CONCEPTUAL DESIGN OF THE WELDON SPRING SITE DISPOSAL CELL: A MODIFIED VALUE ENGINEERING APPROACH

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ABSTRACT

A Modified Value Engineering approach was applied in the conceptual design of the disposal of low-level radioactive and chemically contaminated wastes at the Weldon Spring NPL Site. This approach has proved to be a successful design tool because it provides the designer with decisions on a preferred design alternative through a panel of experts in the early design stages, and it can be systematically applied to any design element that contains a number of alternatives. The preferred design of the disposal cell resulting from the MVE sessions is a single partially below-grade cell for all wastes from the site. The major cell components include a multi-component cover system, a perimeter encapsulation system, specific enplaced waste zones and a basal liner system with leachate collection and removal features.

INTRODUCTION

Remedial action at the Weldon Spring NPL Site includes on-site disposal of over 0.8 cubic meters (1 million cubic yards) of low-level radioactive and chemically contaminated wastes. The contaminated soils, sludges, concrete rubble, and metal debris are the result of past operations at a former DNT and TNT production facility and a former uranium feed materials plant, as well as current site cleanup operations. The Weldon Spring chemical plant site covers about 88 hectares (217 acres), as shown on Fig. 1. Until recently, the site was occupied by more than 40 buildings and structures, many of which have now been dismantled. Four raffinate pits and the Ash Pond still remain. The site is located about 48 kilometers (30 miles) west of St. Louis, Missouri, near the town of Weldon Spring in southwestern St. Charles County.

The on-site disposal cell has been designed to isolate the contaminated wastes from the environment, in compliance with federal and state requirements for long-term waste management. A major portion of the wastes, primarily the raffinate pit sludges, will be treated prior to disposal. Cement-based chemical stabilization/solidification (CSS) is the selected treatment process.

The functional requirements for on-site disposal include: 1) Containment of the wastes for up to 1,000 years, to the extent reasonable achievable, but, in any case, for at least 200 years, 2) reduction of the potential for human and animal intrusion into the waste, 3) isolation of the waste from the environment, and 4) protection of air and groundwater from future contamination.

Design considerations for a sound disposal cell include the location, type, size, and configuration of the cell. These parameters are affected by site conditions, waste volumes, waste characteristics, and the functional and performance requirements. The Weldon Spring disposal cell has been designed to contain 1.15 million cubic meters (1.5 million cubic yards) of waste, which is intended to accommodate a 50 percent contingency factor over current waste volume estimates. The layout of the proposed cell is shown in Fig. 1.

A unique feature of the design process was the adoption of a Modified Value Engineering (MVE) approach for the evaluation of alternatives for all key elements of the facility at the conceptual design level. The MVE approach allows the use of the opinions of a panel of "experts" in a rational, decision-tree procedure to establish the preferred alternative early in the design process. This greatly reduces the subjectivity of the decision making and the impact that an individual may have in the selection of a design alternative. The MVE approach is similar to the Value Engineering (VE) method widely used in large civil and defence design projects. The most significant difference is that "cost" was not the primary factor in the MVE process; greater emphasis is placed on technical and constructibility issues. The panel of experts, utilizing the already established procedures, helps to identify the various alternatives for consideration, established the evaluation criteria and determined the desired selection for each design element. Additional data needs and refinements required during final design has also been identified. The details and an example of the MVE process are discussed in the following sections.

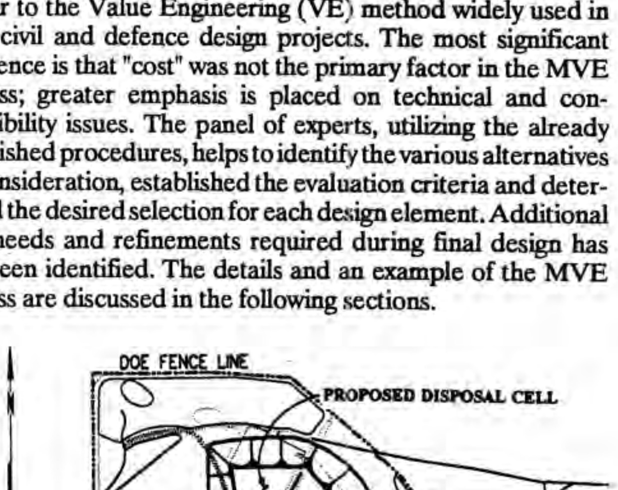

Fig. 1. Layout of proposed disposal cell.

