EARTH-MOUNDED CONCRETE BUNKER DISPOSAL SYSTEM

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ABSTRACT

The DOE/EG&GI commissioned Ebasco Services Incorporated to develop a preliminary design of an American version of the Earth-Mounded Concrete Bunker (EMCB) LLW disposal concept. The paper describes Ebasco's conceptualization of an EMCB disposal system as applied to an actual northeastern U.S. site and disposing of representative U.S. commercial LLW. The preliminary design is the basis of submitting a prototype license application (Safety Analysis Report) to the NRC for review and comment. The prototype license application is a convenient vehicle which to accelerate the identification of potential licensing issues related to the first-of-its-kind disposal of LLW in engineered structures. Application of good engineering practice was used to develop a design to meet NRC's performance objectives and technical requirements for the near-surface disposal of LLW.

INTRODUCTION

Even though there is a national effort to develop new low-level radioactive waste (LLW) disposal sites and introduce engineered enhanced LLW disposal technology by 1993, no developer to date, has submitted a license application under U.S. Nuclear Regulatory Commission (NRC) Part 61. In order to facilitate the licensing process of actual facilities and to demonstrate the feasibility of engineered disposal concepts under Part 61, the U.S. Department of Energy (DOE) has supported a project to develop prototype license applications for two distinct engineered concepts. NRC review and comments on these prototype license applications will provide useful and practical guidance on the identification and resolution of important licensing issues pertaining to engineered disposal of LLW. A discussion of the project overview and objectives are presented in a separate paper (1). This paper describes one engineered concept, the Earth-Mounded Concrete Bunker (EMCB) System developed by Ebasco Services Incorporated for DOE (2).

The EMCB disposal concept is of great public interest because it represents the only engineered alternative disposal technology currently in use. This engineered disposal method is being practiced at Centre de la Manche, France and is the chosen technology for the next planned disposal facility at the Centre de l'Aube (3). The EMCB technology was developed in response to the French experience with traditional shallow land burial (SLB).

The EMCB disposal technology has the distinct advantage of having the capability of being deployed on a site with a shallow groundwater table. Avoidance of waste contact with water is a principal design criterion, therefore, situating the disposal units above the water table is required (though exception may be granted, 10 CFR 61.50(a)(7)). Because the EMCB concept is partially below-grade and partially above-grade, it can be deployed on sites with a shallow groundwater table. This feature permits greater freedom in the site selection process of a LLW disposal facility. In addition, EBASCO believes the EMCB concept is inherently more cost-effective than some other alternatives such as the Below Ground Vault concept because of less excavation, less concrete required, and easier construction.

DESIGN PHILOSOPHY

The design objective was to design an EMCB disposal system specifically to real northeast site conditions with representative U.S. commercial LLW. The facility is designed with a disposal capacity of 250,000 ft^3/ yr for an operational life of 30 years. The site location is assumed to satisfy the technical site suitability requirements in 10 CFR 61.50. The objective was not to imitate the French EMCB concept (because their site and waste conditions are different), but to produce an American EMCB concept custom-tailored to local conditions including American (i.e., NRC) regulatory requirements and guidance. The design was developed to satisfy only NRC Part 61 (4) requirements, not individual state requirements which may go beyond Part 61 requirements.

The EMCB disposal concept is defined here as an earth-covered engineered concrete structure. The engineered concrete structure is situated partially below-grade and partially above-grade. The concrete structure may be either a single vault or a combination tumulus and vault. In the latter case, a below-grade vault acts as a foundation for an above-grade concrete-covered tumulus. The dimensions and shapes of the EMCB structural components are specifically chosen to provide long-term structural stability.

It is part of the standard design philosophy to produce a cost-effective design, i.e., the design features must commensurate with the hazards involved. Since the vast majority of the waste (96% by volume) is Class A waste (the least radiological hazardous waste class), the basic disposal facility is designed for Class A waste disposal. However, the disposal systems responsible for the Class B and C wastes are specifically upgraded, commensurate with the higher hazards involved.

The NRC regulatory framework presents a waste classification that is based on the hazardous nature of the specific radionuclides and their concentration. This classification system has Class A waste as the least hazardous waste class, which is relatively harmless after 100 years of decay. Class C waste is the most hazardous, requiring a 500

year decay time to reduce the waste activity to acceptable levels.

