APPENDIX D
ENGINEERED ALTERNATIVES COST/BENEFIT STUDY REPORT ON PRIORITIZED ENGINEERED ALTERNATIVES FOR FURTHER ANALYSIS

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ENGINEERED ALTERNATIVES COST/BENEFIT STUDY REPORT ON PRIORITIZED ENGINEERED ALTERNATIVES FOR FURTHER ANALYSIS

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1.0 INTRODUCTION

This report documents the approach used to recommend a prioritized list of previously screened engineered alternatives (EA) for further analysis in the Engineered Alternatives Cost/Benefit Study (EACBS); this recommendation does not preclude further analysis of other screened engineered alternatives. The purpose and scope of the EACBS is outlined in the Engineered Alternatives Cost/Benefit Study Scoping Report (WID, 1995b). The specific approach used in screening engineered alternatives from an initial engineered alternatives candidate list is presented in the draft Engineered Alternatives Cost/Benefit Study Screening Report (WID, 1995a).

The EACBS Scoping Report outlines a general approach to screen alternatives. The approach consisted of a multi-disciplinary panel, a specified list of initial EA candidates, and a screening method to perform the screen. A multi-disciplinary panel of technical professionals facilitated the EA candidates for screening. This panel was designated as the Engineered Alternatives Screening Working Group (EASWG).

2.0 BACKGROUND

Fifty three EAs successfully passed the screening process. Analysis of EAs is a lengthy and costly process. Given limited resources, a management tool was needed to prioritize EAs for further analysis. A tool was developed and is presented in this report.

3.0 PRIORITIZATION PROCESS

Engineered Alternatives were prioritized to allow for the generation of detailed information of selected EAs through a focused analysis. This prioritization was done without eliminating any of the aspects of the engineered barrier study prescribed in proposed rule Title 40, Code of Federal Regulations (CFR), Part 194 (40 CFR 194) (EPA, 1995).

This was achieved by assessing each of the screened EAs for technological and regulatory feasibility, as well as effectiveness along four general categories of performance; gas generation, actinide solubility, permeability, and shear strength. Once the qualitative assessments were complete, a prioritization objective statement was developed. From this statement, the screening criteria were developed. Based on the criteria, a suite of EAs were retained for further analysis.

3.1 Qualitative Assessment of the Feasibility of Screened Alternatives

During the initial screening process (WID, 1995), the EASWG determined which EAs passed the definition and screening criteria for an EA. The results comprise 53 individual and combination EAs. In order to provide management guidance regarding the prioritization of EAs for analysis, further discrimination among the successfully screened EAs was required.

The discriminating criteria chosen for the prioritization process were regulatory feasibility and technological feasibility. An approach similar to that used in the 1991 Engineered Alternatives

Task Force (EATF) Final Report (DOE, 1991) was developed for the scoring process. The goal was to provide a relative feasibility score, independent of effectiveness, for each EA. The relative scores provided the input for a management to determine the prioritization of EAs for further analysis. The process assigned a score for technological feasibility, and a score for regulatory feasibility for each of the EAs under consideration by the same multi-disciplinary working group that performed the EA screening. Additionally, an independent facilitator ensured the scoring process had objectivity, help develop consensus within the working group, and maintained the process in accordance with the approach and scoring criteria.

Methodology

The methodology that was developed to score the EAs is described in Attachment D2. Attachment D2 provides the process description, basis for scoring, and example evidence that supports a given score. To assure that all EASWG members understood the meaning of "Regulatory and Technological Feasibility," definitions were provided, considered by the group, and agreed upon. The group evaluated the EAs on the basis of the current status of technology. The group concluded that, for the purpose of scoring, the relative importance or weighting of the regulatory and technology feasibility criteria was equal, and therefore gave each a relative weight of one-half of the total score.

A range of zero to five was used for both feasibility scores. A zero score is defined as not feasible, and the EA is then excluded from further analysis in the EACBS. The score of five is defined as an EA that requires no permitting to be implemented, or that the supporting technology is mature. A score of one is defined as one with a low expectation that the EA could be permitted, or that the technology is at bench or laboratory scale and not in use.

The calculation that provide the total feasibility score is:

$$F = (S_r)\cdot(W_r) + (S_t)\cdot(W_t)$$

Where F = Total weighted feasibility score or Feasibility Index

S_r = Regulatory feasibility score

W_r = Regulatory feasibility weighting (equal to .5)

S_t = Technology feasibility score

W_t = Technology feasibility weighting (equal to .5)

Each EA's score was deliberated until a consensus was formed. In some cases consensus could only be reached by allowing scores that were not whole numbers. This happened in a limited number of cases.

After all the relative scores had been developed, the EASWG went through a final review of the EA scores to determine whether the scores were realistic relative to each other. This resulted in a final list of individual EAs and their relative scores. Combinations of EAs were scored using the individual scores as a basis. Since a combination's feasibility is limited by the lowest scoring

EAs in the grouping, the lowest individual score for each feasibility criterion determined the score for the combination.

Results of the Scoring Process

Feasibility scores, rationale, and specific evidence for each EA score are shown in Attachment D3.

Results of the individual EA scoring process are shown in Attachment D4, and are sorted in a descending order of index feasibility score. The results show that EAs requiring the least amount of development, such as backfilling a waste room, have the highest feasibility, while EAs that require considerable development, such as acid digestion or wet oxidation, have the lowest feasibility.

3.2 Preliminary Assessment of the Effectiveness of Screened Alternatives

A preliminary qualitative assessment of effectiveness was determined for each of the 53 screened EAs shown in Attachment D1; this assessment provides a separate and independent process of the feasibility scoring process. This qualitative approach was efficient in that it provided an adequate level of information for consideration of each EA along several areas of effectiveness for the purpose of prioritizing analyses.

A qualified individual, with direct knowledge and involvement in the 1991 EATF, as well as knowledge of disposal system sensitive parameters, provided the assessments.

The assessment of effectiveness was combined with feasibility scores in an Effectiveness and Feasibility Matrix shown in Attachment D5. This matrix shows the results of a preliminary assessment of the effectiveness of screened engineered alternatives in terms of the following parameters:

- Gas generation
- Actinide solubility
- Waste stack permeability
- Human intrusion.

The significance of these parameters are discussed below.

Gas Generation

Gas may be generated by anoxic corrosion of metals (metallic waste and steel containers) and by microbial degradation of organic waste (paper, plastic, wood, etc.). The generation of low to moderate amounts of gas by the waste can improve performance by repressurizing the repository faster, thus minimizing the total amount of brine inflow. However, if gases are generated at rates that are greater that the rates at which gas can flow away from the repository, then the pressures that are significantly greater than lithostatic are predicted to occur. The physical response of a disposal room to excess pressure is highly uncertain. The room may respond by inflation, fracturing, or some combination of the two. Fracturing may manifest itself as generation of new fractures, or expansion of pre-existing fractures within clay and anhydrite layers. The main concern regarding high gas generation rates is that it introduces an uncertainty with respect to the long-term performance of the disposal system. Alternatives that reduce the rate of gas generation, or eliminate any potential of the particular gas generation mechanism entirely are noted in the matrix.

Actinide Solubility

One pathway considered for the release of radionuclides to the accessible environment is the dissolution of the radionuclides in brine that may come in contact with the waste, followed by transport of the contaminated brine to the accessible environment. Brine can be transported via fractures caused by excessive pressurization of the repository by gas generation, or by pathways created by human intrusions. A key factor controlling release of radionuclides by these mechanisms is the solubility of the radionuclides in brine. Solubility is defined in this case as the maximum mass of a given actinide element that can dissolve in a unit volume of brine of a specified composition. The solubilities of the actinide elements of concern are complex functions of several parameters, however, they all show similar behavior with respect to pH, showing a solubility minimum over a pH range of 8.5 to 10.

The ability of brine to transport radionuclides could be greatly reduced if the pH of any brine that accumulates in the repository is raised from the ambient value of around 6.1 to a value corresponding to the solubility minimum range. Alternatives that buffer the pH to a more favorable range by the addition of lime (calcium oxide, or CaO) or portland-type cement (which contains a major percentage of lime) to either the drum contents of backfill are noted as decrease in actinide solubilities.

Waste Stack Permeability

The permeability of the waste stack is a major factor in controlling the flow of contaminated brine in a waste disposal room toward a human intrusion drill hole that penetrates the room. Alternatives that reduce the permeability of the waste or backfill are noted in the matrix. Supercompaction provides only a slight decrease in permeability, whereas cementation or vitrification provides a large decrease in permeability.

Human Intrusion

One significant pathway for the release of radionuclides in response to human intrusion events is the direct removal of drill cuttings to the surface. The total volume of waste that is brought to the surface in response to a drilling event is equal to the volume of waste that is physically intercepted by the drill bit. This includes the value removed by the bit ($V=\pi r^2 h$), plus any waste surrounding the hole that spalls or erodes into the hole in response to the action of the bit or circulation of drilling mud. The first volume term is directly controlled by the radius of the bit, which is an assumed value. The second volume term is controlled in part by the shear strength of the waste. Alternatives that increase the shear strength of the waste or backfill are noted in the matrix.

3.3 Prioritization Goal and Objective Statements

To prioritize EAs while satisfying the intent of the engineered barrier study prescribed in proposed rule 40 CFR 194, and allowing for the generation of valuable information through a focused analysis of select EAs, the Waste Isolation Division (WID) of Westinghouse Electric Corporation developed a goal and objective statement as follows:

Goal

To ensure a broad spectrum of EAs have been identified for analysis in order to focus resources and efforts on pragmatic solutions to meeting the expected requirements of proposed rule 40 CFR 194.

Objective

To identify a list of engineered alternatives, either as discreet technologies or combinations of technologies, in which further analysis may be performed within the resources available.

3.4 Prioritization Criteria

Based on the goal and objective statements developed for the prioritization process, the WID developed the following steps for selecting specific EAs as recommended candidates for further analysis in the EACBS. The Effectiveness and Feasibility Matrix was the tool used for this selection.

1 At least one of the most effective EAs for each of the four impact areas (gas generation, solubility, permeability, and human intrusion) should be selected.

2 At least one of the most effective EAs from a broad spectrum effectiveness should be selected.

3 At least one high feasibility index EA for each of the four impact areas (gas generation, solubility, permeability, and human intrusion).

A given EA may be identified as potentially optimal for one or more of the criteria steps above. After accounting for the EAs identified in more than one of the criteria above, the final steps are as follows:

4 Identify and consider EAs that have technical merit but currently have no assessment along each of the four impact areas of gas generation, solubility, permeability, and human intrusion.

5 The balance of EAs shall be prioritized based on the feasibility index and broad spectrum effectiveness.

3.5 Developing the Recommended List of EAs

The criteria were applied to the list of screened and scored EAs shown in Attachment D5. The process was designed to maximize objectivity while minimizing subjectivity in the prioritization process. The selection of EAs for each of the criteria are shown in the following Tables D-1 through D-5.

TABLE D-1

SPECIFIC—MOST EFFECTIVE FOR EACH OF THE FOUR IMPACT AREAS (STEP 1)

Gas	Solubility	Permeability	Human Intrusion
#74 EATF Alternative 9—Vitrify sludges, shred and vitrify organics, melt metals with frit to partition actinides, salt aggregate grout backfill, change container material.	#94 SPM IT-9—Enhanced cement sludges, shred and add clay based material to organics and inorganics, salt aggregate grout backfill.	#10 Plasma Processing of All Waste	#10 Plasma Processing of All Waste

1 **TABLE D-2**

BROAD SPECTRUM—MOST EFFECTIVE (STEP 2)

# 10	Plasma Processing of All Waste
# 89	SPM IT-4 Enhanced cement sludges, shred and cement organics and inorganics, salt backfill with CaO.

