A MODULARIZED SYSTEM FOR DISPOSAL OF LOW-LEVEL RADIOACTIVE WASTE

Charles W. Mallory
Dr. Ralph DiSibio
Westinghouse Hittman Nuclear Incorporated
9151 Rumsey Road
Columbia, Maryland 21045

ABSTRACT

A modularized system for the disposal of low-level radioactive waste is presented that attempts to overcome the past problems with shallow land burial and gain public acceptance. All waste received at the disposal site is packaged into reinforced concrete modules which are filled with grout, covered and sealed. The hexagonal shape modules are placed in a closely packed array in a disposal unit. The structural stability provided by the modules allow a protective cover constructed of natural materials to be installed, and the disposal units are decommissioned as they are filled. The modules are designed to be recoverable in the event remedial action is necessary. The cost of disposal with a facility of this type is comparable to current prices of shallow land burial facilities. The system is intended to address the needs of generators, regulators, communities, elected officials, licensees and future generations.

BACKGROUND

The use of shallow land burial for the disposal of radioactive waste has come under increased scrutiny. As shown in Table I, only three of the six commercial low-level waste disposal sites remain in operation.

TABLE I

Commercial Shallow Land Burial Sites

Site	Opened	Status
Beatty, NV	1962	Operating
Maxey Flats, KY	1963	Closed 1977
West Valley, NY	1963	Closed 1975
Richland, WA	1965	Operating
Sheffield, IL	1967	Closed 1978
Barnwell, SC	1971	Operating

The planners of future low-level radioactive waste dispoal sites should carefully consider the conditions which led to the closure of the three sites. In addition, one must consider how these conditions can affect the ultimate decommissioning of these sites.

In many respects the conditions leading to the closure of the three low-level sites were similar. Using the Maxey Flats facility as an example, the conditions leading to closure are summarized as follows:

- The trenches were constructed in an impervious strata; however, the construction of the trenches caused permeability.
- Inadequate surface drainage combined with depressions caused by subsidence allowed water to infiltrate the trenches.
- Since the sides and bottom of the trenches were relatively impervious, the trenches filled with water because of the "bath tub" effect.
- The water in the trenches came in contact with the waste, became contaminated, and eventually migrated to the surface.
- There was some evidence of radioactivity moving between the trenches, and the greatest concern was lateral migration and possible off-site contamination via the springs on the surrounding hillside.

A leachate management program had been initiated in 1973, and concurrent with the closure of the Maxey Flats site, an extensive remedial action program was undertaken. This program consisted of:

- Pumping the trenches to remove the estimated 7,000,000 gallons of water in the trenches and to reduce the potential for vertical and lateral migration of radioactivity.
- Evaporation of the trench leachate to reduce the volume of water to be stored and subsequently processed for burial.
- Complete regrading of the site to promote drainage including the installation of lined channels to carry runoff, and the removal of ponds that were acting as recharge basins.
- Daily inspection and repair of subsidence as it occurs.
- Installation of additional sumps to allow removal of water trapped in the trenches.
- Installation of plastic membrane over the entire site to reduce infiltration to a minimum and the amount of water that must be subsequently pumped and processed.

In 1984, it was estimated that about 3.5 million gallons of leachate remained in the trenches.

A decommissioning plan has been prepared for the Maxey Flats site (Reference 1). This plan is described as follows:

- The key element of the plan will be the stabilization of the site to minimize subsidence. Of the various methods investigated, concrete slabs on piles and grouting of the trenches were considered the only viable approaches based on present technology.

- Once the site is stabilized, a multi-layer protective cover will be installed to permit decommissioning. The cover will consist of a clay infiltration barrier, sand and gravel subsurface drains, a cobble biointrusion barrier and a vegetative cover to control wind and water erosion.

- It will also be necessary to install cut-off trenches and drainage walls to divert subsurface flow around the trenches.

As shown in Table II, decommissioning of an existing site is very expensive. However, the cost of decommissioning is less than the cost of providing custodial care throughout the entire institutional control period.