Based upon this regulatory framework, the basic design philosophy of the disposal facility is to have two different types of disposal units. The Class A disposal units is designed for a 100-year design life, while the Class C disposal units is designed for a 500-year design life. All Class B waste is disposed of in the Class C disposal units for additional conservatism. The disposal units were designed and are to be constructed in a manner to assure their long integrity, consistent with the recommendations of the Army Corp of Engineers (5).

The disposal system is designed to have modular disposal units to permit interim closure of each unit as it is filled. Each disposal unit is individually monitored and incorporates a water collection and leak detection system. This modular feature facilitates potential remediation of the disposal unit or waste recovery efforts. The individual Class A disposal units are sized to the expected Class A waste volume to permit the frequent interim closure of units. The engineered soil cover is designed to prevent water infiltration into the disposal units.

The individual disposal units are constructed sequentially (as needed) in a planned cluster. When an entire cluster is completely filled with waste, the permanent (multi-layer) cap is constructed over the entire cluster.

GENERAL DESCRIPTION

The disposal facility is situated on a site of 165 acres. The restricted area for disposal operations occupies 65 acres, surrounded by a buffer zone, 500 ft wide. The disposal facility (Fig. 1) consists of eight EMCB clusters, four clusters for Class A waste and four clusters for Class B/C waste. The proposed facility design has all the necessary facilities to support the waste disposal operation, including: (a) temporary waste storage building (b) administration building, (c) access control building, (d) truck wash and inspection station, (e) maintenance building, and (f) retention ponds. A description of the key (and unique) design features are provided below.

Disposal Units For Class A Waste

The EMCB for Class A waste is shaped like a truncated pyramid. The engineered structure for the EMCB cluster is 360 ft. square and 28 ft. high. The structure consists of a 15 ft. high tumulus above a 13 ft.-high concrete vault. The concrete vault is completely filled and acts as a foundation for the tumulus.

The concrete vaults lay on a gravel drainage bed. The vault has 3 ft. thick concrete walls supported by concrete footings. The vault interior is partitioned into 60 ft. x 60 ft. disposal compartments with precast concrete block walls. The precast concrete blocks are 3 ft. high, 3 ft. wide, and 6 ft. long. The interior concrete partition walls lay on concrete footings. The vault is backfilled with concrete. When a compartment is filled, a 1 ft. thick concrete slab (with rebar) is installed over the vault compartment.

When the vault portion is completely filled (4.5 years), waste emplacement in the tumulus begins. The lower portion of the tumulus is backfilled with sand and the upper portion is backfilled with concrete. As each compartment of the tumulus is completed, it is capped with a 0.5 ft. thick concrete cap. When the entire tumulus is completely filled (4.5 years), an engineered interim cover system is installed over the disposal structure. The specified construction material is concrete made with Type II cement.

Disposal Units for Class B/C Waste

The EMCB for Class B/C waste is a concrete vault, partially below-grade and above-grade. The vault is approximately 100 ft. square and 20 ft. high. The Class B/C vault is modular, similar to the Class A vault.

The Class B/C vault has a concrete floor and lies on a gravel drainage bed. The vault has 3 ft. thick exterior and interior concrete walls. The interior walls partition the EMCB into 25 ft x 25 ft disposal compartments. All walls rest on concrete footings. The vault is backfilled with concrete. When a compartment is filled, a 1 ft. thick concrete slab (with rebar) is installed over the vault. When the entire vault is completely filled (8 years), an engineered interim cover system is installed over the disposal structure. The specified construction material is concrete made with Type II cement.

Covers

When each concrete structure is completely filled with waste, an interim engineered cover is immediately installed over the concrete structure. Figure 2 presents the details of the engineered cover. A 6 ft. thick cover is installed over Class A EMCB while an 8 ft. cover is installed over a Class B/C EMCB. The final site cover (at site closure) adds another 2 ft. of soil above the interim cover.

Above the concrete structure, the slope of the cover is 2 percent. Off the concrete structure, the slope of the cover is 5:1 (horizontal:vertical). The cover surface is stabilized with native grass vegetation.

Surface Water Control Features

The facility's surface water drainage system has several elements. Off-site water is directed away from the disposal facility by a drainage ditch and berm surrounding the facility. The design is consistent with the natural topography of the site.

The on-site drainage system is designed to direct water flow away from the disposal units and leave the facility by gravity, consistent with the site topography. During operations, any precipitation falling in a disposal unit is directed to a retention pond, where the water is sampled. If the water is found to be contaminated, it is treated prior to being released.