1 **TABLE D-3**

SPECIFIC—HIGH FEASIBILITY (STEP 3)

Gas	Solubility	Permeability	Human Intrusion
# 95 SPM IT-10 Decontaminate surface of metallic waste for LLW disposal, change container material, salt aggregate grout backfill.	# 111 Clay Based Backfill	# 63 Change Waste Container Shape	# 12 Salt Backfill Around Drums and Waste Stack
# 111 Clay Based Backfill	# 83 Salt backfill with CaO	# 111 Clay Based Backfill	
		# 33 Salt Plus Clay Backfill	

1 **TABLE D-4**

TECHNOLOGICAL MERIT (STEP 4)

# 53	Seal Individual Rooms
# 60	Depressurize Castile Reservoir

1 **TABLE D-5**

BROAD SPECTRUM—HIGH FEASIBILITY (STEP 5)

12 Salt Backfill Around Drums and Waste Stack

63 Change Waste Container Shape

83 Salt backfill with CaO

95 SPM IT-10 Decontaminate surface of metallic waste for LLW disposal, change container material, salt aggregate grout backfill.

35 Salt Aggregate Grout Backfill Around Drums

75 EATF Alternative 10 - Decontaminate surface of metallic wastes for LLW disposal, no backfill, change container material and shape, 10x31x188 rooms.

After accounting for duplicates in the above tables, Table D-6 shows the recommended EAs for further analysis in the EACBS. A list of these recommended prioritized EAs with feasibility and effectiveness ratings is shown in Attachment D6.

4.0 SUMMARY

As part of the EACBS, 54 EAs successfully passed the screening process. Analysis of EAs is a lengthy and costly process. Given limited resources, a management tool was developed to prioritize EAs for further analysis. The objective of the management tool was to prioritize EAs while satisfying the intent of the engineered barrier study prescribed in proposed rule 40 CFR 194, and allowing for the generation of valuable information through a focused analysis of select EAs. Qualitative assessments of feasibility and effectiveness were made for each screened EA. A criteria, consistent with the goals and objectives of this prioritization, were developed and applied to the list of screened and scored EAs shown in Attachment D5. The results of this systematic process is a recommended list of EAs (Attachment D6) for further analysis in the EACBS.

TABLE D-6

RECOMMENDED PRIORITIZED EAs

ID Number	Description
# 10	Plasma Processing of All Waste
# 12	Salt Backfill Around Drums and Waste Stack
# 33	Salt Plus Clay Backfill
# 35	Salt Aggregate Grout Backfill Around Drums
# 53	Seal Individual Rooms
# 60	Depressurize Castile Reservoir
# 63	Change Waste Container Shape
# 74	**EATF Alternative 9** - Vitrify sludges, shred and vitrify organics, melt metals with frit to partition actinides, salt aggregate grout backfill, change container material.
# 75	**EATF Alternative 10** - Decontaminate surface of metallic wastes for LLW disposal, no backfill, change container material and shape, 10x31x188 rooms.
# 83	Salt backfill with CaO
# 89	**SPM IT-4** Enhanced cement sludges, shred and cement organics and inorganics, salt backfill with CaO.
# 94	**SPM IT-9** Enhanced cement sludges, shred and add clay based material to organics and inorganics, salt aggregate grout backfill.
# 95	**SPM IT-10** Decontaminate surface of metallic waste for LLW disposal, change container material, salt aggregate grout backfill.
# 111	Clay Based Backfill

APPENDIX D
ATTACHMENT D1

SCREENED ENGINEERED ALTERNATIVES—DESCRIPTION

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SCREENED ENGINEERED ALTERNATIVES—DESCRIPTION

The following is a listing of Engineered Alternatives that passed the screening process.

1	Supercompact Everything Except Sludges
2	Incinerate and Cement Solid Organic Waste
3	Shred and Vitrify Solid Organic Waste
4a	Wet Oxidation and Cement Solid Organic Waste
4b	Wet Oxidation and Vitrify Solid Organic Waste
5	Shred and Bituminize Everything Except Sludges
6	Shred and Compact Everything Except Sludges
7	Shred and Cement Everything Except Sludges
8	Shred and Cold Polymer Encapsulate Everything Except Sludges
9	Shred, add Salt and Compact Everything Except Sludges
10	Plasma Processing of All Waste
11a	Melt Metals into transuranic (TRU) waste ingots
11b	Melt Metals with Frit to Partition Actinides
12	Salt Backfill Around Drums and Waste Stack
15	Shred, Add Clay Based Material to Everything Except Sludges
16a	Acid Digestion and Cementation of Solid Organics
16b	Acid Digestion and Vitrification of Solid Organics
19	Add Lime to Solid Organic Waste
22	Decontaminate Surface of Metallic Wastes for low level waste (LLW) Disposal.
29	Microwave Melt Sludges
33	Salt Plus Clay Backfill
35	Salt Aggregate Grout Backfill Around Drums
36	Bitumen Backfill
38	Reduce Room Dimensions to Minimize Space Around Waste Stack
51	Change Mined Extraction Ratio
53	Seal Individual Rooms
60	Depressurize Castile Reservoir
63	Change Waste Container Shape
64	Change Waste Container Material
66	The 1991 Engineered Alternatives Task Forces Final Report (EATF Alternative 1 - Shred and cement organics and inorganics only, salt backfill.
67	EATF Alternative 2—Enhanced cement sludges, shred and cement organics and inorganics, salt backfill.
68	EATF Alternative 3—Enhanced cement sludges, shred and cement organics and inorganics, salt aggregate grout backfill.
69	EATF Alternative 4—Enhanced cement sludges, incinerate and cement organics, shred and cement inorganics, salt backfill.
70	EATF Alternative 5—Enhanced cement sludges, incinerate and cement organics, shred and cement inorganics, salt aggregate grout backfill.
71	EATF Alternative 6—Vitrify sludges, shred and vitrify organics, melt metals into TRU waste ingots, salt backfill.
72	EATF Alternative 7—Vitrify sludges, shred and vitrify organics, melt metals into TRU waste ingots, salt aggregate grout backfill.

73 EATF Alternative 8—Vitrify sludges, shred and vitrify organics, melt metals with frit to partition actinides, salt backfill, change container material.

74 EATF Alternative 9—Vitrify sludges, shred and vitrify organics, melt metals with frit to partition actinides, salt aggregate grout backfill, change container material.

75 EATF Alternative 10—Decontaminate surface of metallic wastes for LLW disposal, no backfill, change container material and shape, 10x31x188 rooms.

76 EATF Alternative 11—Supercompact organics and inorganics, salt backfill, monolayer of 2,000 drums in a 6x33x300 room.

77 EATF Alternative 12—Supercompact organics and inorganics, salt aggregate grout backfill, monolayer of 2,000 drums, in a 6x33x300 room.

78 EATF Alternative 13—Vitrify sludges, shred and vitrify organics, melt metals with frit to partition actinides, no backfill, alternate container, 10x31x188.

79 EATF Alternative 14—Supercompact organics, and inorganics, salt backfill, seal individual rooms, 2,000 supercompacted drums per room.

83 Salt backfill with CaO

87 Systems Prioritization Methodology (SPM) IT-2 Enhanced cement sludges, shred and cement organics and inorganics, salt backfill, change container material.

89 SPM IT-4 Enhanced cement sludges, shred and cement organics and inorganics, salt backfill with CaO.

90 SPM IT-5 Enhanced cement sludges, shred and compact organics and inorganics, salt backfill, 2,000 drum monolayer, 6x33x300 room.

92 SPM IT-7 Enhanced cement sludges, shred and compact organics and inorganics, salt backfill with CaO, 2,000 drums monolayer, 6x33x300 room.

93 SPM IT-8 Enhanced cement sludges, shred and add clay based material to organics and inorganics, salt backfill.

94 SPM IT-9 Enhanced cement sludges, shred and add clay based material to organics and inorganics, salt aggregate grout backfill.

95 SPM IT-10 Decontaminate surface of metallic waste for LLW disposal, change container material, salt aggregate grout backfill.

110 Enhanced Solidification of Sludges

111 Clay Based Backfill

APPENDIX D
ATTACHMENT D2

SCORING APPROACH

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ENGINEERED ALTERNATIVES SCREENING WORKING GROUP
SCORING APPROACH

Scoring Process Description

The working group is to assign feasibility scores for each EA. Feasibility is defined in terms of two attributes:

1) **Regulatory Feasibility**

Ease or difficulty of achieving federal and state regulatory compliance for implementation of an EA

The working group is to identify the activities required to obtain all necessary approvals and permits to implement and consider whether the EA technology has ever been permitted, the difficulties involved with obtaining permits, the time required to achieve regulatory compliance, and if significant, the cost of permitting.

2) **Technological Feasibility**

Technological feasibility of the EA

The working group is to consider the maturity of the technology that forms the basis for the EA, the level of difficulty required to reach technical maturity that would allow implementation of the EA.

Basis for Scoring

Scores resulting from this process provides a measure of relative feasibility for the EA with respect to each other, rather than assessing an absolute score. The guidelines below are intended to provide consistency during the scoring process

General Considerations

As you address each EA, the following considerations are provided to assist in structuring the thought process;

1) On a broad scale, what activities, processes, and facilities will be required to implement this EA, and/or to operate the waste disposal process with the EA incorporated.

2) Consider the evidence that exists that would give us confidence that we can successfully implement and/or operate the waste disposal process with this EA. Consider;

    a. Similar processes that have operated successfully

    b. Perceived complexities

    c. Magnitude of effort

d. Research and development status of technology

e Safety considerations.