MODIFIED VALUE ENGINEERING APPROACH

The Modified Value Engineering (MVE) process adopted for the Weldon Spring project is described below. To further illustrate and clarify the process, this discussion is followed by an example of an actual MVE session conducted during the conceptual design process.

The MVE process involves the following steps:

Step 1: A panel of three to eight members with expertise pertinent to the MVE subject is selected for each MVE session. The success of the process hinges greatly on the experience of the members of the panel. To achieve the maximum benefit from the process, the MVE panel should reflect a broad range of professional backgrounds: designers, field construction specialists and regulatory specialists, for example. A trained facilitator is designated, and this individual sets the schedule, provides guidance, and dictates the course of the session. A recording secretary is chosen among the participants to document the session's findings.

Step 2: The panel is introduced to the problem for which a solution is being sought. For instance, if remedial action for waste material is being investigated, the panel will be advised of the types and volumes of the wastes, the levels of contamination, and the applicable laws and regulations. Generally, pertinent references on the subject are made available to the panel for review before the MVE session takes place. In addition, designated consultants (not members of the panel) are made available to answer and clarify issues as required.

Step 3: Next, the panel initiates a brainstorming session to list all possible alternatives for solving the problem. A key element of this step is to encourage unrestricted imagination. Therefore, many ludicrous, unusual, and apparently unrealistic alternatives may be initially identified. However, an open discussion among the panel members is then initiated, and each of the alternatives is discussed with an eye to retaining only those which merit further consideration. For example, for the disposal of wastes, a possible alternative suggestion is the dumping of the wastes into the sea. Upon further examination, this option proves to be unfeasible and is dropped from the list of alternatives.

Step 4: This step establishes the criteria upon which alternatives will be evaluated. The criteria are ranked on the basis of their importance to the evaluation process, generally through open panel discussion. Similar to Step 3, all pertinent criteria are listed first, and upon further discussion, some may be deleted. Each criterion retained should be clearly defined to enable comparison and to identify the preference of one criterion over another. The preferences are then scored on a scale of 1 to 4. A score of 1 indicates no preference, and a score of 4 indicates more preference for one criterion over another. The score for each criterion is then totaled to establish the ranking, with the highest total score being the top ranked. Usually, only the top 5 or 6 criteria are retained, and the lower-ranked criteria are dropped. The score for each criterion will be used as relative weight in Step 5.

Step 5: This is essentially the final step in the evaluation process. Each of the alternatives developed in Step 3 is evaluated for each of the criteria established in Step 4. Points are allotted to an alternative based on how well it satisfies a particular criterion. Points range from a 5 for excellent (indicating there is excellent fulfillment of the particular criterion) to a 1 for poor. The points allocated by each panel member for each criterion are summed and averaged. If there is a wide discrepancy in the point allocation, further discussion takes place. In particular, if a member, or members, allots points that greatly differ from the allocation of other panel members, that member is asked to explain his or her reasoning, which generally results in further discussion. Subsequently, any member may change his or her scoring.

Once the entire process is completed, all points are tallied by a) multiplying the points allotted by the relative weight of the criterion and b) adding all the products for each alternative. The preferred alternative is the one with the highest total.

Step 6: This auxiliary step is carried out after the preferred alternative has been established in Step 5. The purpose is to serve as a "sanity check" for the entire MVE process. This sanity check is conducted by listing all the alternatives that have been evaluated (those retained after Step 3). The advantages and disadvantages of each alternative are then summarized, and the panel members take a second look at the alternatives to satisfy themselves that the preferred alternative established in Step 5 is clearly defensible. Or, if something has been overlooked, another alternative may be more preferable. This step also includes preparing a list that shows the uncertainties associated with the present MVE process because pertinent data are not available at the time of the session. It is implied that this additional data will be available before final design begins to establish the preferred alternative more firmly.