At site closure, the entire site is covered with additional soil and regraded to minimize flow velocities and prevent water erosion. The drainage ditches have a 6-in sand bed with a 1-ft thick riprap liner.

The drainage system is designed to handle a 100-year storm. If a worst kind of storm (i.e., PMP) occurs, no significant health impacts are expected. Temporary flooding is not expected to lead to irreparable damage. During the

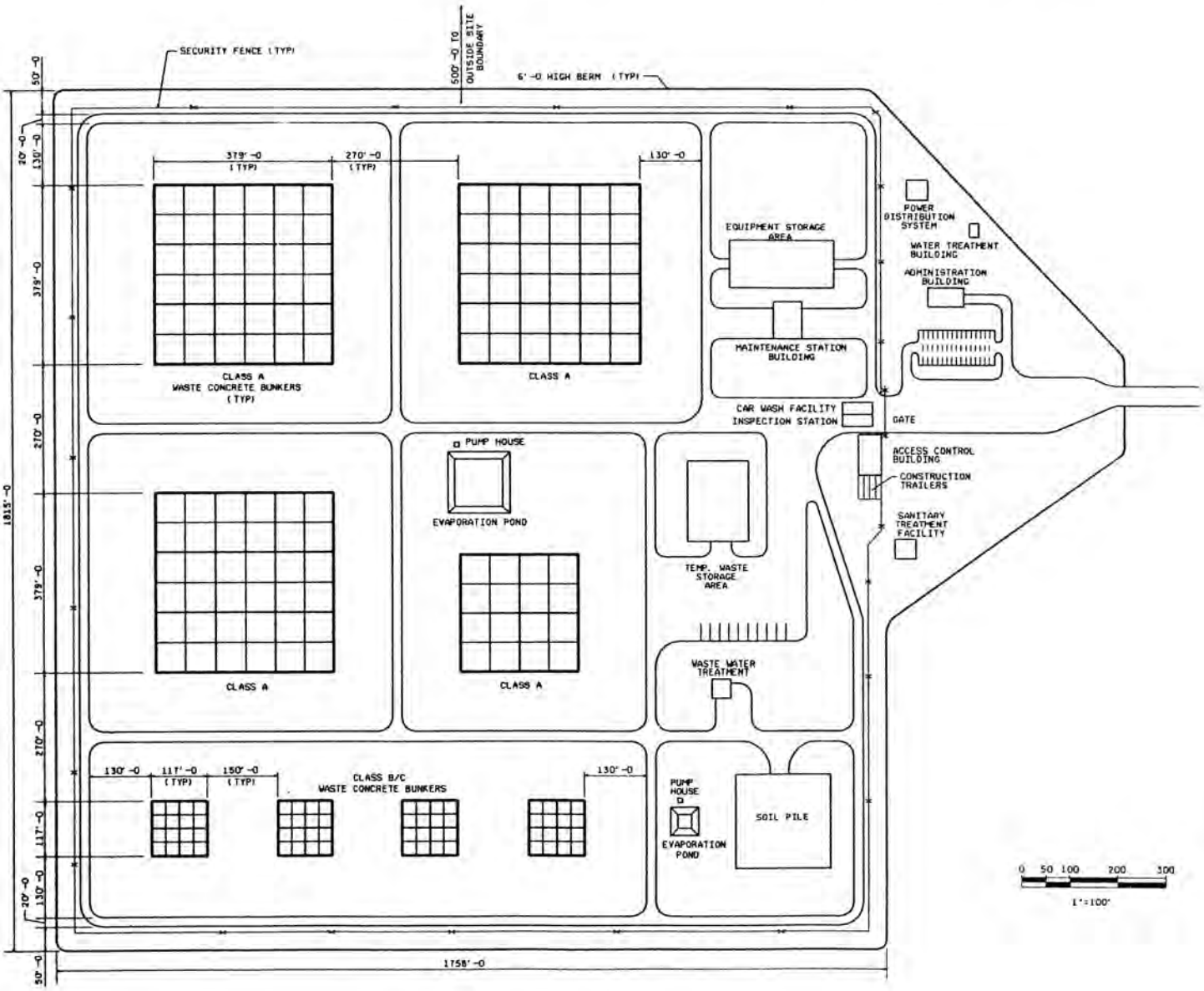

Fig. 1. Disposal Facility Site Plan.

operational period and the 100-year active institutional care period, repair to the drainage system is readily available. After the 100-year active institutional care period, the Class A EMCBs are not as important because the Class A waste has decayed to relatively harmless levels. The Class B/C EMCBs are fully expected to withstand the PMP without any significant release of radionuclides. Even if the top portion of the engineered cover is eroded, the bottom portion is expected to remain. As a last resort, the concrete roof is expected to remain intact.