APPENDIX D
ATTACHMENT D3

FEASIBILITY SCORES WITH RATIONALE

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FEASIBILITY SCORES WITH RATIONALE

EA #01 Description:
Supercompact everything except sludges

Regulatory Feasibility 4	Technical Feasibility 4.5
- Rocky Flats Plant (RFP) in interim status of Resource Conservation and Recovery Act (RCRA) Part B Permit - Not yet permitted	- Technology mature at RFP for transuranic (TRU) waste - RFP experience not necessarily transferrable - Not widely applied at other sites for TRU waste due to need - Widely used for low-level waste (LLW)

EA #02 Description:
Incinerate and cement solid organic waste

Regulatory Feasibility 2	Technical Feasibility 4
- Los Alamos National Laboratories (LANL) incinerator permitted (controlled air incinerator for hazardous) - Moratorium on new hazardous waste incinerators - Major effort required to permit future incinerator	- Technology mature for hazardous constituents—some engineering still required for TRU waste - SEG, Japan, and France commonly use for LLW - No TRU waste incinerator currently operating - Many examples of commercial incinerators used to destroy multiple waste streams

EA #03 Description:
Shred and vitrify solid organic waste

Regulatory Feasibility 2.5	Technical Feasibility 2
- Not yet permitted for TRU waste - Questions exist regarding ability to permit - U.S. Environmental Protection Agency (EPA) has favored vitrification as a waste form	- Vitrification of combustible solids a new technology - Bench Scale - Not applied to organics currently - France's (Marcoule Facility) currently making glass radioactive logs

EA #4a Description:
Wet oxidation and cement organic solid waste

Regulatory Feasibility 2	Technical Feasibility 1
- Technology never permitted - Safety considerations (high press. and high temp.) - Not enough information to score otherwise	- At bench-scale—questions exist regarding ability to handle all organic wastes - Safety issues - Currently used to treat organics in water

EA #4b Description:
Wet oxidation and vitrify organic solid waste

Regulatory Feasibility 2	Technical Feasibility 1
- Technology never permitted - Safety considerations (high press. and high temp.) - Not enough information to score otherwise	- At bench-scale—questions exist regarding ability to handle all organic wastes - Safety issues - Currently used to treat organics in water

EA #5 Description:
Shred and bituminize everything except sludges

Regulatory Feasibility 1	Technical Feasibility 3
- Low expectation that permit can be obtained—Safety has been questioned for commercial nuclear power plant applications - Never permitted	- Technology is mature but not applied to TRU waste - Development work required - Expect technology can be applied to TRU waste - Except for sludges, never been used for solid waste - Used in Japan for radioactive resins and sludges

EA #6 Description:
Shred and compact everything except sludges

Regulatory Feasibility 4	Technical Feasibility 4
- Never been permitted for TRU - It has been allowed for commercial LLW - Process will not require thermal/chemical treatment and attendant products - Permitting problems are not expected	- Commercial nuclear plants routinely use compaction of LLW - Shred and compact not being done for TRU waste—has not been demonstrated for TRU - Equipment readily available (off the shelf) from manufactures for commercial application

EA #7 Description:
Shred and cement everything except sludges

Regulatory Feasibility 4	Technical Feasibility 4
- Cementation of TRU sludges under interim status at U.S. Department of Energy (DOE) facilities - Not been done for solid TRU wastes - Process will not require thermal/chemical treatment and attendant products - Permitting problems are not expected	- Shred and cement not being done for TRU - LLW grouting being done at Hanford (J. Ward) - Possible German applications (J. Waters & N. Rempe) - Technology is off the shelf

EA #8 Description:

Shred and cold polymer encapsulation everything except sludges

May not be an effective treatment for RH

Regulatory Feasibility 4	Technical Feasibility 4
- Allowed for LLW under commercial power plant license - Not been done for solid TRU wastes - Process will not require thermal/chemical treatment of the waste and attendant products - Permitting problems are not expected	- LLW is being polymerized commercially - Not being done for TRU - Technology is off the shelf

EA #9 Description:

Shred, add salt and compact everything except sludges

Regulatory Feasibility 4	Technical Feasibility 4
- Compaction allowed for LLW - Not permitted for TRU - Permitting problems not expected	- Process is not being done for TRU - Equipment off the shelf - LLW compaction being done at power plants

EA #<u>10</u> Description:

Plasma processing of all waste

Regulatory Feasibility 2.5	Technical Feasibility 2
- Not yet permitted for TRU waste - Questions exist regarding permitability - Current Western Governors Association (WGA) considers this a promising technology - Cleaner technology than incinerate—lower level of off gas	- Beyond bench scale but not yet approaching mature technology - Commonly used for exotic metals refining - Pilot test completed for Pit 9, Idaho National Engineering Laboratory (INEL) application (simulated waste) - Design of a full scale unit is approx. 90% complete at INEL (Lockheed)

EA #<u>11a</u> Description:

Melt Metals

Regulatory Feasibility 3	Technical Feasibility 3
- Not yet permitted for TRU waste - Expect that permits could be obtained	- Technology is mature but not applied to TRU waste - Development work required - Expectation that technology can be applied to TRU waste

EA #11b Description:
Melt Metals with frit to partition actinides

Regulatory Feasibility 3	Technical Feasibility 3
- Not yet permitted for TRU waste - Expect that permits could be obtained - Potential for recycle as low level waste containers; perceived as a good thing to do	- Technology is mature but not applied to TRU waste - Development work required - Expectation that technology can be applied to TRU waste

EA #12 Description:
Salt backfill around drums and waste stack

Regulatory Feasibility 5	Technical Feasibility 5
- No permitting required - Original Final Safety Analysis Report (FSAR) already considers this process	- Mature - Equipment available - Operation understood

EA #15 Description:

Shred, add clay based material to everything except sludges

Regulatory Feasibility 4	Technical Feasibility 4
- Not permitted for radioactive waste - Permitting problems not expected - Process will not require thermal/chemical treatment and attendant products	- Shred and add clay process is not being done for TRU waste - Equipment off the shelf

EA #16a Description:
Acid digestion and cementation of solid organics

Regulatory Feasibility 2	Technical Feasibility 2
- Technology not been permitted - Disposition of (RCRA) hazardous constituents may be an issue - Not enough information to score otherwise	- 1972–1980 5,000 kg TRU processed with sulfuric acid at Hanford (pilot scale) - Current technology 180°C and 15 psig at bench (Savannah River Site [SRS]) - Belgium (recovery of Pu with sulfuric acid) and SRS experience with phosphoric acid (bench scale) - Feed requires shredding - Acid handling a commercial process - Development required for stabilization of residue, off gas systems, and spent acid treatment and disposal - Disposition of (RCRA) hazardous constituents during and after process unknown - Cementation of the resultant sludges has not been demonstrated

EA #16b Description:
Acid digestion and vitrification of solid organics

Regulatory Feasibility 2	Technical Feasibility 2
- Technology not been permitted - Disposition of (RCRA) hazardous constituents may be an issue - Vitrification not yet permitted for TRU waste - Questions exist regarding ability to permit vitrification - EPA has favored vitrification as a waste form - Not enough information to score otherwise	- 1972–1980 5,000 kg TRU processed with sulfuric acid at Hanford (pilot scale) - Current technology 180°C and 15 psig at bench (SRS) - Belgium (recovery of Pu with sulfuric acid) and SRS experience with phosphoric acid (bench scale) - Feed requires shredding - Acid handling a commercial process - Development required for stabilization of residue, off gas systems, and spent acid treatment and disposal - Disposition of (RCRA) hazardous constituents during and after process unknown - Cementation of the resultant sludges has not been demonstrated - Vitrification of combustible solids a new technology - Vitrification of solid organics at bench scale - Vitrification not applied to organics currently - France's (Marcoule Facility) currently making glass radioactive logs

EA #19 Description:
Add lime to solid organic waste

Regulatory Feasibility 4	Technical Feasibility 5
- May require a permit - Potential waste acceptance criteria and TRUPACT-II certification impact Chemical reaction Particulate	- Assumed that no shredding is required - This is a material handling process—no treatment technology involved - Aluminum would have to be removed for existing waste

EA #22 Description:
Decontaminate surface of metallic wastes for LLW disposal

Regulatory Feasibility 4	Technical Feasibility 5
- May require a permit - Expect permit to be obtained, if required	- Mature technology - Commonly used for alpha decontamination - Off-the-shelf technology

EA #29 Description:

Microwave melting of sludges

Regulatory Feasibility 3	Technical Feasibility 2
- Problems expected but permit can be obtained - Microwave technology generally accepted by public - WGA considers microwave melting a promising technology	- Unit operations only have been developed—complete systems (feed systems, and off gas systems) have not been developed - Has been demonstrated for radioactive waste

EA #33 Description:
Salt plus clay backfill

Regulatory Feasibility 5	Technical Feasibility 5
- No permitting required - Original FSAR does not explicitly consider this process	- Mature - Equipment available - Operation understood

EA #35 Description:
Salt aggregate grout backfill around drums

Regulatory Feasibility 5	Technical Feasibility 5
- No permits required - Only DOE requirements need to be satisfied	- Technology is mature - Brine saturated grouts used in mining and petroleum industry

EA #36 Description:
Bitumen backfill

Regulatory Feasibility 2	Technical Feasibility 5
- Will impact RCRA no-migration; large increase in a hazardous constituent - Uncertainty in safety requirements due to combustible nature - Major regulatory uncertainty	- Material handling technology is mature - Bitumen backfill used in Germany (J. Myers) Asse or Gorleben - Off-the-shelf equipment

APPENDIX D
ATTACHMENT D4

FEASIBILITY SCORES TABLE

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TABLE D4-1

FEASIBILITY SCORES TABLE

Primary Key: Index Feasibility				
Secondary Keys	Human Intrusion	Permeability	Actinide Solubility	Gas Generation
Alternative Numbers	12	35	35	35
▪	35	111	111	33
▪	33	33	33	111
▪	111	12	83	83
▪	83	83	12	12
▪	38	38	38	38
▪	95	63	95	95
▪	110	95	110	63
▪	19	110	19	75
▪	63	75	63	22
▪	75	22	75	51
▪	64	64	51	64
▪	51	51	64	19
▪	22	19	22	110
▪	60	53	60	60
▪	53	60	53	53
▪	77	77	77	77
▪	79	76	76	76
▪	76	79	79	79
▪	1	1	1	1
▪	89	89	89	89
▪	94	94	94	15
▪	93	92	93	67
▪	68	93	67	68
▪	67	90	68	87
▪	87	68	87	66
▪	92	67	92	7
▪	90	87	66	8
▪	66	66	7	94
▪	7	8	15	92
▪	9	7	90	93
▪	15	9	9	90
▪	8	15	8	9
▪	6	6	6	6
▪	36	36	36	36
▪	69	69	70	70
▪	70	70	69	69
▪	2	2	2	2
▪	11.2	11.2	11.2	11.2
▪	11.1	11.1	11.1	11.1
▪	29	29	29	29
▪	10	10	74	74
▪	74	74	72	73
▪	72	73	10	10
▪	73	72	73	72
▪	71	71	71	71
▪	78	78	78	78
▪	3	3	3	3
▪	16.2	5	16.1	16.2
▪	16.1	16.2	16.2	5
▪	5	16.1	5	16.1
▪	4.2	4.2	4.2	4.2
▪	4.1	4.1	4.1	4.1

