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Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Project Hanford Management Contractor for the
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INTRODUCTION

Background

An engineering evaluation/cost analysis (EE/CA) was performed at the Hanford Site's Plutonium Finishing Plant (PFP). The purpose of the EE/CA was to identify the sub-grade items to be evaluated; determine the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) hazardous substances through process history and available data; evaluate these hazards; and as necessary, identify the available alternatives to reduce the risk associated with the contaminants. [1]

The sub-grade EE/CA considered four alternatives for an interim removal action: (1) No Action; (2) Surveillance and Maintenance (S&M); (3) Stabilize and Leave in Place (Stabilization); and (4) Remove, Treat and Dispose (RTD). Each alternative was evaluated against the CERCLA criteria for effectiveness, implementability, and cost.

Purpose

Federal guidance does not specify a method for removal action alternatives analysis using CERCLA criteria. The Federal Register for the National Contingency Plan alludes to future development of a methodology for comparative analysis of alternatives against the CERCLA criteria, but guidance has yet to be prepared. There have been some good but complicated attempts recently for use by Remedial Investigation/Feasibility Studies of a multi-attribute preference theory in an effort to quantify the subjective elements of CERCLA criteria analysis.

Therefore, the PFP Subgrade EE/CA project team developed a qualitative-quantitative method, the specifics

of which are unique. This paper presents the method for potential use by others.

MODEL DEVELOPMENT

CERCLA Criteria

CERCLA requires that removal action alternatives be evaluated against three primary criteria: effectiveness and implementability, which are qualitative; and cost, which is quantitative. The challenge was to combine the three with a systematic evaluation method.

To provide a more comprehensive evaluation, the EE/CA divides the criteria of effectiveness and implementability into several subcategories. The removal action alternatives were evaluated against these criteria and subcategories specified below.

Criterion #1: Effectiveness, with subcategories of:

- o Protectiveness
 - Overall protection of human health and the environment
 - Protection of workers during implementation
 - Protection of the environment
- o Compliance with applicable federal and state laws and regulations (e.g., applicable or relevant and appropriate requirements)
- o Long-term effectiveness and permanence
- o Ability to achieve removal action objectives
- o Reduction of toxicity, mobility, or volume through treatment
- o Short-term effectiveness

Criterion #2: Implementability, with subcategories of:

- **Technical feasibility**
 - Construction and operational considerations
 - Demonstrated performance/useful life
 - Adaptable to environmental conditions
 - Contributes to remedial performance
 - Can be implemented quickly
- **Availability of equipment, personnel, services, and disposal**
 - Equipment
 - Personnel and services
 - Treatment and disposal services

Criterion #3 is Cost. There are no specified subcategories. For this EE/CA, activity-based cost estimates were conducted.

Approach and Method Development

The EE/CA team wanted to use a method that would combine the qualitative criteria of Effectiveness and Implementability with the quantitative criterion of Cost into an overall relative score for the alternatives. In addition, the team wanted to avoid the implied degree of precision with an often-used 1 to 10 grading approach.

Qualitative Criteria Grading

Expert judgment was used for relative scoring of the Effectiveness and Implementability criteria. Judgment was based on the characteristics of the alternatives as they relate to each criterion and subcategory. A key to the method was to score each subcategory with simple numerical values of +1, 0, or -1 for each alternative; or an "na" indicator could be assigned. Guidance for scoring is shown in Table I.

TABLE I. Scores Used for Grading.

Score	Guidance
1	The alternative is very effective or readily implemented
0	The alternative is somewhat effective or nominally implemented
-1	The alternative is ineffective or difficult to implement
na	The condition does not exist or the criterion is not relevant for the alternative

When "na" was assigned, the process ignored the score in the subsequent normalization steps. This is important because had a 0 been assigned, the results would be highly skewed. (This effect is similar to that observed by Richard Feynman, when serving on the California textbook selection committee, that a mathematics textbook scored with "blanks" ranked higher than the two other books to which it was being compared. [2])

An example of a scoring matrix for one of the alternatives that illustrates the scoring is shown in

Figure 1. The overall score for this alternative and criterion is obtained by averaging first by each row, then vertically for criteria with sub-elements, such as Technical Feasibility and Availability, and then separately for the elements of Effectiveness (scoring matrix not shown) and Implementability.