Intruder Barrier

The human intruder barrier for the Class C waste is the concrete vault, which is backfilled with concrete. The roof of the vault is a 1-ft thick concrete slab (with rebar). The specified construction material is concrete with Type II cement. The engineered cover has a cobble layer to deter biointrusion. Since Class C waste may be located less than 5 m from the surface, the explicit engineered intruder barrier is required to have an effective life of 500 years.

Site Utilization Plan

Figure 1 shows a general arrangement of the disposal facility. An access road is constructed to connect the facility with the nearest state highway. The administration building and support facilities (e.g., power distribution, well water

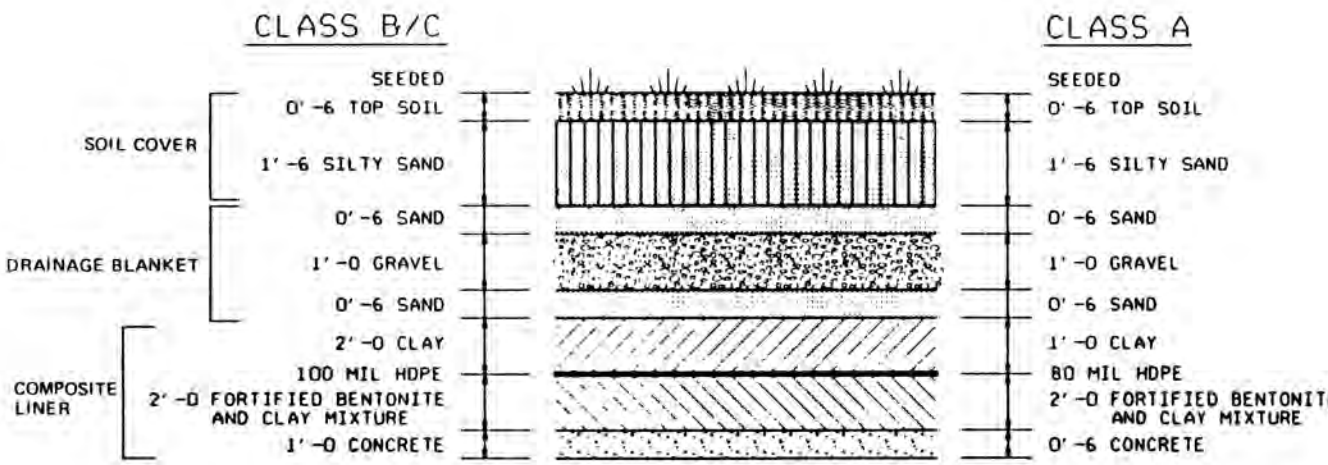

Fig. 2. Multi Layer Engineered Cover.

treatment, sanitary treatment, parking lot) are located outside the fenced-in and guarded restricted area. All personnel and vehicle access to the restricted area is through the front gate. The truck inspection station/truck wash is located just inside the gate. The front gate is controlled from the Access Control Building. Construction trailers are located adjacent to the Access Control Building.

Other support facilities include the equipment storage area, equipment maintenance building, waste water treatment, two evaporation/retention ponds, soil pile, and the temporary waste storage building (TWSB).

The clusters are separated by a minimum of 130 ft from each other and the site road system. This separation distance will assure that completed disposal units are not disturbed by ongoing disposal operations at nearby active disposal units. The facility's road system is constructed in phases, in parallel with the development of the EMCB clusters. The site drainage system is developed in parallel with the road system.

Completely surrounding the active disposal area is a perimeter berm and ditch to divert off-site precipitation from running on-site.

Temporary Waste Storage Building

The TWSB provides separate facilities to store both high activity and low activity waste. The primary function of the TWSB is to store high-activity waste until it is convenient to conduct waste disposal operations. Low activity waste is disposed of immediately upon arrival. However, the TWSB does have a two-week storage capacity for low activity waste in the event of a site contingency. The nominal design storage capacity for high-activity waste is two months. In addition, the TWSB has the capacity to repackage certain defective waste packages.