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ATTACHMENT D5

PRELIMINARY QUALITATIVE ASSESSMENT OF EFFECTIVENESS AND FEASIBILITY

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No.	Engineering Alternative Title	Feasibility Index: Reg	Feasibility Index: Tech	Feasibility Index: Index	Gas Generation: Microbial: Solid Organics	Gas Generation: Anoxic Corrosion: Metallic Waste	Gas Generation: Anoxic Corrosion: Metallic Drums	Actinide Solubility: In Waste Stack: Solid Organics	Actinide Solubility: In Waste Stack: Solid Inorganics	Actinide Solubility: In Waste Stack: Sludges	Actinide Solubility: In Backfill: All Materials	Permeability: In Waste Stack: Solid Organics	Permeability: In Waste Stack: Solid Inorganics	Permeability: In Waste Stack: Sludges	Permeability: In Backfill: All Materials	Human Induced Events: Shear Strength: Solid Organics	Human Induced Events: Shear Strength: Solid Inorganics	Human Induced Events: Shear Strength: Sludges	Human Induced Events: Shear Strength: Backfill	External Drivers: Anything
	Relative Weight ->	0.5	0.5	1																
12	12 Salt Backfill Around Drums and Waste Stack	5	5	5	Small Decrease in Rate	Small Decrease in Rate	Small Decrease in Rate								Small Decrease	Small Increase	Small Increase	Small Increase	Increase	
33	33 Salt Plus Clay Backfill	5	5	5	Decrease Rate	Decrease Rate	Decrease Rate				Additional Actinide Sorption				Decrease				Increase	
83	83 Salt backfill with CaO	5	5	5	Decrease Rate	Decrease Rate	Decrease Rate				Decrease				Small Decrease				Increase	
36	36 Salt Aggregate Grout Backfill Around Drums	5	5	5	Decrease Rate	Decrease Rate	Decrease Rate				Decrease				Decrease				Increase	
38	38 Reduce Room Dimensions to Minimize Space Around Waste Stack	5	5	5	May Reduce Rate	May Reduce Rate	May Reduce Rate													
111	111 Clay Based Backfill	5	5	5	Decrease Rate	Decrease Rate	Decrease Rate				Additional Actinide Sorption				Decrease				Increase	
51	51 Change Mined Extraction Rate	4	5	4.5	May Reduce Rate	May Reduce Rate	May Reduce Rate													Enhances Closure
63	63 Change Waste Container Shape	4	5	4.5	Decrease Rate	Decrease Rate	Decrease Rate					Decrease	Decrease	Decrease						
19	19 Add Lime to Solid Organic Waste	4	5	4.5	Decrease Rate			Decrease												
53	53 Seal Individual Rooms	4	5	4.5																
64	64 Change Waste Container Material	4	5	4.5			Eliminates Potential													
75	75 EATF Alternative 10 - Decontaminate surface of metallic wastes for LLW disposal, no backfill change container material and shape, 100X1X100 rooms	4	5	4.5		Eliminate Potential	Eliminate Potential													
95	95 SPM II 10 Decontaminate surface of metallic waste for LLW disposal, change container material, salt aggregate grout backfill	4	5	4.5		Eliminate Potential	Eliminate Potential				Decrease				Decrease				Increase	
110	110 Enhanced Solidification of Sludges	4	5	4.5						Decrease				Small Decrease				Increase		
72	22 Decontaminate Surface of Metallic Wastes for LLW Disposal	4	5	4.5		Eliminate Potential														
80	80 Depressurize Castile Reservoir	4	5	4.5																Reduce Brine Volume in E1 and E1E2 Scenarios
1	1 Supercompact Everything Except Sludges	4	4.5	4.25	May increase rate and potential	May increase rate and potential						Small Mechanical Decrease	Small Mechanical Decrease			Increase	Increase			
77	77 EATF Alternative 12 - Supercompact organics and inorganics, salt aggregate grout backfill, monolayer of 2000 drums in a 100X100 room	4	4.5	4.25	Decrease Rate	Decrease Rate	Decrease Rate				Decrease	Decrease	Decrease		Decrease	Increase	Increase		Increase	
76	76 EATF Alternative 11 - Supercompact organics and inorganics, salt backfill, monolayer of 2000 drums in a 100X100 room	4	4.5	4.25	Decrease Rate	Decrease Rate						Decrease	Decrease		Decrease	Increase	Increase		Increase	
79	79 EATF Alternative 14 - Supercompact organics, and inorganics, salt backfill, seal individual rooms, 2000 supercompacted drums per room	4	4.5	4.25	Decrease Rate	Decrease Rate						Decrease	Decrease		Decrease	Increase	Increase		Increase	
94	94 SPM II 9 Enhanced cement sludges, shred and add clay based material to organics and inorganics, salt aggregate grout backfill	4	4	4			Decrease Rate	Additional Actinide Sorption	Additional Actinide Sorption	Decrease	Decrease	Decrease	Decrease	Decrease	Decrease	Increase	Increase	Increase	Increase	
67	67 EATF Alternative 2 - Enhanced cement sludges, shred and cement organics and inorganics, salt Backfill	4	4	4	Decrease Rate	Decrease Rate		Decrease	Decrease	Decrease		Decrease	Decrease	Small Decrease	Decrease	Increase	Increase	Increase	Increase	
68	68 EATF Alternative 3 - Enhanced cement sludges, shred and cement organics and inorganics, salt aggregate grout backfill	4	4	4	Decrease Rate	Decrease Rate		Decrease	Decrease		Decrease	Decrease	Decrease	Small Decrease	Decrease	Increase	Increase	Increase	Increase	
90	90 SPM II 6 Enhanced cement sludges, shred and compact organics and inorganics, salt backfill, 2000 drum monolayer, 100X100 room	4	4	4						Decrease		Decrease	Decrease	Decrease	Decrease	Increase	Increase	Increase	Increase	
93	93 SPM II 8 Enhanced cement sludges, shred and add clay based material to organics and inorganics, salt backfill	4	4	4				Additional Actinide Sorption	Additional Actinide Sorption	Decrease		Decrease	Decrease	Decrease	Decrease	Increase	Increase	Increase	Increase	
92	92 SPM II 7 Enhanced cement sludges, shred and compact organics and inorganics, salt backfill with CaO, 2000 drums monolayer, 100X100 room	4	4	4			Decrease Rate			Decrease	Decrease	Decrease	Decrease	Decrease	Decrease	Increase	Increase	Increase	Increase	
89	89 SPM II 4 Enhanced cement sludges, shred and cement organics and inorganics, salt backfill with CaO	4	4	4	Decrease Rate	Decrease Rate	Decrease Rate	Decrease	Decrease	Decrease	Decrease	Decrease	Decrease	Decrease	Decrease	Increase	Increase	Increase	Increase	
86	86 EATF Alternative 1 - Shred and cement organics and inorganics only, salt backfill	4	4	4	Decrease Rate	Decrease Rate		Decrease	Decrease			Decrease	Decrease		Decrease	Increase	Increase		Increase	
6	6 Shred and Compact Everything Except Sludges	4	4	4	May increase rate and potential	May increase Rate and potential						Small Decrease	Small Decrease			Small Increase	Small Increase			
9	9 Shred, add Salt and Compact Everything Except Sludges	4	4	4	May Increase Rate and Potential	May Increase Rate and Potential						Decrease	Decrease			Increase	Increase			
87	87 SPM II 3 Enhanced cement sludges, shred and cement organics and inorganics, salt backfill, change container material	4	4	4	Decrease Rate	Decrease Rate		Decrease	Decrease	Decrease		Decrease	Decrease	Decrease		Increase	Increase	Increase	Increase	
15	15 Shred, Add Clay Based Material to Everything Except Sludges	4	4	4	Decrease in Rate	Decrease in Rate	Decrease in Rate	Additional Actinide Sorption	Additional Actinide Sorption			Decrease	Decrease			Small Increase	Small Increase			
7	7 Shred and Cement Everything Except Sludges	4	4	4	Decrease Rate	Decrease Rate		Decrease	Decrease			Decrease	Decrease			Increase	Increase			
8	8 Shred and Cold Polymer Encapsulate Everything Except Sludges	4	4	4	Decrease Rate, Increase Potential	Decrease Rate						Large Decrease	Large Decrease			Small Increase	Small Increase			
35	35 Bitumen Backfill	2	5	3.5	Increase Potential	Decrease Rate	Decrease Rate								Large Decrease				Increase	
70	70 EATF Alternative 6 - Enhanced cement sludges, incinerate and cement organics, shred and cement inorganics, salt aggregate grout backfill	2	4	3	Eliminate Potential	Decrease Rate		Decrease	Decrease		Decrease	Decrease	Decrease	Small Decrease	Decrease	Increase	Increase	Increase	Increase	
69	69 EATF Alternative 4 - Enhanced cement sludges, incinerate and cement organics, shred and cement inorganics, salt backfill	2	4	3	Eliminate Potential	Decrease Rate		Decrease	Decrease			Decrease	Decrease	Small Decrease	Decrease	Increase	Increase	Increase	Increase	
2	2 Incinerate and Cement Solid Organic Waste	2	4	3	Eliminate			Decrease				Decrease				Increase				
11.1	11a Melt Metals into TRU Waste Ingots	3	3	3		Decrease Rate														
11.2	11b Melt Metals with Fe to Partition Actinides	3	3	3		Eliminate Potential														
29	29 Microwave Melt Sludges	3	2	2.5	Decrease Available Water	Decrease Available Water	Decrease Available Water			May Increase Solubility, Decrease Leachability				Large Decrease				Large Increase		
3	3 Shred and Vitrify Solid Organic Waste	2.5	2	2.25	Eliminate							Large Decrease				Large Increase				
71	71 EATF Alternative 5 - Vitrify sludges, shred and vitrify organics, melt metals into TRU waste ingots, salt backfill	2.5	2	2.25	Eliminate Potential	Decrease Rate				Increase Solubility but Decrease Leach Rate		Decrease	Decrease	Decrease	Decrease	Increase	Increase	Increase	Increase	
72	72 EATF Alternative 7 - Vitrify sludges, shred and vitrify organics, melt metals into TRU waste ingots, salt aggregate grout backfill	2.5	2	2.25	Eliminate Potential	Decrease Rate				Increase Solubility but Decrease Leach Rate	Decrease	Decrease	Decrease	Decrease	Decrease	Increase	Increase	Increase	Increase	
73	73 EATF Alternative 8 - Vitrify sludges and vitrify organics, melt metals with Fe to partition actinides, salt backfill, change container material	2.5	2	2.25	Eliminate Potential	Eliminate Potential	Eliminate Potential			Increase Solubility but Decrease Leach Rate		Decrease	Decrease	Decrease	Decrease	Increase	Increase	Increase	Increase	
10	10 Plasma Processing of All Waste	2.5	2	2.25	Eliminate Potential	Decrease Rate		Decrease Leachability	Decrease Leachability	May Increase Solubility, Decrease Leachability		Large Decrease	Large Decrease	Large Decrease		Large Increase	Large Increase	Large Increase		
74	74 EATF Alternative 9 - Vitrify sludges, shred and vitrify organics, melt metals with Fe to partition actinides, salt aggregate grout backfill, change container material	2.5	2	2.25	Eliminate Potential	Eliminate Potential	Eliminate Potential			Increase Solubility but Decrease Leach Rate	Decrease	Decrease	Decrease	Decrease	Decrease	Increase	Increase	Increase	Increase	
78	78 EATF Alternative 13 - Vitrify sludges and vitrify organics, melt metals with Fe to partition actinides, no backfill, alumina container, 100X1X100	2.5	2	2.25	Eliminate Potential	Decrease Rate				Increase Solubility but Decrease Leach Rate		Decrease	Decrease	Decrease		Increase	Increase	Increase		
16.2	16b Acid Digestion and Vitrification of Solid Organics	2	2	2	Eliminate Potential							Large Decrease				Large Increase				
16.1	16a Acid Digestion and Cementation of Solid Organics	2	2	2	Eliminate Potential			Decrease				Decrease				Increase				
5	5 Shred and Bituminize Everything Except Sludges	1	3	2	Decrease Rate, Increase Potential	Decrease Rate						Large Decrease	Large Decrease			Small Increase	Small Increase			
4.1	4a Wet Oxidation and Cement Solid Organic Waste	2	1	1.5	Eliminate			Decrease				Decrease				Increase				
4.2	4b Wet Oxidation and Vitrify Solid Organic Waste	2	1	1.5	Eliminate			Decrease				Large Decrease				Large Increase				

