenance of Property."
	41. DOE Manual Chapter 0529 (with Appendix), "Safety Standards for the Packaging of Fissile and Other Radioactive Materials."

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<u>Section</u>	<u>Reference(s) - Continued</u>
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	44. DOE Manual Chapter 2405, "Physical Protection of Unclassified Special Nuclear Material."
	45. DOE Manual Chapter 2406, "Physical Protection of Property."
4.0 Operations and Administration	46. DOE Manual Chapter 0511, "Radioactive Waste Management."
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<u>Section</u>	<u>Reference(s) - Continued</u>
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APPENDIX A

5.1 Volume Reduction

5.1.1 Volume Reduction Processes

The following volume reduction methods should be evaluated and implemented where applicable:

5.1.1.1 Waste Sorting

- (1) Wastes should be sorted at the source of generation.
- (2) Wastes should be sorted to separate combustibles from non-combustibles and to identify and remove hazardous materials where possible. Final categorization would be determined by the treatment options selected and utilized.

5.1.1.2 Shredding

Shredding should be used on combustible waste to produce pieces properly sized for the particular combustion process.

5.1.1.3 Decontamination

Decontamination should be applied, where practical, to provide the following advantages:

- (1) Reduce activity levels so that equipment or components could possibly be reused instead of requiring disposal.
- (2) Reduce activity levels from high to low or low to a non-radioactive category that could eliminate the need for waste burial.
- (3) Reduce activity levels so that the resultant waste can be handled, packed, transported, and buried with minimal risk.
- (4) Recover transuranic material from contaminated waste.

5.1.1.4 Compaction

- (1) Compaction, being one of the easiest processes for reducing the volume of waste, should be utilized to the maximum practical extent.

- (2) Precaution should be taken to prevent airborne contamination, which could occur when air is forced out of the container during compaction of flexible materials.

5.1.1.5 Fragmentation (Mechanical Disassembly)

- (1) Fragmentation should be considered for large items that must be reduced in size or materials that are highly contaminated.
- (2) Methods for fragmenting waste include electric arc or oxyacetylene torches, reciprocating saw, circular saw and abrasive cutting wheel, and shears. Crushing and shredding machines can also be used for glass and plastic wastes and filters.

5.1.1.6 Combustion (Oxidation) Techniques

- (1) Combustion (oxidation) techniques should be considered for combustible wastes.
- (2) Process equipment utilizing this volume reduction technique should be equipped with appropriate control and safety systems to prevent the escape of radioactive gases into the working area.
- (3) Combustion systems which have been developed or are in use include:
 - (a) incinerators of various types
 - (b) acid digestion process
 - (c) fluidized bed combustion
 - (d) molten salt combustion

5.1.2 Applications of Volume Reduction

The advantages of volume reduction are:

- (1) Provides reduction of weight and volume which promotes safety for handling and storage/disposal operations.

- (2) Provides economics due to a reduction in costs associated with construction (containers and burial facilities), transportation of wastes, and site operations.
- (3) Provides for a more suitable waste form from a handling standpoint.
- (4) Promotes standarization of containers.
- (5) Reduces land used for storage/disposal and maximizes available volume.

5.2 Waste Packaging

Packaging of solid radioactive waste for storage or disposal should meet the following requirements.

5.2.1 General Packaging Requirements

5.2.1.1 Type of Container

Containers should be appropriate for the waste forms.

5.2.1.2 Design of Container

Containers should meet the requirements of DOE Manual Chapter 0529 and be standardized as much as possible.

5.2.1.3 Package Weight

Weight should be appropriate to the storage/disposal method to be used. Weight limits of other packages should be determined by the container design, contents, or handling methods used for transport and storage.

5.2.1.4 Effective Package Loading

- (1) The generator/shipper of the solid waste should be responsible for minimizing the volume of waste and its radioactive content to best utilize the package.

- (2) For both economic reasons and to minimize the impact of a collapsing package in the burial grounds the generator-shipper should fully utilize the capacity of each package.

5.2.1.5 Surface Contamination of Package

Exterior surfaces of packages should be free of smearable contamination. Limits should be established according to applicable regulations.

5.2.1.6 Shielding - Radiation Levels

- (1) Shielding of the container should be appropriate for the handling, transport and storage/disposal methods to be used so that personnel exposure is ALAP.
- (2) Dose rates on offsite shipments should meet DOT requirements found in Title 49 CFR173.393(i)(j). Onsite shipments will meet the requirements of applicable onsite regulations based on ALAP requirements.

5.2.1.7 Thermal Output

Heat output limits for specific packages should be assessed. The heat generated within the package because of radioactive materials should not at any time during transport or storage have an adverse effect upon the efficiency of the package or surrounding packages. Deviation from this limit should require specific site management approval.

5.2.1.8 Fissile Content Determination

Waste packages containing fissile materials such as plutonium, U^{233} , Pa^{233} , or U^{235} , should be assayed to determine fissile content, and should be properly labeled. Minimum quantity requiring assay should be specified for the facility.

5.2.1.9 Transuranic Waste Packaging

(1) TRU Determination

Waste containing greater than 10 nCi transuranic contamination per gram of waste matrix should be packaged and be

readily retrievable for up to a minimum of 20-years. Packages should be designed to remain intact, contamination-free and be able to withstand onsite transport at the end of this period. Two basic methods can be used to determine whether the waste meets the 10 nCi/g requirement.

- (a) Assay - Waste packages are counted or measured by an authorized assay method.
- (b) Source - Waste from areas known to contain TRU radionuclides can be considered to be potentially contaminated and therefore placed in TRU storage.

(2) Material Separation

During packaging, combustible waste should be segregated from noncombustible waste.

(3) Labeled for Cross Reference

Transuranic waste packages should be labeled so that the waste can be identified by cross reference to permanent records.

(4) Possible Pressurization in Containers

The packaged waste should be of such a nature and/or the container should be designed such that potential gas generation from the packaged waste does not result in rupture of the containment system.

(5) Double Containment

Transuranic solid wastes should be packaged inside at least two containment barriers (the burial/storage container and an inner liner).

5.2.1.10 Offsite Waste - Double Containment

All radioactive solid waste from offsite generator/shippers should be packaged inside at least two containment barriers.

5.2.2 Onsite Containers

- 5.2.2.1 Onsite containers should meet the requirements of DOE Manual Chapter 0529 so as to keep exposure to individuals as low as practical during the transportation and handling of packages.
- 5.2.2.2 Prior to use, each container used for the shipment and burial of radioactive solid waste should have a safety evaluation/analysis approved by a function equivalent to the Hanford burial site Packaging and Shipping Safety Committee (PSSC).

5.2.3 Offsite Containers

Containers used for offsite shipments should meet DOE, DOT, NRC or IAEA requirements as applicable during transit. DOE Manual Chapter 0529 delineates the safety standards for the packaging of fissile and other radioactive material.

5.2.4 Overpacks

Overpacks should be used to provide container protection to survive an accident during shipment, to provide radiation protection and shielding where necessary, and to assure proper sealing for contamination containment. Transport overpacks require DOT certificates to operate outside of a DOE facility. Overpacks used onsite should meet DOE Manual Chapter 0529 requirements. Nonreusable overpacks that are to be stored or disposed of in a burial site should be labeled as burial containers.