MVE PROCESS SUMMARY

The MVE process established as part the conceptual design process for the Weldon Spring project demonstrated the following advantages over a conventional process:

1. The decision reflects the combined thinking of individuals representing a wide range of technical and professional backgrounds. This helps to offset the inherent bias of one or two individuals who initiated the design process and whose ideas may become the final design.
2. The process offers a wide variety of options for discussion; therefore, new ideas that may have otherwise been ignored get due consideration. On some occasions, this may result in the selection of a suitable alternative that normally would not have even been considered.
3. Establishing and ranking criteria and evaluating each alternative against a given criteria offer a rational basis for the evaluation of an alternative, thereby removing, to a great extent, subjectivity in the selection process.

This MVE process also established that cost was not to be the main criterion, because it was recognized that environmental protection and safety cannot be compromised for cost. This modification is a departure from the traditional Value Engineering process commonly applied in the industry; hence, the process is called Modified Value Engineering. Cost, however, generally is considered during the process, reflected in items such as ease of construction, east of maintenance, and availability of material.

Finally, the MVE process has been adapted to a single-person MVE session (a panel of one) on numerous occasions. By employing the MVE process in this manner, the individual is forced to consider and evaluate various alternatives in a rational manner. This promotes the identification of alternatives and a establishes firmer basis for the selection of a particular alternative. It is recognized, however, that the results may still reflect some subjectivity based on the inherent biases and limitations of the individual.

ILLUSTRATION OF AN MVE

An actual MVE session conducted as part of the Weldon Spring conceptual design process is described below. To further illustrate the process, the session results, documented on the actual forms used, follow this discussion. The MVE session was held to determine the preferred number of cells for containing the Weldon Spring wastes, including the CSS-treated raffinate pit sludge which represents a significant portion of the waste volume.

A seven-member panel was identified (Step 1): three geotechnical engineers, two civil engineers, and two construction specialists. In addition, two consultants were identified to address specific concerns: a geologist with extensive knowledge of the site geology and a chemical engineer familiar with the CSS treatment process.

Specific data were presented that addressed previous studies on site geology, site suitability, regulations, and waste placement techniques (Step 2).

After some discussion, the following four alternatives were selected for further evaluation (Step 3):

1. Single cell for all wastes.
2. Two cells: one for mixed low-level radioactive soil and sludge and one for the concrete rubble and metal building debris.
3. Two cells: one for the CSS-treated waste and one for the remaining untreated wastes.
4. Single cell for all non-rubble waste, with rubble to be placed below grade outside the cell.

As part of Step 4, a large number of criteria were developed for consideration (Table I). After further discussions, the list was shortened and consolidated into 11 criteria. The 11 criteria (A through K) were then compared with one another by assigning a score to the preferred criteria, as shown in the tabulated form in Fig. 2. The raw score for each criteria is the sum of scored points from each criteria. This score is then used as the relative weight in the analysis in Step 5.

The results of Step 5 of this MVE session are illustrated in Fig. 3, which shows the form typically used to document MVE results. The results show that the totals for Alternatives 1 and 4 are close enough for both options to be rated as preferred alternatives.

The listing of advantages and disadvantages (Step 6 - sanity check) is presented in Table II. The sanity check does not reveal

	Criteria	Raw Score	Ranking of Criteria
A.	Ability to adjust volume	15.0	3
B.	Aesthetics	6.9	9
C.	Performance	33.5	1
D.	Worker exposure	24.6	2
E.	Constructability	13.5	4
F.	Surveillance & maintenance	9.6	7
G.	Land use	0	11 - out
H.	Simplicity of design	5.8	10
I.	Utilization of waste material	10.5	6
J.	Minimize construction material	12.0	5
K.	Sequencing	7.3	8