APPENDIX D
ATTACHMENT D6

PRIORITIZED EAs FOR FURTHER ANALYSIS

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Engineering Alternative Title	Feasibility Index: Reg	Feasibility Index: Tech	Feasibility Index: Index	Gas Generation: Microbial — Solid Organics	Gas Generation: Anoxic Corrosion — Metallic Waste	Gas Generation: Metallic Drums	Actinide Solubility: In Waste Stack — Solid Organics	Actinide Solubility: In Waste Stack — Solid Inorganics	Actinide Solubility: In Waste Stack — Sludges	Actinide Solubility: In Backfill — All Materials	Permeability: In Waste Stack — Solid Organics	Permeability: In Waste Stack — Solid Inorganics	Permeability: In Waste Stack — Sludges	Permeability: In Backfill — All Materials	Human Initiated Events: Shear Strength — Solid Organics	Human Initiated Events: Shear Strength — Solid Inorganics	Human Initiated Events: Shear Strength — Sludges	Human Initiated Events: Shear Strength — Backfill	External Drivers: Anything
Relative Weight >	0.5	0.5	1																
33 Salt Plus Clay Backfill	5	5	5	Decrease Rate	Decrease Rate	Decrease Rate	-	-	-	Provide Additional Actinide Sorption	-	-		Decrease	-	-	-	Increase	-
12 Salt Backfill Around Drums and Waste Stack	5	5	5	Small Decrease in Rate	Small Decrease in Rate	Small Decrease in Rate	-	-	-	-		-		Small Decrease	Small Increase	Small Increase	Small Increase	Increase	
35 Salt Aggregate Grout Backfill Around Drums	5	5	5	Decrease Rate	Decrease Rate	Decrease Rate	-	-	-	Decrease	-	-		Decrease	-	-	-	Increase	-
111 Clay Based Backfill	5	5	5	Decrease Rate	Decrease Rate	Decrease Rate	-	-	-	Provide Additional Actinide Sorption	-	-	-	Decrease	-	-	-	Increase	
83 Salt backfill with CaO	5	5	5	Decrease Rate	Decrease Rate	Decrease Rate	-	-	-	Decrease	-	-		Small Decrease		-		Increase	-
95 SPM IT-10 Decontaminate surface of metallic waste for LLW disposal, change container material, salt aggregate grout backfill	4	5	4.5	-	Eliminate Potential	Eliminate Potential	-	-	-	Decrease	-	-		Decrease	-	-	-	Increase	-
75 EATF Alternative 10 - Decontaminate surface of metallic wastes for LLW disposal, no backfill, change container material and shape, 10X31X100 rooms	4	5	4.5	-	Eliminate Potential	Eliminate Potential	-	-	-	-	-	-	-	-	-	-	-	-	-
63 Change Waste Container Shape	4	5	4.5	Decreases Rate	Decreases Rate	Decreases Rate	-	-	-	-	Decrease	Decrease	Decrease	-	-	-	-	-	-
60 Depressurize Castile Reservoir	4	5	4.5	-	-	-	-	-	-	-	-	-		-	-	-	-	-	Reduce Brine volume in E1 and E1E2 Scenarios
53 Seal Individual Rooms	4	5	4.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
94 SPM IT-9 Enhanced cement sludges, shred and add clay based material to organics and inorganics, salt aggregate grout backfill	4	4	4	-	-	Decrease Rate	Additional Actinide Sorption	Additional Actinide Sorption	Decrease	Decrease	Decrease	Decrease	Decrease	Decrease	Increase	Increase	Increase	Increase	-
89 SPM IT-4 Enhanced cement sludges, shred and cement organics and inorganics, salt backfill with CaO	4	4	4	Decrease Rate	Decrease Rate	Decrease Rate	Decrease	Decrease	Decrease	Decrease	Decrease	Decrease	Decrease	Decrease	Increase	Increase	Increase	Increase	-
74 EATF Alternative 8 - Vitrify sludges, shred and vitrify organics, melt metals with frit to partition actinides, salt aggregate grout backfill, change container material	2.5	2	2.25	Eliminate Potential	Eliminate Potential	Eliminate Potential	-	-	Increase Solubility but Decrease Leach Rate	Decrease	Decrease	Decrease	Decrease	Decrease	Increase	Increase	Increase	Increase	-
10 Plasma Processing of All Waste	2.5	2	2.25	Eliminate Potential	Decrease Rate		Decrease Leachability	Decrease Leachability	May Increase Solubility, Decrease Leachability	-	Large Decrease	Large Decrease	Large Decrease	-	Large Increase	Large Increase	Large Increase	-	-

APPENDIX D
ATTACHMENT D7

ENGINEERED ALTERNATIVE COST/BENEFIT STUDY SCREENING REPORT

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TABLE OF CONTENTS

PREFACE

This report documents the approach that was used to screen a list of engineered alternative (EA) candidates for the purpose of exclusion or retention in the Engineered Alternatives Cost/Benefit Study (EACBS). The EACBS is outlined in the Engineered Alternatives Cost/Benefit Study Scoping Report, WIPP/WID 95-2093.

The EACBS Scoping Report outlined a general approach to screen EAs. The approach includes use of a multi-disciplinary panel (working group), a list of initial EA candidates, and a screening method to ensure that the most viable alternatives are focused upon in the cost/benefit study. This report documents the screening process used by the Engineered Alternatives Screening Working Group (EASWG) and presents the results of the screening process.

WIPP/WID-95-2104
Revision 0

Engineered Alternatives Cost/Benefit Study Screening Report

May 1995

United States Department of Energy
Waste Isolation Pilot Plant

Carlsbad Area Office
Carlsbad, New Mexico

1.0 INTRODUCTION

The Engineered Alternatives Cost/Benefit Study (EACBS) Scoping Report (WIPP/WID 95-2093) was prepared to document the approach for gathering of technical data necessary for decision making regarding engineered alternatives (EA) to be used for meeting the Title 40 Code of Federal Regulations 191 (40 CFR 191)assurance requirements. The study will provide the technical basis for determining whether or not engineered alternatives should be included in the repository as assurance measures to either increase the performance of the disposal system beyond containment requirements or to reduce uncertainty associated with the performance prediction. The screening of initial EAs to be analyzed in the study is a key part of the study. Engineered Alternatives that pass the screen will be considered for further analysis in the EACBS.

The screening process is a non-ranking pass or fail type of screen which uses a panel of technical professionals. The process is such that any prospective alternative can be investigated to determine if it should be considered for further analysis in the EACBS.

The screening process is outlined in Sections 3.1 to 3.2.3 of the scoping report. This process compiles a list of EA candidates, compares these candidates to the definitions of an EA, and screens those that meet the definition against screening criteria. Those that meet the criteria will be used in the EACBS analysis and those that do not meet the definition and/or screening criteria are documented with a justification for rejection. This process is performed by a screening panel known as the Engineered Alternatives Screening Working Group (EASWG). The EASWG was allowed to refine and improve the process outlined in the scoping report.

The following sections detail the screening process used, the results, and describe any modifications made to the process outlined in the scoping report. Justification for these changes are also provided.

1.1 WIPP Mission Description

The Waste Isolation Pilot Plant (WIPP) is a research and development facility of the U.S. Department of Energy (DOE), designed to demonstrate the safe transportation, handling, and disposal of defense generated transuranic (TRU) radioactive waste. The facility is located 26 miles east of Carlsbad, New Mexico. The repository is located in a mined geologic salt deposit, 2,150 feet below ground. The waste will be shipped to the facility and placed in the underground repository for disposal. After the WIPP repository is filled with waste, the access ways will be closed, shafts sealed, and the surface facilities removed.

1.2 EACBS Program Purpose

The DOE has initiated a cost benefit study to provide a technical basis for the selection and rejection of EAs for the WIPP beyond the engineered barriers required for compliance with containment requirements. The results of this study will be presented in the EACBS Final Report.

Engineered Alternatives included engineered barriers, waste modifications, facility modifications, process changes, or any other approach that after qualitative analysis with respect to performance assessment sensitivity and uncertainty analysis results, would reduce uncertainty in predictions of long-term performance.

1.3 EACBS Program Background

In accordance with Subparts B and C of 40 CFR 191, the WIPP Performance Assessment (PA) is used to predict the expected cumulative release of radionuclides to the accessible environment over the long-term repository performance period. The PA uses numerical modeling to predict whether the performance of the disposal system can reasonably be expected to meet the requirements of 40 CFR 191. The numerical modeling is supported by experimental programs and expert judgement. Results of the PA are quantitative in nature and indicate the WIPP design either does or does not meet the performance criteria and release limits imposed by the regulation. The WIPP disposal system performance assessment and the 40 CFR 191 standard are designed to ensure that a margin of safety is built into the evaluation process. The calculated results of PA can therefore only be used to conclude that the disposal system will or will not comply. Relative "degrees" of compliance cannot be deduced from a mean complementary cumulative distribution function (CCDF) resulting from the WIPP PA.

The regulation specifies that assurance requirements be used to provide additional confidence for long-term compliance. These assurance requirements introduce a "defense-in-depth" concept to the disposal system design by using engineered barriers, active and passive institutional controls, long-term monitoring, and permanent markers in addition to the natural and engineered systems to contain and isolate the waste. The assurance requirements in

40 CFR 191 are used to complement the disposal system containment requirements. As part of the assurance requirements, EAs may be used to provide additional confidence in the containment requirements which also has an added benefit of possibly enhancing disposal system performance and/or reduce uncertainty in the calculated performance results.

A distinction between containment and assurance must be maintained. Containment relates to the regulatory performance limits, whereas assurance relates to reducing the uncertainty associated with a compliance determination. The disposal system design meets the multiple barrier assurance requirements specified in 40 CFR § 191.14(d). This study will provide information about additional EAs which can be evaluated within the context of a compliant disposal system.

2.0 Engineered Alternatives Screening Process

The EACBS requires an input of EA to be used in the cost/benefit analysis. Since the analysis of EAs is a lengthy and costly process, the input EAs are examined prior to the analysis to determine if they are valid and viable alternatives with some expectation that they can improve the disposal system performance and/or reduce the uncertainty in the prediction of this performance. The screening process was designed to examine the prospective inputs to determine the validity of the alternatives.

The screening was performed by the EASWG. The EASWG is composed of a professional facilitator and technical professionals from the following fields:

Waste Management
Waste Processing
Probablistic Risk Assessment
Transportation Engineering
Environmental Engineering
Mine Engineering
Radiation Risk Assessment
Chemical Engineering
Cost/Schedule Assessment
Public Relations

Personnel that had technical experience from the listed fields and had direct knowledge of the WIPP project and/or other DOE waste programs were chosen. Members were chosen by the EACBS project managers. The members of the EASWG and their resumes are listed in Appendix B.

The EASWG met on April 24, 25, and 26, 1995, and again on May 1, 2, and 3, 1995. The working group initially broke the process down into the steps listed below which were derived from the scoping report.

1. Review the definition of an EA.
2. Review the screening criteria.
3. Review the EA candidates and their definitions.
4. Outline the screening process.
5. Compare the EA candidates to the EA definition. Document the results.
6. Determine if the EAs that met the definition also meet the screening criteria.
7. Document the results.

Each step is detailed in the following sections.

2.1 Review the Definition of an Engineered Alternative

The definition stated in Section 3.2.2 of the scoping report is:

> An EA is a process, technology, method, disposal system design, or waste form modification which makes a significant positive impact on the disposal system in terms of reducing uncertainty or improving long-term performance.
>
> In order for an EA concept to be considered as an engineered alternative, it must be technically feasible and must meet at least one of the following criteria.
>
> - Reduce permeability of the waste stack
> - Increase the shear strength of the waste form
> - Reduce the total gas produced from the waste form by:
>   - Reducing corrosion rate - oxic, anoxic, or both
>   - Reducing microbial activity

- Isolating or lowering available water/brine contact with the waste (Radiolysis gas generation is not a critical issue and is not a significant factor in gas generation)

- Reduce the transport rate of radionuclides
- Reduce the consequences of human initiated processes or events
- Reduce the solubility of the radionuclides

The working group concluded that the definition should also state that the final waste form must meet the Waste Acceptance Criteria (WAC). The working group decided that this change was required because all waste shipped to the WIPP for disposal must met the WAC and that any alternative that modifies the waste such that it could not meet the WAC would not be considered. No other changes were made.