The high activity portion of the TWSB is constructed with a minimum of 2-ft thick concrete walls. The remaining portion of the building is constructed with sheet metal.

Support Facilities

The principal support facilities inside the restricted area are the Access Control Building and the waste water treatment facility. The Access Control Building supports many site functions, including facility security, Health Physics (HP) Laboratory, change rooms, offices, and a lunch/ meeting room. Transient construction workers of the EMCB are provided separate support facilities (e.g., construction trailers) abutting the Access Control Building.

The waste water treatment facility (located in the TWSB) consists of a cartridge filter and a mixed bed demineralizer. The treatment facility is intended to process waste water resulting from facility decontamination procedures, the truck wash, and active disposal units.

Utility Supplies and Systems

Off-site electricity and telephone lines are brought in along the access road. The facility's power distribution system (transformers) is located north of the administration building. Emergency electricity is provided by on-site diesel

generators. Diesel fuel is stored on site behind the administration building. The diesel fuel is channeled to the maintenance building by an underground pipeline.

The facility's water supply is from a well located in the buffer zone. The well water is filtered in the water treatment building, which is located north of the administration building. This water is of adequate quality and quantity to satisfy all anticipated water needs except laboratory requirements. Bottled water is used for laboratory requirements. Water usage at the facility is estimated at 6500 gallons/day. The well pump is designed for 100 gpm.

DISPOSAL OPERATIONS

All waste shipments are scheduled for convenience of the disposal operation. Upon arrival, shipments and waste manifest are inspected and checked for compliance. Normally, Class A waste are directed immediately to the disposal unit. Waste emplacement of Class A is conducted continuously in a planned sequence. Certain characteristics of the waste form affect their placement in the disposal unit. High activity waste are preferentially placed under low activity waste to minimize worker exposure. High-density waste are distributed evenly across the floor of the disposed unit to minimize differential settlement of the disposed unit. The emplaced waste is backfilled with concrete in the vault portion. In the tumulus, granular sand is used to backfill the lower portion of the tumulus, while concrete is employed in the upper portion.

Due to the limited amount of Class B or C waste, its disposal operation is conducted as a batch process. Such waste may be stored in the TWSB until sufficient volume is accumulated to complete the emplacement and backfill of an entire waste layer. Concrete is the backfill material in the Class B/C unit. Provisions to minimize worker exposure include the use of: (1) concrete shielding blocks, (2) earth berm surrounding an active disposal unit, and (3) remote operations with canes, camaras, etc.

As each disposal unit is completed, the concrete cover is installed. (Additional earth cover maybe added to reduce the surface radiation.) When an entire cluster is completed, the engineered cover is installed over the entire cluster. The concrete cylinder benchmarks denoting the location of disposal units are then installed.

At the end of commercial disposal operation, the facility's decontamination and decommissioning (D&D) is initiated. The remaining disposal units are closed after disposal of the facility's radioactive D&D waste. Other site closure activities includes: (a) partial dismantlement of the site perimeter berm, (b) D&D of retention ponds, and (c) installation of the final site cover.

COST ESTIMATE

The life cycle cost of this disposal facility is shown on Table 1. The estimates are in 1988 dollars. The annual operations cost includes a levelized annual construction cost for the EMCB structure. This cost estimate for EMCB disposal is comparable with the cost of other engineered disposal alternatives.

TABLE I

Cost Estimate EMCB Disposal Facility

DEVELOPMENT (6 year total)		Total $30,100,000
a.	land	700,000
b.	Licensing	10,800,000
c.	Property Development	7,100,000
d.	Buildings	8,200,000
e.	Equipment	3,300,000
OPERATIONS (Annual)Total		$ 7,300,000
a.	Salaries	2,700,000
b.	Bunker Cluster Construction	
	Class A	1,100,000
	Class B/C	400,000
c.	Administrative and Utility	400,000
d.	Maintenance Expenses	1,100,000
e.	Interest Expenses (1st year)	1,600,000
f.	Operator's Fee (and taxes)	- Not Included -
CLOSURE AND SURVEILLANCE (5 year total)		Total $ 8,000,000
LONG-TERM INSTITUTIONAL CARE (Annual)		Total $ 200,000

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