	B	C	D	E	F	G	H	I	J	K
A	A 2.5	C 3.2	D 2.7	E 2.6	A 2.5	A 4.0	A 2.0	A 2.4	A 1.6	K 1.0
B		C 3.3	D 2.7	E 1.0	B 1.0	B 2.9	H1 B1	B 1.0	J 1.6	B 1.0
C			C 3.6	C 3.0	C 3.7	C 4.0	C 2.9	C 3.6	C 3.3	C 2.9
D				D 1.8	D 3.0	D 3.3	D 2.9	D 3.1	D 2.9	D 2.2
E					E 3.0	E 3.3	E1 H1	J 1.0	J 1.6	E 2.6
F						F 2.9	F 2.7	F 2.3	J 2.0	F 1.7
G							H 2.8	I 3.3	J 3.9	K 4.0
H								I 3.0	H 1.0	K 2.3
I									I 1.2	I 2.0
J										J 2.9

How Important

4 - Major preference
3 - Medium preference
2 - Minor preference
1 - No preference, score one point for each letter.

NOTE:
Drop Criteria With A Raw Score of 2 or Less.

Fig. 2. Example criteria weighing process for number of cells.

TABLE I

Example for Possible Criteria for Evaluation of Numbers of Disposal Cells

1. Flexibility	18. Future land use
2. Adequate volume capacity	19. Height
3. Aesthetics	20. Mataerial balance
4. Regulatory compliance	21. Interior cell construction (radon flux, drainage)
5. Cost	22. Groundwater level - Impact on construction
6. Minimize settlement	23. Allows construction within aquifer
7. ALARA	24. Allow construction of cell while dismantling the chemical plant
8. Ease of construction	25. Schedule flexibility (start date)
9. Surveillance and maintenance	26. Need to have cell(s) to separate TSCA, RCRA, UMTRA, San. Landfill, LLW wastes.
10. Surface water control (including erosion)	27. Simplify design effort
11. Slope stability	28. Construction water control
12. Long term effect on groundwater	29. Optimize utilization of waste material
13. Geomorphic stability	30. Minimize volume of waste material
14. Availability of construction material	31. Minimize construction quantities
15. Availability of waste material (treatment schedule)	32. Minimize construction time period
16. Public perception	
17. Meets boundary limits (space of 1 vs. 4)	

any surprises, and the ratings developed in Step 5 are confirmed. Finally, the following items are identified as requiring further action before proceeding with final design:

- Discuss possible variance from Missouri requirements for material above the uppermost aquifer.
- Revisit study area boundary for cell layout.
- Revisit volume contingency for cell optimization.
- Obtain additional waste characterization data for site.
- Consider possible additional boring program outside the study area.
- Evaluate temporary structures regarding final use.
- Evaluate long-term need for water treatment plant.
- Revisit maximum height limit of 32.6 meters (74 feet).

FUNCTION BEING ANALZYED: CSS Alternative

Criteria	Rel. Wts.	Alternatives							
		1 Cell all mat'l		2 Cells, one for CSS, one for other waste		2 Cells, one for non-rubble waste, one for bldg. rubble		1 Cell, with rubble below grade outside of cell	
		1		2		3		4	
A. Ability to Adjust Volume	15	4	60	2	30	3	45	2	30
B. Aesthetics	6.9	4	28	3	21	3	21	4	28
C. Performance	33.5	4	134	2	67	3	101	4	134
D. Worker Exposure	24.6	3	74	4	98	4	98	4	98
E. Constructibility	13.5	4	54	3	41	4	54	4	54
F. Surveillance & Maintenance	9.6	4	38	3	29	3	29	3	29
G. Simplicity of Design	5.8	4	23	2	12	2	12	3	17
H. Simplicity of Design	10.5	2	21	1	11	1	11	1	11
I. Minimize Const. Material	12	4	48	2	24	3	36	5	60
J. Sequencing	7.3	3	22	3	22	4	29	4	29
TOTAL		502		355		436		490	
FINAL RANK		1		3		2		1	

Excellent - 5 Very Good - 4 Good - 3 Fair - 2 Poor - 1

Note: The two 1-Cell alternatives scored close enough to be both ranked 1.

Fig. 3. Example analysis matrix for number of cells.

THE RESULTING DISPOSAL CELL CONCEPTUAL DESIGN

The conceptual design of the disposal cell described below is the result of more than six major MVE sessions. The subjects for the sessions conducted include number and geometry of cells, above/below grade cell, perimeter system, cover system, liner system, internal cell configuration, cell foundation, integrated schedule for cell construction and others.