2.2 Review the Screening Criteria

The EASWG reviewed the three screening criteria, Regulatory Compliance and Permitting, Availability of Technology, and Schedule of Implementation. These criteria are described in Section 3.2.3 of the scoping report. The EASWG concluded that these criteria are based on feasibility and abbreviated two of the titles to Regulatory Feasibility and Technical Feasibility. The definitions for these two criteria were considered adequate by the EASWG. The working group noted that schedule is inherent in these two criteria. There was therefore no reason to consider schedule as a separate measure for viability determinations made during screening.

2.3 Review Engineered Alternatives and their Definitions

The EA scoping report contains the initial listing of EA candidates that were used in the screening process. This list was compiled from the 64 individual and 14 EA combinations found in the 1991 Engineered Alternatives Task Force Final Report (EATF), the 20 EAs that were considered by Sandia National Laboratories (SNL) for the Systems Prioritization Methodology-II (SPM-2), and the 10 EAs listed in the proposed rule 40 CFR 194. This list is found in Appendix C of this report.

The EASWG reviewed the list of EAs and the definitions of the 64 individual technologies listed in the EATF. Definitions for the remaining EAs were not required because the remaining EAs are either combinations or duplicates of the 64. The working group modified the 64 EATF definitions to clarify and expand the definitions or update advancements in the technologies since 1991. Some of the original titles were modified to expand on which waste types are used with the technologies. The definitions are listed in Appendix D of this report.

2.4 Outline the Screening Process

The EASWG developed a basic outline to screen the EAs. The outline is:

1. Compare EA to definition
2. Determine if the EA is detrimental to the disposal system
3. Identify duplicate EAs and delete
4. Compare remaining EAs to screening criteria
   a. Regulatory Feasibility
   b. Technology Feasibility

2.5 Compare the Engineered Alternative Candidates to Definition

The EASWG, after reviewing the modified definition of an EA in Section 3.2.2 of the scoping report, compared the initial list of EA candidates (Appendix C) to the definition. Those that met the definition were noted as such and those that did not were documented with a brief description why the working group concluded that it did not meet the definition. Duplicates were also deleted at this time. The initial EA list was divided into a Pass and Reject list. This list can be found in Appendix E.

In reviewing the EAs, the EASWG also considered any detrimental effects due to the implementation of an EA. Any EA that would have a detrimental impact on the performance of the disposal system was deleted.

2.6 Compare the Engineered Alternatives to the Screening Criteria

The remaining EAs that meet the definition were screened by assessing Regulatory and Technical Feasibility. The scoping report definitions for these criteria were used. After a thorough review, no EAs that met the definition were screened out due to regulatory or technical feasibility. Comments from the EASWG on regulatory and technical feasibility are listed in Appendix E.

2.7 Screening Results

After completing the screening process, a Pass and Reject list with justifications was compiled and finalized. The pass list by number and title only are shown in Table 2 - 1 and the rejection list by number and title only are shown in Table 2 - 2.

Table 2 - 1
Engineered Alternative Pass List

The following is a listing of Engineered Alternatives that passed the screening process.

1 Supercompact Everything Except Sludges
2 Incinerate and Cement Solid Organic Waste
3 Shred and Vitrify Solid Organic Waste
4a Wet Oxidation and Cement Solid Organic Waste
4b Wet Oxidation and Vitrify Solid Organic Waste
5 Shred and Bituminize Everything Except Sludges
6 Shred and Compact Everything Except Sludges
7 Shred and Cement Everything Except Sludges
8 Shred and Cold Polymer Encapsulate Everything Except Sludges
9 Shred, add Salt and Compact Everything Except Sludges
10 Plasma Processing of All Waste
11a Melt Metals into TRU waste ingots
11b Melt Metals with Frit to Partition Actinides
12 Salt Backfill Around Drums and Waste Stack
15 Shred, Add Clay Based Material to Everything Except Sludges
16a Acid Digestion and Cementation of Solid Organics
16b Acid Digestion and Vitrification of Solid Organics
19 Add Lime to Solid Organic Waste
22 Decontaminate Surface of Metallic Wastes for low level waste (LLW) Disposal.
29 Microwave Melt Sludges
33 Salt Plus Clay Backfill
35 Salt Aggregate Grout Backfill Around Drums
36 Bitumen Backfill
38 Reduce Room Dimensions to Minimize Space Around Waste Stack
51 Change Mined Extraction Ratio
53 Seal Individual Rooms
60 Depressurize Castile Reservoir
63 Change Waste Container Shape
64 Change Waste Container Material
66 The 1991 Engineered Alternatives Task Forces Final Report (EATF Alternative 1 - Shred and cement organics and inorganics only, salt backfill.
67 EATF Alternative 2 - Enhanced cement sludges, shred and cement organics and inorganics, salt backfill.

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Table 2 - 1
Engineered Alternative Pass List

68 EATF Alternative 3 - Enhanced cement sludges, shred and cement organics and inorganics, salt aggregate grout backfill.

69 EATF Alternative 4 - Enhanced cement sludges, incinerate and cement organics, shred and cement inorganics, salt backfill.

70 EATF Alternative 5 - Enhanced cement sludges, incinerate and cement organics, shred and cement inorganics, salt aggregate grout backfill.

71 EATF Alternative 6 - Vitrify sludges, shred and vitrify organics, melt metals into TRU waste ingots, salt backfill.

72 EATF Alternative 7 - Vitrify sludges, shred and vitrify organics, melt metals into TRU waste ingots, salt aggregate grout backfill.

73 EATF Alternative 8 - Vitrify sludges, shred and vitrify organics, melt metals with frit to partition actinides, salt backfill, change container material.

74 EATF Alternative 9 - Vitrify sludges, shred and vitrify organics, melt metals with frit to partition actinides, salt aggregate grout backfill, change container material.

75 EATF Alternative 10 - Decontaminate surface of metallic wastes for LLW disposal, no backfill, change container material and shape, 10x31x188 rooms.

76 EATF Alternative 11 - Supercompact organics and inorganics, salt backfill, monolayer of 2,000 drums in a 6x33x300 room.

77 EATF Alternative 12 - Supercompact organics and inorganics, salt aggregate grout backfill, monolayer of 2,000 drums, in a 6x33x300 room.

78 EATF Alternative 13 - Vitrify sludges, shred and vitrify organics, melt metals with frit to partition actinides, no backfill, alternate container, 10x31x188.

79 EATF Alternative 14 - Supercompact organics, and inorganics, salt backfill, seal individual rooms, 2,000 supercompacted drums per room.

83 Salt backfill with CaO

87 Systems Prioritization Methodology (SPM) IT-2 Enhanced cement sludges, shred and cement organics and inorganics, salt backfill, change container material.

89 SPM IT-4 Enhanced cement sludges, shred and cement organics and inorganics, salt backfill with CaO.

90 SPM IT-5 Enhanced cement sludges, shred and compact organics and inorganics, salt backfill, 2,000 drum monolayer, 6x33x300 room.

92 SPM IT-7 Enhanced cement sludges, shred and compact organics and inorganics, salt backfill with CaO, 2,000 drums monolayer, 6x33x300 room.

93 SPM IT-8 Enhanced cement sludges, shred and add clay based material to organics and inorganics, salt backfill.

Table 2 - 1
Engineered Alternative Pass List

94 SPM IT-9 Enhanced cement sludges, shred and add clay based material to organics and inorganics, salt aggregate grout backfill.
95 SPM IT-10 Decontaminate surface of metallic waste for LLW disposal, change container material, salt aggregate grout backfill.
110 Enhanced Solidification of Sludges
111 Clay Based Backfill

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Table 2 - 2
Engineered Alternatives Rejection List

The following is a listing of Engineered Alternatives that failed the screening process.

4	Wet Oxidation
11	Melt Metals
13	Add other Sorbents
14	Add Gas Suppressant
16	Acid Digestion
17	Sterilization
18	Add Copper Sulfate
20	Add Fillers
21	Segregate Waste Forms
23	Change Waste Generation Process
24	Add Anti-Bacterial Material
25	Accelerate Waste Digestion Process
26	Alter Corrosion Environment
27	Alter Bacterial Environment in WIPP
28	Transmutation of Radionuclides
30	Salt Backfill Only
31	Salt Backfill Plus Gas Getters
32	Compact Backfill
34	Preformed Compacted Backfill
37	Add Gas Suppressant
39	Segregate Waste in WIPP
40	Decrease Amount of Waste per Room
41	Emplace Waste and Backfill Simultaneously
42	Selected Vegetative Uptake
43	Brine Isolating Dykes
44	Raise Waste Above the Floor
45	Brine Sump and Drains
46	Gas Expansion Volume
47	Seal Repository Room Walls
48	Vent Facility
49	Ventilate Facility
50	Add floor of Brine Sorbents

Table 2 - 2
Engineered Alternatives Rejection List

52 Change Room Configurations
54 Two Level Repository
55 Monument Forest Over Repository
56 Monument Covering the Entire Repository
57 Buried Steel Plate Over the Repository
58 Artificial Surface Layer Over the Repository
59 Add Marker Dye to Strata
61 Grout Culebra Foundation
62 Increase Land Withdrawal Area
65 EATF Baseline - As Received with Salt Backfill
80 SPM-Baseline
81 SPM-A Salt backfill
82 SPM-B Salt/Bentonite backfill 50-50 mix, 50% filling efficiency
84 SPM-D Cement grout backfill
85 SPM-E Salt/Grout backfill
86 SPM IT-1 Shred and cement organics and inorganics, salt backfill - Deleted
88 SPM IT-3 Enhanced cement sludges, shred and cement orginics and inorganics, salt aggregate grout backfill.
91 SPM IT-6 Enhanced cement sludges, shred and compact organics and inorganics, salt aggregate grout backfill, 2,000 drum monolayer, 6x33x300 room.
96 SPM EATF-8 Vitrify sludges, shred and vitrify organics, melt metals with frit to partition actinides (metals are eliminated from the WIPP inventory), salt backfill, change waste container material.
97 SPM EATF-9 Vitrify sludges, shred and vitrify organics, melt metals with frit to partition actinides (metals are eliminated from the WIPP inventory), salt aggregate grout backfill, change waste container material.
98 SPM DOE-1 Passive markers- no specific scenario given reduce human intrusion probability parameters.
99 SPM DOE-2 Compartmentalization of waste - various unspecified scenarios.
100 194- Cementation
101 194- Shredding
102 194- Supercompaction
103 194- Incineration
104 194- Vitrification
105 194- Improved Waste Containers

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Table 2 - 2
Engineered Alternatives Rejection List

106 194- Grout and Bentonite Backfill
107 194- Metal Melting
108 194- Alternative Configuration of Waste Emplacement
109 194- Alternative Disposal System Dimensions

Engineered Alternative Working Group

Members (resumes attached)

Peter Carson
John Case
Sayan Chakraborti
Terry DeBiase
Andrew Dykes
Michael Emerson
Denise Gelston
Dave Lechel
John McFee
Jonathan Myers
Rod Palanca
David Palmer
James Ward
James Waters
Maggie Wood

Facilitator
Hans Kresney

Program Oversight
Jayne Davis
John Magyar
Steve Wagner

APPENDIX A

Engineered Alternatives Screening Working Group Resumes

Peter H. Carson

Waste Management Engineer

8 Years of Relevant Experience

SUMMARY:

Mr. Carson has more than eight years of experience in providing support to the U.S. Department of Energy (DOE) and its contractors in the area of radioactive and hazardous waste management. Mr. Carson's experience also includes performing work in waste stream characterization, waste certification, project management, RCRA permit applications, waste treatment technology development, waste management and environmental restoration planning and strategy development, and waste minimization cost/benefit analysis.