TABLE II

Projected Cost to Decommission an Existing Site (Constant 1983 dollars without interest)

	Structural Concrete w/Composite Cover ($000)	Grouted Trench w/Composite Cover ($000)	Custodial Care w/"20 yr" Cover ($000)
Implementation Cost (4 Years)	$38,239	$28,001	$ 5,993
Active Observation (10 Years)	3,070	3,070	9,910
Institutional Control (90 Years)	24,300	24,300	94,941
Total Cost (104 Years)	$65,609	$55,371	$110,844

At the time the Maxey Flats facility was closed in December 1977, approximately 4.75 million cubic feet of waste containing 2.4 million curies of radioactive material had been buried. Based on Table II, it now appears that the cost for decommissioning will range from $11.66 to $23.34 per cubic foot.

Need for Alternatives

The experience at Maxey Flats, and the other commercial and government disposal sites, has dramatically demonstrated the need to either vastly improve shallow land burial practices or to use alternative approaches for the disposal of low-level radioactive waste. This experience clearly shows that stability and the avoidance of subsidence are the key factors in design and operation of future land disposal facilities for low-level waste. The detrimental effects of subsidence are:

- Formation of depressions which cause increased water infiltration.

- Continual maintenance until the trenches are fully stabilized.

- Deferral of the installation of trench covers and drainage systems needed to fully decommission.

- Potential damage to trench covers after decommissioning, requiring prolonged surveillance of the site.

The public is aware of the problems that have been experienced in the disposal of low-level radioactive waste. A public attitude survey was recently conducted in connection with the siting of a low-level waste disposal facility in Texas, in which nine hundred ninety-eight persons were contacted (Reference 2). The results of the survey were:

- Eighty percent opposed the location of a low-level radioactive waste disposal site in their county.

- Fifty-three percent said radioactive wastes are one of the most serious threats facing the world.

- Only fifty percent believe science can develop safe disposal technologies.

- Only twenty-eight percent feel that present technology is adequate.

The need for new approaches can be summarized as follows:

- Problems in decommissioning existing sites
- Ongoing maintenance and surveillance costs
- Public objection to shallow land burial
- Public demand for remedial measures
- Public assurance of long-term isolation
- No precedent for 10 CFR 61 licensing
- Time required to obtain license

The Modularized Approach

The modularized system for the disposal of low-level radioactive waste is based on packaging all waste into standardized reinforced concrete modules as shown in Fig. 1.

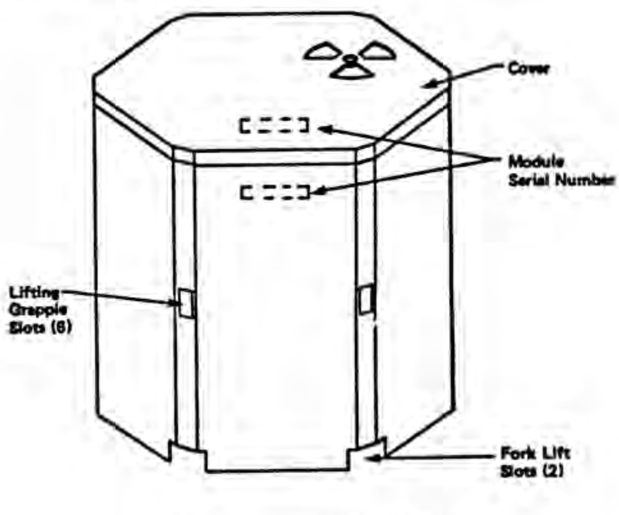

Fig. 1. Disposal Module.

The modules have a cylindrical cavity which is sized to receive most of the radioactive waste packages currently in use. As shown in Fig. 2, the disposal modules are designed to handle:

- o Steel Liners
- o High Integrity Containers
- o Uncompacted Drums
- o L.S.A. Boxes

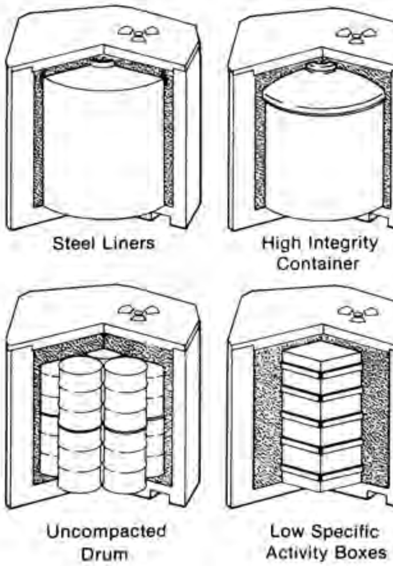

Fig. 2. Disposal Module Contents.