Based on the results of the MVE process, a single partially below-grade cell for all wastes is the preferred design. This design incorporates provisions for meeting the State's siting requirements for a waste disposal facility. Specifically, the State requires that a minimum of 9.1 meters (30 feet) of natural foundation material with a permeability no greater than 10^{-7} cm/sec separates the wastes from the uppermost regional aquifer. Alternatively, the State will accept a suitable natural foundation material with a thickness of at least 6.1 meters (20 feet) that provides an equivalent protection of 9.1 meters (30 feet) of 10^{-7} cm/sec permeability material against contaminant migration into the uppermost aquifer. The site is a suitable area for the disposal cell because the foundation materials include adequate thickness of relatively incompressible low-permeability soils consisting of the Ferrelview Formation and Clay Till soil units. In addition, the cell design promotes positive leachate drainage at the leachate collection retention basin for low maintenance.

Figure 4 presents a typical detailed schematic section of the disposal cell showing the various components (foundation,

TABLE II

Example Table on Advantages/Disadvantages for Sanity Check

PROJECT: Weldon Spring **TASK ITEM:** CDR - Cell Siting - Number of Cells

Initial Ranking	Selected Alternatives	Advantages	Disadvantages	Final Rating
1	Single Cell	Simplicity, Constructibility, Performance, maximum potential for use of waste, minimizes construction, material requirements, maximizes flexibility to adjust to volume changes in the limited area available. Simplifies surveillance and maintenance and surface water control. Reduces number of cells open at once.	· Must be designed for worst waste. · Worker protection must be for worst waste.	1
2	Two Cells, one for CSS one for other wastes.	· Allows separate designs for separate waste types, including possibility of going below grade. Easier to use different base elevations to best use existing topography. · Better for worker exposure.	· More complex construction required. · Requires more complex design especially regarding surface water control features. · Does not minimize construction material · Low ability to adjust to volume. · Performance worse than others in terms to stability, settlement, surface water control, erosion, infiltration.	3
3	Two Cells, one for non rubble wastes, one for building rubble.	· Same as above.	· Requires more complex design expecially regarding surface water content. · All other disadvantage as above, but to a lesser degree.	2
1	Place rubble below grade outside cell. Cell above grade for remaining waste. Rubble voids to be filled with smaller rubble pieces only.	Allows separation of rubble, eliminating need for special work of placing other wastes in voids of rubble. Greater flexibility, requiring less coordination of waste placement. Improves overall performance of disposal facility by: 1. Reducing potential for settlement of main cell. 2. Reducing volume of main cell which reduces infiltration and enhances stability. Also reduces worker exposure because rubble placement takes place in relative clean area. Minimizes construction material requirements due to reduced size of main cell and availability of excavation material or possibly better use of existing topography.	May require additional studies and negotiations to get state concurrence to go below grade, not have a liner, and use other less restrictive criteria. Area disturbed will be larger. Rubble area has initial potential for surface settlement and increased maintenance required. Design and construct additional cell. Reduced flexibility for expansion of cells.	1-Option