EDUCATION:

B.S., Chemical and Petroleum Refining Engineering, Colorado School of Mines, 1984

RELEVANT EXPERIENCE:

Authoring chapters of the interim Preliminary Safety Analysis Report (PSAR) for the Lockheed Environmental Systems and Technologies (LESAT) Pit 9 waste retrieval and processing system as part of the INEL Pit 9 Interim Action. This effort includes contributing to the hazards analysis, preparing the facility description, and authoring chapters relating to radioactive waste management and quality assurance.

Provided regulatory compliance support to LESAT for INEL Pit 9 Interim Action Proof-of-Process (POP) Tests. These POP tests will demonstrate LESAT's ability to retrieve and process buried low-level, transuranic (TRU), hazardous, and mixed waste from a shallow land burial disposal pit at the Idaho National Engineering Laboratory (INEL). This project also addresses the handling and treatment of contaminated soils from the pit. Specific assignments include preparing the Quality Assurance Program Plan, assisting in the development of the Treatment/Storage/Disposal Plan, and identifying and resolving potential compliance issues.

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Participated as a member of the Waste Isolation Pilot Plant (WIPP) Waste Acceptance Group Audit Team. This team conducted an audit of EG&G Idaho, Inc. and Argonne National Laboratory-West (ANL-W) activities directed toward selecting, characterizing, and packaging TRU waste for experimental activities at WIPP. The audit was required to demonstrate compliance with the WIPP RCRA Part B Permit Application.

Supported the INEL Transuranic Waste Program by preparing and reviewing programmatic planning documents. This work was directed toward ensuring consistency between the Waste Management Division Strategic Plan, the TRU Waste Implementation Plan, and the INEL Roadmap. Specific tasks included preparing sections of the test, resolving review comments, and suggesting improvements in the planning process.

Supported the Experimental-Waste Characterization Program (E-WCP) at the Rocky Flats Plant (RFP). This support included preparing a Project Management Plan, reviewing and revising operating procedures from various organizations at RFP that are participating in the E-WCP, assisting in the preparation of the Quality Assurance Project Plan, and participating in the development of a self-evaluation program. The E-WCP selected, characterized, repackaged, and shipped to WIPP various transuranic waste forms for experimental activities required to demonstrate that WIPP meets regulatory requirements.

Contributed to preparation of the WIPP Strategic Plan. This plan detailed at several levels the steps required to make WIPP an operating disposal facility. This work included conducting a requirements analysis and a stakeholder analysis, defining the goals and objectives of the WIPP program, creating activity logic diagrams, and analyzing alternate strategies for attaining programmatic goals.

Supported the WIPP Management Control Task Force. This support included preparing a Test Phase Management Plan, which establishes organizational roles and responsibilities for the DOE WIPP Project Office, Westinghouse Waste Isolation Division (WID), and Sandia National Laboratories, the three primary participants in the WIPP program.

Consulted for Rockwell International as part of the Joint Integration Office. Contributed to planning and systems integration efforts related to the Defense TRU Waste Program. Possesses in-depth knowledge of the TRU waste management systems at many DOE locations, including the Idaho National Engineering Laboratory, Oak Ridge National Laboratory, Savannah River Site, and Hanford Reservation. Responsible for preparing long-range plans, cost/schedule optimization studies, and system integration implementation plans.

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Supported the Westinghouse Waste Isolation Division by assisting in revising the WIPP Waste Acceptance Criteria (WAC). Also preparing a Transportation System Management and Operating Plan utilizing detailed knowledge of TRU waste certification and transportation requirements.

PUBLICATIONS:

Carson, P.H., et al., 1990. *Sources of Waste*, Radioactive Waste Management and the Nuclear Fuel Cycle, Vol. 14 (1-2), pp. 27-44.

Kallas, J.A., Tipton, J.B., Carson, P.H., October 3, 1991. *Planning for Environmental Management Activities at the Rocky Flats Plant*, Proceedings from the 5th Annual Colorado Hazardous Waste Management Society Conference.

Ebra, M.A., Carson, P.H., Pierce, G.D., 1988. *Management of Remote-Handled Defense Transuranic Wastes*, Waste Management Eighty Eight, Volume 2 - High-Level Waste and General Interest, pg. 303.

John B. Case, PE

Professional Qualifications

Mr. Case is a Registered Professional Engineer with more than 16 years of experience in ground and surface water hydrology and geotechnical engineering. He is a specialist in sealing technology for nuclear waste and hazardous waste management. He has been involved in many hydrological, thermomechanical, and structural analyses conducted on nuclear waste repository projects including the Waste Isolation Pilot Plant (WIPP), the Basalt Waste Isolation Project (BWIP), the Office of Nuclear Waste Isolation (ONWI), the Yucca Mountain Project (YMP), and the Office of Waste Technology Development. His work for the BWIP, the YMP, the ONWI, and the OWTD has been primarily as a Principal Investigator, and has included analyzing hydrological, stress, and thermal effects using the boundary element, finite element, and finite difference methods; modeling heat conduction; analyzing the thermomechanical behavior of seals; analyzing room closure for salt creep; analyzing consolidation of crushed salt and other backfill materials; analyzing stress buildup on waste packages in salt; analyzing groundwater flow through seals and fractured rock; and evaluating the extent of the damage zone around boreholes, shafts, and tunnels. In addition, Mr. Case assisted in performing geotechnical, hydrologic, and structural analyses for certifying existing and new underground hazardous waste tank systems and developing spill prevention plans for surface and underground tank systems.

In support of IT-Albuquerque's Geotechnical Design specialty, Mr. Case is responsible for developing and implementing project plans using critical path methods, resource leveling, and cost-tracking methods. He is a member of IT's Senior Technical Associate program.

Education

M.S., Civil Engineering, University of Colorado, Boulder, Colorado; 1974
B.S., Civil Engineering, University of Colorado, Boulder, Colorado; 1972

Registrations/Certifications

Registered Professional Engineer, New Mexico, Colorado, Arizona

Experience and Background

1976 - 1980
1981 - Present

Project Manager, Geotechnical Design, International Technology Corporation (IT), Albuquerque, New Mexico. As a project manager, Mr. Case is responsible for projects involving nuclear waste and hazardous waste disposal, including evaluations of seal and rock behavior for repositories in basalt, tuff, and salt, and for deep-well injection.

- Evaluated the disturbed zone that resulted from drilling, blasting, or machine excavation around shafts and tunnels in salt, tuff, and basalt. Utilized the elasto-plastic theory to assess the mechanical properties of rock, stress distribution, and displacements around openings.

- Prepared field test plans for repository sealing in tuff.
- Developed a Borehole Sealing Strategy for exploratory boreholes at the YMP.
- Conducted performance assessment of repository seals for air and water flow above the groundwater table for the YMP.
- Developed field test plans for seals in terms of air flow and episodic water flow for the YMP.
- Graded quality assurance activities at the YMP for Sandia National Laboratories, Albuquerque (SNL).
- Performed selected analyses to evaluate the impact of the exploratory shaft test facility on the performance of the YMP repository.
- Designed the rock support systems at the BWIP using boundary element and rock-support interaction methods and developed the field test plans.
- Conducted performance assessment of a repository seal system in basalt at the BWIP using finite element and stochastic methods.
- Developed a numerical model to predict how cement hydration would affect the interface stress on a concrete plug at the Waste Isolation Pilot Plant (WIPP).
- Analyzed the flow of pressurized brine to and from the WIPP repository through boreholes. This represented the worst-case breach scenario for the WIPP.
- Developed a completed numerical model for evaluating brine inflow data for the WIPP.
- Provided peer review of field tests and made recommendations on test performance for the Stripa Project.
- Developed a spill prevention plan for surface and underground tanks at SNL.

1980 ***Senior Engineer, Rockwell Hanford Operations, Richland, Washington.*** Conducted thermal mechanical analyses in basalts and general rock mechanics analyses including:

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- Numerical modeling and analysis of the full-scale heater tests simulating radioactive waste emplacement for the BWIP. Team Leader of the Numerical Modeling Group responsible for planning and reviewing laboratory and field tests in rock mechanics, and for selecting thermal and thermomechanical properties used in numerical analysis. Provided a preliminary analysis of temperature data recovered after 70 days of heater test operations.

- Planned, directed, and analyzed the results of rock mechanics characterization tests in basalt associated with the BWIP to provide thermal and thermomechanical data necessary for predicting the response of the host rock to waste-induced heating.

Professional Affiliations

American Institute of Mining Engineers
American Society of Civil Engineers
Kiwanis International
National Society of Professional Engineers
Tau Beta Pi, National Engineering Association

Publications

Fernandez, J. A., J. B. Case, and J. Tyburski, 1992, "Proposed Sealing Field Tests for a Potential High-Level Waste Repository in Unsaturated Tuff," Proceedings of the Third International Conference on High-Level Radioactive Waste Management, Las Vegas, Nevada, Vol. 2, pp. 2290-2297.

Case, J. B., J. A. Fernandez, and J. R. Tyburski, 1992, "Supporting Hydration Calculation for Small- to Large-Scale Seal Tests in Unsaturated Tuff," Proceedings of the Third International Conference on High-Level Radioactive Waste Management, Las Vegas, Nevada, Vol. 2, pp. 2298-2305.

Cook, R., and J. Case, 1991, "Design and Construction Issues Associated with Sealing of a Repository in Salt," *Waste Management '91, Proceedings of the Symposium in Waste Management*, Tucson, Arizona, Vol. 2, pp. 735-742.

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Wallace, M. G., J. M. Dietz, B. A. Lauctes, J. B. Case, and D. E. Deal, 1990, "Coupled Fluid-Flow Through Salt Around Excavations for the Waste Isolation Pilot Plant (WIPP) in the Permian Salado Formation" *Waste Management '90,* *Proceedings of the Symposium in Waste Management*, Tucson, Arizona, Vol. 2, pp. 873-880.

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Case, J. B., and D. Deal, 1987, "Preliminary Hydrologic and Geomechanical Evaluations of Brine Inflow from Bedded Salt to a Nuclear Waste Repository," *Geological Society of America, Abstracts with Programs*, Vol. 19, No. 7, pp. 614-615.

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Deal, D. E., and J. B. Case, 1987, "Brine Sampling and Evaluation Program - Phase I Report," *DOE-WIPP-87-008*, U.S. Department of Energy, Carlsbad, New Mexico.

Fernandez, J. A., P. C. Kelsall, J. B. Case, and D. Meyer, 1987, "Technical Basis for Performance Goals, Design Requirements, and Material Recommendations for the NNWSI Repository Sealing Program," *SAND84-1895*, Sandia National Laboratories, Albuquerque, New Mexico.

Kelsall, P. C., J. B. Case, D. Meyer, J. G. Franzone, and W. E. Coons, 1986, "Schematic Designs for Penetration Seals for a Repository in the Richton Dome," *ONWI-565*, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, Ohio.