With this approach, all waste received from the generators will be required to meet the packaging requirements of 10 CFR 61. All the waste packages will be placed into the hexagonal concrete disposal modules and grouted in place. A reinforced concrete cover will be used to permanently seal the module. This provides a four barrier system consisting of the module, grout, waste package and the waste form to preclude water infiltration and the release of contamination. All waste will be packaged in the modules, and no unstable waste will be placed in the disposal unit.

THE DISPOSAL UNIT

The primary purpose of the modular low-level waste disposal system is to structurally stabilize the waste and reduce subsidence to a minimum. As shown in Fig. 3, the hexagonally shaped modules are designed to allow them to be placed in a closely packed array in the disposal trench.

The hexagonal shape was chosen to reduce the voids between the modules to a minimum and to facilitate the placement of the modules. With cylindrial modules, the voids would be at least 10%, even with the containers staggered. Theoretically, cubes could be placed in an array with no voids, however, placement of cubes would be difficult. The sides of the hexagonal modules guide them into place and the voids are minimal, even with the corner chamfered to avoid chipping. The voids between the modules will be filled with crushed rock, and spacers will be used to fill the forklift slots.

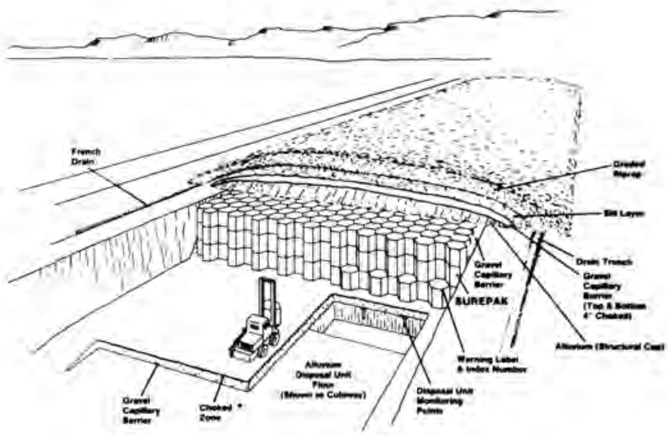

Fig. 3. The Disposal Unit.

A disposal unit 120 feet wide and 500 feet long, with modules stacked three high, would contain about 4,000 modules. The total volume of the cavities would be over 800,000 cubic feet, or about 60 percent of the gross volume occupied by the modules themselves.

One of the greatest benefits of this system is the ability to decommission the disposal units as they are filled. The modules would be placed on a layer of gravel which will serve as an underdrain during the operational phase and as a capillary barrier when decommissioned. After the disposal unit is filled with modules and the voids are filled, the sides of the disposal unit can be filled and the protective cover installed. The construction will depend upon the location and climate of the disposal facility. For an arid climate, the sides of the disposal unit will be filled with gravel to provide a capillary barrier. The protective cover will be shaped using locally available materials. A layer of gravel covered with a layer of silt will be used as a wick to carry any moisture to adjacement drains. Rip-rap will be used as a cover to prevent wind and water erosion.

In a humid climate, local materials would be used to shape the cover. Clay is used to fill the sides of the trenches and form an infiltration barrier over the modules. A sand and gravel underdrain would be used to carry the water allowed to infiltrate the cover to lateral drains. This will also keep the infiltration barrier moist. If needed, a barrier constructed of cobble will be used to prevent intrusion by roots and burrowing animals. A vegetative cover supported by sand and gravel will be used to convey excess water to drains and minimize wind and water erosion.