Cost Criterion Scoring

An activity-based cost estimate was performed for each of the alternatives. Because a low cost is favorable, and the method favors a high score, the reciprocal of the cost for each alternative was used prior to normalization as the initial score.

Combining the Scores

The individual "raw" scores were combined in a three-step process to arrive at an overall comparison of alternatives.

Step 1: Tabulating the raw scores for each alternative for the two qualitative criteria and the activity-based cost.

Step 2: Normalizing each criterion individually to a total score of 100. The inverse of the cost is used prior to normalization, as a high cost should result in a low score.

Step 3: Applying a weight to each criterion and summing the score for each alternative.

Weighting

To arrive at total scores for the alternatives, each criterion was assigned a weight of 33.3 percent; therefore each criterion was given equal weighting.

Calculations

The method was applied using conventional spreadsheets. The primary complexity was using a standard spreadsheet counting function to ignore the "na" entries when averaging scores.

RESULTS/LESSONS LEARNED

Overall Result

The overall result of this three-step process is shown in Table II. The S&M alternative scored highest.

Sensitivity Analyses

Regarding the criterion of cost, sensitivity analyses were conducted to verify that the results were not inadvertently skewed in favor of the lowest cost alternative. Three analyses were performed:

- Reduced mobilization costs for the Stabilization alternative and the three options within the RTD alternative. This reflects the estimating method that has multiple mobilizations because of the multiple sites.

Alternative 4 (RTD) Option A (All Slabs) Score = 0.10 of maximum of 1.00		Slabs		Pipelines		UPRs		Other	
		Other Slabs	Priority Slabs	Other Pipelines	Pipelines to 241-Z	Beneath Slabs	Beneath Pipe Trench	Ductwork	Injection Wells
II. Implementability									
A. Technical Feasibility									
a. Construction and operational considerations	-1	-1	0	-1	0	0	-1	0	
b. Demonstrated performance/useful life	na	na	na	na	na	na	na	na	
c. Adaptable to environmental conditions	na	na	na	na	na	na	na	na	
d. Contributes to remedial performance	1	1	1	1	1	1	1	1	
e. Can be implemented quickly	-1	-1	-1	-1	-1	-1	-1	-1	0
B. Availability									
a. Equipment	0	0	0	0	0	0	0	0	0
b. Personnel and services	0	0	0	0	0	0	0	0	0
c. Treatment and disposal services	1	1	1	1	1	1	1	1	1

Fig. 1. Qualitative Criterion Scoring Matrix

TABLE II. Overall Results.

Alternative	Scoring Result	Rank
One (No Action)	0	Last
Two (S&M)	31.2	First
Three (Stabilization)	19.2	Second
Four (RTD) Option A (All Slabs)	14.9	Fifth
Four (RTD) Option B (Priority Slabs)	16.0	Fourth
Four (RTD) Option C (No Slabs)	18.7	Third
Sum	100.0	

- o Eliminated S&M costs for the RTD alternative though it does not actually eliminate all S&M needs.
- o Reduced the importance (weight) of the cost criterion to 10% and increased the others to 45% each.

All sensitivity analyses ranked Alternative Two as first, demonstrating no bias.

Uniqueness of the Method

An extensive internet and literature search was conducted for EE/CA evaluation methods. The method described here appears to be unique in that nothing comparable was found. The method is simple and easy to use to compare removal action alternatives.

CONCLUSION

An EE/CA was performed to evaluate alternatives for a removal action to reduce hazards associated with the PFP sub-grade items. Specific guidance regarding the analysis of the performance of alternatives for removal actions was not found. Therefore, the analysis of the

alternatives for the sub-grade EE/CA was performed using a straightforward qualitative-quantitative model developed by the sub-grade EE/CA team. To test for subjective bias, a sensitivity analysis was also performed.

This model provides a method to evaluate alternatives for remedy selection in removal actions in a simple and unbiased fashion.

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