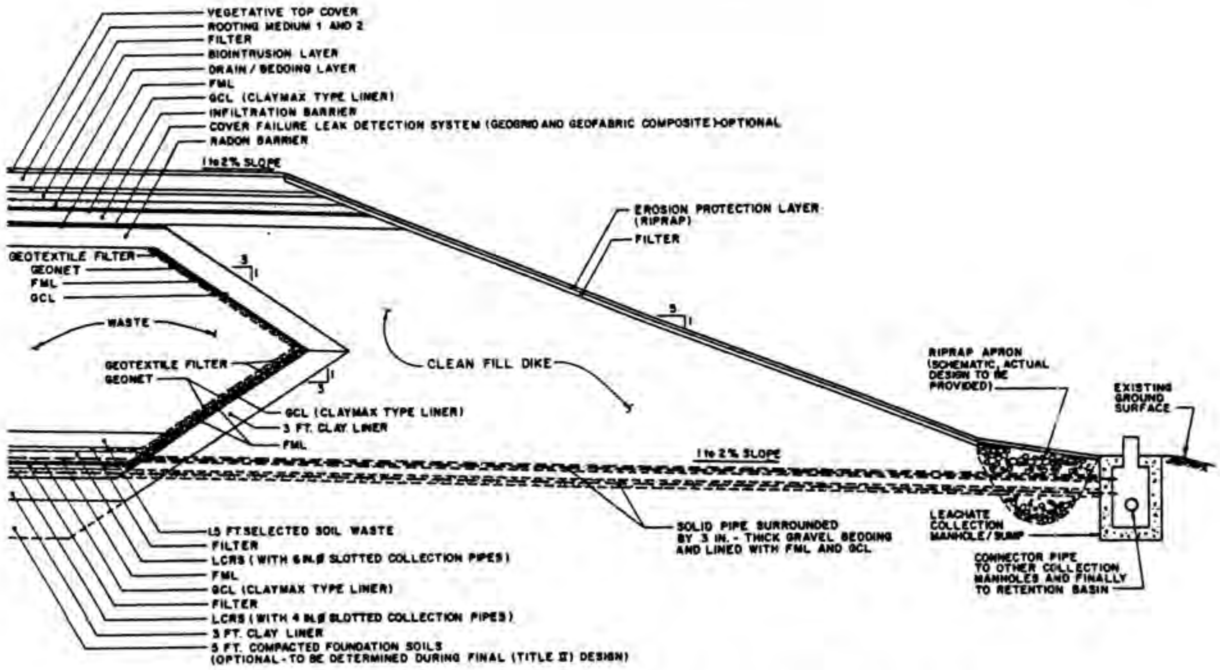

Fig. 4. Schematic section of disposal cell with various components.

leachate collection and removal systems, clean-fill dike, and cover). These major cell components, their related design features and governing criteria are listed in Table III.

A stepped cell bottom is featured to maximum the foundation excavation without violating the minimum thickness siting requirement. Immediately above the foundation bottom, and on the cell interior side slopes, a basal liner system will be installed to prevent leachate from escaping into the foundation. The basal liner, which consists of a combination of liners and leachate and collection and removal systems (LCRS), will collect and allow monitoring of the leachate generated. The leachate will be collected outside the cell in individual collection sumps/manholes that are connected to a leachate collection retention basis located outside the northern end of the cell.

Figure 5 presents the design concepts for the basal liner system. This double-liner system, featuring two leachate collection and removal systems, is the preferred alternative. In descending order, the basal liner system components are:

- Primary leachate collection and removal system
- Primary composite liner
    - Flexible membrane liner
    - Geosynthetic clay liner
- Redundant leachate collection and removal system
- Secondary composite liner
    - Flexible membrane liner
    - Compacted clay liner

Both CSS-treated and untreated wastes will be placed and stabilized within the cell in a controlled, engineered condition to support the cover system and to minimize settlement, volume occupancy, and radon emissions.

In addition to the basal liner system, the emplaced waste will be contained by a perimeter encapsulation system, referred to as the clean-fill dike, and covered with a multicomponent