RECOVERABILITY

The modularized packaging system is designed as a disposal system and not a storage system. However, the modules are designed to be recoverable. If radioactive materials are detected by the monitoring system, the location of probable source would be determined, and a section of the protective cover would be removed to gain access. Probes would then be used to determine the location of the problem. The modules are designed to be placed using forklifts but have provision for installing lift lugs to allow the modules to be lifted. This allows modules to be removed from the disposal unit. Because of the shielding provided by the modules and grout, removal could be performed with minimal personnel exposure. Compared to recovery of waste from a shallow land burial facility, the effort and exposure will be much less.

A system in which the waste is recoverable has advantages over a facility designed for retrievability. If no problems are encountered with a recoverable system, no further action is needed. With a retrievable system, decommissioning of the entire facility must eventually be performed.

A retrievable facility would require some form of engineered facility to store and handle the waste. Such a structure would be more vulnerable to structural and seismic damage than the modular system, where the modules can move independently along eight planes.

WASTE PACKAGING

With the modular packaging system, the waste received from the generators would be packaged into the concrete modules in a waste packaging facility. A typical packaging building is shown in Fig. 4.

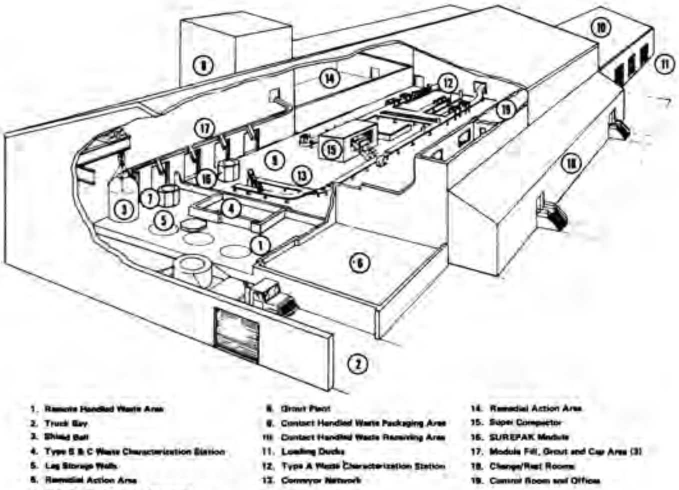

Fig. 4. Waste Packaging Building.

The waste packaging facility will typically be divided into two sections. One section will handle the high activity shipments received in shielded casks. As shown in Fig. 5, shield bells will be used to remove the waste packages from the cask. The packages will be remotely inspected and placed into the concrete modules. If the waste package does not conform to the manifest, it will be placed in a shielded cell.

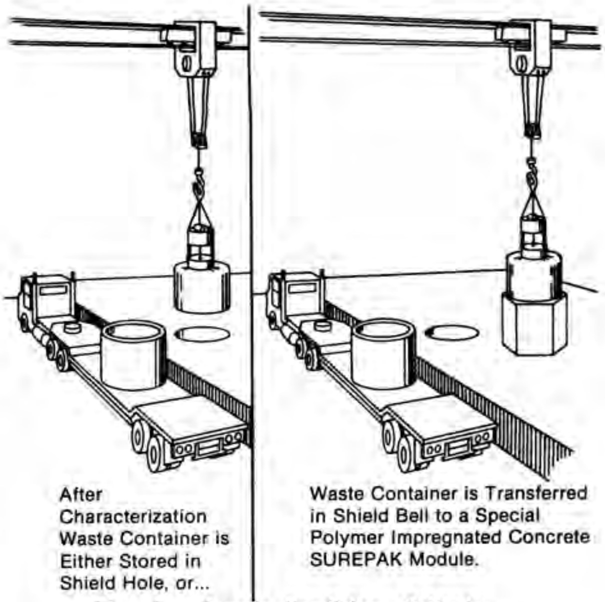

Fig. 5. Remote Handling of Waste.

The other section of the packaging building will handle waste received in shielded and unshielded vans. Even though the majority of this waste could be contact-handled, shielded forklifts, conveyors, remotely operated grapples, etc., will be used to reduce personnel exposure. This section of the facility will include a high force compactor to reduce the volume of drums containing compressible waste. This will greatly reduce the number of modules required and the use of space in the disposal unit. The compacted drums will be placed directly into the modules and grouted in place. Figure 6 shows a disposal module filled with compacted drums.