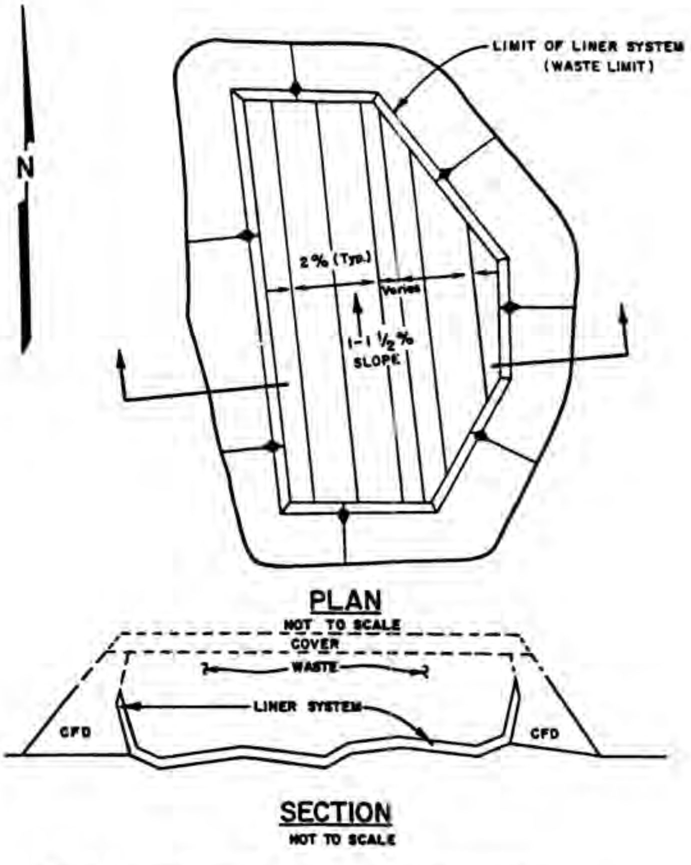

Fig. 5. Conceptual design for basal liner system.

TABLE III
Disposal Facility System Components

Disposal Cell Components	Design Features	Governing Criteria
Top Cover System - Vegetated Cover	• Vegetation provides long-term erosion resistance and self healing capability. Allow evaporation and transpiration of infiltrating moisture. • A rooting zone that also serves as protection for the radon/infiltration barrier. This zone also stores moisture until it can be evaporated or transpired by the vegetation. • A filter layer that prevents piping of rooting media soil into the underlying biointrusion barrier. Also provides thickness for frost protection. • A Biointrusion barrier consisting of coarse gravel that discourages burrowing animals, provides frost protection, acts as a capillary break for the upward migration of moisture, and provides rapid lateral drainage if the upper rooting zone becomes saturated. • A bedding layer to cushion the biointrusion barrier material from the geomembrane. • A geomembrane to prevent the infiltration of moisture into the disposal cell and to provide the same degree of transmissivity as the liner system. • A compacted clay radon and infiltration barrier that acts as the liner system. • A compacted clay radon and infiltration barrier that acts with the geomembrane to form a composite liner to reduce infiltration, and provides sufficient thickness to attenuate the radon.	• Minimize the amount of infiltration entering the waste. • Reduce the radon flux through the cover to ALARA, and applicable regulations. • Protect the waste from human, animal, and biological intrusion. • Prevent erosion and instability of the disposal cell. • Provide a cover with a permeability of at least as low as the lowest permeability element of the liner.
Clean Fill Dikes	• Rock erosion layer provides protection from surface water runoff on the steeper side slope. • Filter/bedding layer prevents plucking of the underlying clean fill dike material by interstitial flows in the rock erosion barrier. • Clean fill dike allows for deep root penetration of vegetation growing on the rock erosion layer, without penetrating the waste. • Dike configuration isolates the waste from the outer slopes of the disposal cell, decreasing the potential for instability affecting the waste. • Allows for increased infiltration through the rock cover, without contacting the waste. • Provides massive zone that decreases radon releases.	• Enhance stability of the disposal cell. • Protect the disposal cell from erosion due to natural forces. • Protect the waste from intrusion by humans, animals and plants. • Reduce the radioactive hazard of the waste to ALARA. • Reduce the potential of seepage exiting the sides of the disposal cell. • Allow for deep rooting of plants in the surface riprap. • Minimize the potential for differential settlement of the cover.
Waste	• Use of CSS or VIT treatment of selected wastes allows a stable cover to be constructed. • Use of CSS- or VIT-treated materials to encapsulate and fill voids of demolition debris. • CSS or VIT treatment retards movement of the hazardous constituents within the wastes for the disposal cell design life. • Homogeneous placement of debris on a macro scale (See Section 5.8.6.22) minimizes differential settlement. • Potential zonation of waste material to enhance internal cell drainage if infiltration occurs.	• Minimize differential settlement and/or subsidence of the cover. • Minimize the potential for leachate generation due to the exposure of waste to percolating water or vadose zone moisture flux. • Potential to provide pathways for moisture to move downward through the waste due to gravity.
Liner and Leachate Collection and Removal System	• Leachate collection and removal system collects water infiltrating during construction and after closure of the cell. Allows monitoring of cover tightness and leachate generation. • Geomembrane prevents leachate from exiting the cell and in combination with the underlying clay liner, minimizes the potential for leaks. • Clay liner retards the migration of leachate and provides geochemical attenuation of contaminants. • Vadose zone monitoring system provides leak detection. Access tubes for VMS provide secondary leachate collection.	• Collect the leachate generated during construction and after cell completion until leachate is no longer generated. • Retard the movement of leachate out of the disposal cell. • Prevent the movement of leachate from the disposal cell for as long as practicable by means of the FML components. • Potential for attenuation of the hazardous constituents in leachate.
Disposal Cell Foundation	• Although not technically part of the disposal cell, the foundation provides additional benefits for system performance. • The upper layer (3 to 5 feet) may be recompacted to provide a low permeability foundation and to uniformly repair damage cause by the site cleanup. • A total of at least 20 feet of natural foundation soil lies between the base of the cell and the uppermost aquifer. • A vadose zone monitoring system is placed in the foundation to monitor changes in moisture and quality of vadose flux below the cell. • The 30 feet of clay or its equivalent will act as a geochemical barrier to attenuate contaminants that might exit the bottom of the disposal cell.	• Provide a thickness of at least 20 feet of natural foundation soil with a permeability that provides an equivalent protection of 30 feet of 10^{-7} cm/sec permeability against contaminant migration into the uppermost regional aquifer. • Provide a zone for a vadose zone monitoring system.