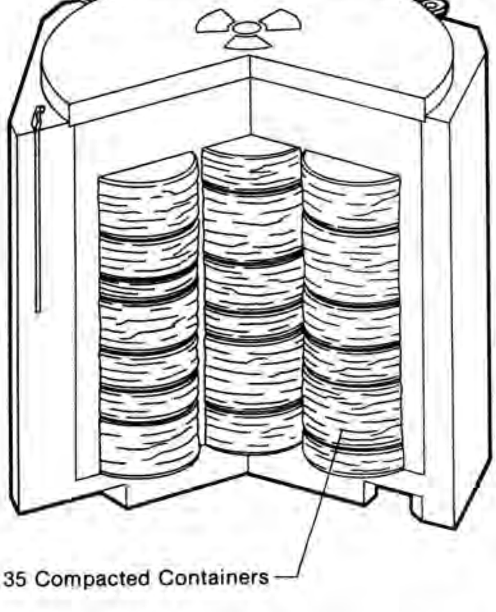

Fig. 6. Module Filled with Compacted Drums.

ECONOMICS

The cost of disposal using the modularized packaging system depends on the type and quantity of wastes, the cost of developing and licensing the facility, the cost of operating the facility, the cost of procuring and packaging the modules, the cost of decommissioning and monitoring and other factors. Each application must be considered individually. Table III lists the categories of low-level waste that would be received at a disposal facility.

TABLE III

Waste Categories

Category	Class	Radiation Level
1	A	< .1 R/hr
2	A	< .1 R/hr
3	A	.1-1 R/hr
4	A,B	1-10 R/hr
5	A,B,C	10-100 R/hr
6	A,B,C	100-1000 R/hr

An evaluation was made of the costs associated with designing, developing, licensing, operating and decommissioning a site in an arid environment handling about 450,000 cubic feet of waste per year. Table IV shows the disposal prices that would have to be charged to recover the costs, including a normal rate of return based on private investment. It is noted that prices are comparable to the prices now being charged at commercial shallow land burial facilities.

TABLE IV

Typical Pricing Structure
(Initial Year of Operation)

Waste Category	Percent Volume ($/CF)	Fixed Charges ($/CF)	Variable Charges* ($/CF)	Total ($/CF)
1	20.7	$13.30	$ 6.30	$ 19.60
2	34.2	$13.30	$ 11.52	$ 24.82
3	34.8	$13.30	$ 22.39	$ 35.69
4	6.6	$13.30	$ 24.56	$ 37.86
5	2.3	$13.30	$ 52.61	$ 65.91
6	1.2	$13.30	$158.94	$172.24

Composite Average $ 27.48

* Includes modules, grout, community aid, closure, insurance and return on investment.

SUMMARY

The modularized system for the disposal of low-level radioactive waste is an attempt to solve the problems that have been encountered in shallow land burial facilities. It attempts to overcome the public objections to low-level waste disposal in general and specifically to shallow land burial. It is an engineered system that strives to meet a complex set of needs. These include:

- Generators
  - Disposal at reasonable cost
  - Reliable source of disposal
- Regulators
  - Responsive compliance
  - Fully meet criteria
- Community
  - Maximum environmental protection
  - Beneficial involvement
- Elected Officials
  - Implementation of compacts
  - Satisfied constituency
- Future Generations
  - Avoidance of active maintenance, inadvertent impacts, or remediation.
- Licensee
  - Reasonable rate of return
  - Avoid abnormal business risks

REFERENCES

1. Hittman Nuclear & Development Corporation, "*Decommissioning Plan for the Maxey Flats Disposal Site, Task 3: Evaluation of Alternatives,*" WTSD-TME-019, December 1983.
2. Hill, D.B., and Dyer, J.A., "*An Analysis of Public Opinion on Low-Level Radioactive Waste Disposal in Selected Texas Counties,*" Public Policy Resources Laboratory, Texas A&M University, 1984.