cover. The term "clean fill" indicates that the dike will be constructed using uncontaminated soil. The clean-fill dike and cover system are designed to resist erosion; promote runoff; limit infiltration into the waste; minimize radon emissions; minimize long-term maintenance; minimize plant, animal, and human intrusions into the waste; and reduce the risk to human health and the environment.

The clean-fill dike is designed to provide stable, lateral containment of the entombed waste. The dike will have an exterior slope of 5(H):1(V) and an interior slope (dike-waste interface) of 3(H):1(V), and will have a large embankment cross section constructed with engineered fill. The surface of the outside slope will be riprapped to protect against erosion from the design storm, which is the probable maximum precipitation event. (The sloping surface may be vegetated if a lesser design storm is allow.) As a result, the clean-fill dike will be a very stable structure that prevents the escape of wastes and protects against erosion and biointrusion, including inadvertent intrusion by humans or animals.

The preferred top cover design is a multicomponent cover system. This system features various components, shown in Fig. 4. In descending order, the major components include:

- A vegetated top cover to protect against erosion caused by precipitation and to promote evapotranspiration.
- A filter and drain layer to segregate different materials and to promote drainage of infiltrated water.
- A biointrusion barrier to prevent intrusion of plant roots, humans and animals into the infiltration barrier below.
- A leak detection layer (optional) to monitor the effectiveness of the cover in preventing infiltration.
- An infiltration barrier to minimize infiltration.
- A radon barrier to limit radon emissions.

The preferred cell occupies a footprint area of about 29 hectares (72 acres), and the stepped cell bottom ranges from 1.5 to 3.7 meters (5 to 12 feet) below existing ground level. The emplaced waste is about 6.7 to 8.5 meters (22 to 28 feet) thick, the cover system about 3 meters (10 feet) thick, and the basal liner system 2 meters (6.5 feet) thick. The total cell thickness is therefore about 11.9 to 13.7 meters (39 to 45 feet). The height of the cell from the toe to the crest break line, averaged around the cell perimeter from adjacent finish grade, is about 13.1 meters (43 feet).

CONCLUSIONS

The MVE process provided a very attractive framework for the conceptual design of the disposal cell for the Weldon Spring site. The process allowed a large number of alternatives to be identified by a panel of experts for each key element of the cellearly in the design process. A great deal of the subjectivity generally inherent with the conventional design process could also generally be eliminated.

However, the success of the process depends greatly on the quality and variety of the backgrounds of the members of the MVE panel, as well as the atmosphere created by the facilitator to encourage a free flow of ideas. The application of the MVE process to the design of large, complex projects is greatly encouraged.

The conceptual design of the disposal cell meets the regulatory requirements, public expectations, engineering requirements, and cost-effectiveness for the disposal of the Weldon Spring wastes. It is expected that the conceptual deign has provided a firm basis for further fine-tuning during final design.