Kelsall, P. C., J. B. Case, W. E. Coons, J. G. Franzone, and D. Meyer, 1986, "Schematic Designs for Penetration Seals for a Repository in the Permian Basin", *ONWI-564*, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, Ohio.

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Case, J. B., and P. C. Kelsall, 1985, "Coupled Processes in Repository Sealing," *Proceedings of the International Symposium on Coupled Processes Affecting the Performance of a Nuclear Repository*, Academic Press, Orlando, Florida, pp. 531-604.

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Case, J. B., P. C. Kelsall, and J. W. Holland, 1984, "The Development of Interface Stress in a Concrete Plug During Cement Hydration," presented at the Symposium on Concrete and Cementitious Materials for Radioactive Waste Management, American Concrete Institute, New York, New York.

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Kelsall, P. C., J. B. Case, C. R. Chabannes, W. E. Coons, R. D. Ellison, D. Meyer, D. K. Shukla, and D. E. Stephenson, 1982, "Schematic Designs for Penetration Seals for a Reference Repository in Bedded Salt," *ONWI-405*, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, Ohio.

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Case, J. B., 1980, "A Technical Approach to Resolving Issues on Rock Mechanics as Applied to Development of a Nuclear Waste Repository in a Crystalline Rock Formation," *RHO-BWI-SA51*, Rockwell Hanford Operations, Richland, Washington.

Case, J. B., A. D. Krug, and J. Williams, 1980, "Full Scale Heater Results," *RHO-BWI-LD34*, Rockwell Hanford Operations, Richland, Washington.

Case, J. B., J. W. Nelson, and D. E. Shaw, 1980, "Thermal Expansion Effects in Oil Storage Caverns," presented at the American Society of Mechanical Engineers, Energy Technology Conference and Exhibition, New Orleans, Louisiana.

Case, J. B., J. G. Gusek, and D. E. Shaw, 1979, "Explosive Casting Technology in Surface Mining," *Proceedings of the 20th U.S. Symposium on Rock Mechanics*, University of Texas, Austin, Texas.

Case, J. B., 1974, "The Constitutive Relations of Pittsburgh Coal Subjected to a Multiaxial State of Stress," Master's Thesis, University of Colorado, Boulder, Colorado.

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Sayan Chakraborti

Professional Qualifications

Mr. Chakraborti is a Chemical Engineer with more than five years of experience in radioactive waste management. This includes a wide variety of projects completed in support of both the U.S. Department of Energy-Headquarters (DOE-HQ) and the DOE sites in the areas of mixed transuranic (TRU) waste, mixed low-level waste (MLLW), low-level waste (LLW), and spent fuel management. As a staff member of the Transuranic and Mixed Waste Assessment Group at IT-Albuquerque, Mr. Chakraborti was the project coordinator and one of the primary contributors to the report of the Engineered Alternatives Task Force (EATF) that was prepared for DOE in support of the Waste Isolation Pilot Plant (WIPP) project. Subsequently he was also involved in the Engineered Alternatives Program (EAP) that was the follow-on effort to the EATF. He also provided support to the WIPP project in preparation of the Waste Characterization Program Plan and the RCRA Part B permit application. More recently he supported the Hanford Site in the evaluation of impacts of WIPP uncertainties on its Solid Waste Operations Complex and the technical review of the Waste Receiving and Processing (WRAP) 1 Title I design with respect to the WIPP Waste Acceptance Criteria (WAC). His recent accomplishments include the preparation of a report on the cost and schedule of selected engineered alternatives in support of the WIPP System Prioritization Initiative. His other accomplishments during the past two years include support to DOE-HQ in the development of the MLLW Systems Analysis Methodology, preparation of the Interim Mixed Waste Inventory Report in response to the Federal Facility Compliance Act (FFCA), and support to the Idaho National Engineering Laboratory in the preparation of background reports for LLW and spent fuel in the DOE system.

Education

M.B.A., Marketing Management, University of New Mexico, Albuquerque, New Mexico; 1989

M.S., Chemical Engineering, University of New Mexico, Albuquerque, New Mexico; 1985

Bachelor of Technology, Chemical Engineering, Indian Institute of Technology, Kharagpur, India; 1983

Experience and Background

1990–Present ***Chemical Engineer and Technical Associate, IT Corporation, Albuquerque, New Mexico.*** Mr. Chakraborti has developed diverse and comprehensive expertise in both the technical and programmatic aspects of DOE radioactive waste management through his active involvement in a variety of projects for DOE-HQ and the DOE sites that addressed many different types of radioactive waste. He is currently involved in the development of an automated cost and schedule estimation model that will be used for evaluation of DOE's site treatment plans for mixed waste. During the past two years he has co-authored several publications with DOE-HQ staff on various topics of radioactive waste management.

TRU Waste

- Task Manager for preparation of a report that estimated the life cycle cost and schedule of implementing engineered alternatives (EAs) for the WIPP in response to the draft version of 40 CFR 194. Report compared the cost of processing the waste to the WIPP-WAC versus alternative immobilization technologies.

- Primary contributor to a variety of tasks completed for the EATF project, including cost/benefit analyses of various engineered alternatives to the current TRU waste forms and the repository design; preparation of DOE reports on behalf of two expert panels that were organized for the project; preparation of all weekly, biweekly, and monthly project status reports; and coordination of all technical groups working on the project within IT.

- Primary contributor to many tasks for the EAP, which was the follow-on effort to the EATF project. Developed a program plan for the use of alternate containers for TRU waste and also prepared the technical requirements document for an alternate container for TRU waste.

- Investigated the impact of potential changes in the WIPP-WAC on the design of different facilities in the Hanford Site Solid Waste Operations Complex (SWOC) and determined if any major design modifications would be required as a result of these changes. Also estimated the impact of these potential design changes on the capital cost and implementation schedule for the Hanford SWOC.

- Analyzed the effects of supercompacting TRU waste on both the potential performance of the WIPP repository and the transportation costs. The analysis, which was conducted for Westinghouse-WIPP, evaluated the incremental effects on WIPP performance from supercompacting only Rocky Flats' waste as well the effect of supercompacting different percentages of the entire WIPP inventory.

- Involved in the development and preparation of Revision 2.0 of the WIPP TRU Waste Characterization Program Plan, which described TRU waste characterization requirements for the originally planned WIPP Test Phase, and also served as a DOE planning document for developing and implementing site-specific TRU waste characterization programs.

- Revised the TRUPACT-II Content Codes (TRUCON) document with the objective of simplifying it in order to reduce the time and effort required for review of future payload amendments by the U.S. Nuclear Regulatory Commission (NRC). The revised document is ready for presentation to the NRC for final approval.

- Contributed to the development and finalization of the waste analysis plan in support of the WIPP RCRA Part B permit application to ensure RCRA compliance for TRU waste to be accepted at the WIPP facility.

- Evaluated the Title I design of Module 1 of the proposed WRAP facility at the Hanford Site with respect to Revision 4 the WIPP-WAC and provided recommendations to ensure that the final TRU waste forms generated by the facility will satisfy the WIPP-WAC.

- Primary author of a memorandum to the EPA that helped DOE to successfully negotiate the exclusion of certain compounds from EPA-imposed flammability testing requirements for TRU waste in the Conditional No-Migration Determination granted by the EPA in 1990.

- Prepared a report for DOE that evaluated potential flammability concerns associated with TRU waste destined for disposal at the WIPP and concluded that adequate safety regulations currently exist for minimization of flammability concerns. The report helped DOE to address flammability concerns expressed by external agencies.

- Developed complete engineering design specifications for volatile organic compound monitoring systems for five locations at the WIPP facility. Specifications included sampling method and frequency, selection of sampler and accessories, instrumentation and control requirements, fabrication and assembly drawings of the entire monitoring system, equipment layout, and field execution and quality control procedures.

Mixed Low-Level Waste

- Deputy Project Manager for IT for the development of a Systems Analysis Methodology for evaluation of "cradle-to-grave" options for management of DOE MLLW that include all major components of MLLW management, such as waste characterization, treatment, storage, transportation, and disposal. The methodology, which was developed for EG&G Idaho in support to DOE-HQ, is an analytical tool for evaluation of MLLW options in terms of the performance of final waste forms in a disposal facility, life-cycle cost and schedule for implementing options, health and safety risks associated with the options, and also the regulatory impact of each option. Apart from routine responsibilities as Deputy Project Manager for the 18-month duration of this $2.4 million project was also the leader for the development of the life-cycle cost and schedule estimation methodology.

- Provided direct support to DOE-HQ in the preparation of the Interim Mixed Waste Inventory Report that was submitted to the EPA in May 1993 in response to the FFCA. Interfaced with DOE site representatives and completed technical review of waste profile sheets for a number of waste streams from these sites to verify the correctness and consistency of the data provided by the sites.

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Low-Level Waste

- Primary author of many sections of the draft "Low-Level Waste Background Report," which was prepared for EG&G Idaho in support of the waste type-specific strategic planning process for DOE-HQ. The report presented an overview of LLW management in the DOE complex, with an emphasis on current challenges requiring attention and potential future courses of action.

- Contributed to the development of a macroengineering design for remediation of the 100 Area at the Hanford Site. Responsible for the development of a conceptual design of an efficient on-site system for transportation of excavated waste between different areas and facilities at the Hanford Site. Also prepared cost estimates and equipment specifications for this system.

Spent Fuel

- Primary author of many sections of the draft "Spent Fuel Background Report," which was prepared for EG&G Idaho in support of the waste type-specific strategic planning process for DOE-HQ. The report summarized the DOE spent fuel inventory and applicable regulations for management of spent fuel in the DOE complex and also discussed historical spent fuel management practices at each DOE site

M

- Primary author of many sections of a report titled, "Issues Related to DOE Management of Spent Nuclear Fuel," which was prepared for EG&G Idaho in support of DOE-HQ. This report summarized current spent fuel management issues (both site-specific and DOE complexwide) and discussed their potential implications on the DOE system.

1987–1989 ***Graduate Assistant, Anderson School of Management, University of New Mexico, Albuquerque, New Mexico.*** Responsible for assisting professors in research and course work. Tutored undergraduates in financial management courses and graded graduate-level financial management course work. Collected and summarized data from the Wall Street Journal in different areas of investment analysis.

1988 ***Marketing Intern, Southwest Airlines, Albuquerque, New Mexico.*** Assisted Area Marketing Manager in marketing activities, analyzed market share data, initiated sales calls, and prepared monthly airline market analysis reports.

1984–1986 ***Research Assistant, Department of Chemical Engineering, University of New Mexico, Albuquerque, New Mexico.*** Assisted professors with research in the areas of heterogeneous catalysis and solar engineering.

- Developed a comprehensive computer model for the design, performance analysis, and optimization of a gel solar pond for domestic heating purposes. Included detailed modeling and simulation of heat collection, temperature profiles as a function of depth, and process heat exchange from any given size pond. The model was subsequently used to design and construct a pond 5 meters deep and 400 square meters in area for a local business center in Albuquerque.

- Designed and fabricated an automatic fine particle generator to prepare nonporous spherical TiO_2 particles to be used as supports for Rh catalysts. Investigated the metal-support interactions of Rh catalysts using nonporous oxide supports of model shapes (silica and titania spheres, magnesia cubes).

1983–1984 ***Teaching Assistant, Department of Chemical Engineering, University of New Mexico, Albuquerque, New Mexico.*** Assisted professors with undergraduate courses and grading and supervised undergraduates in Unit Operations Lab. Guided undergraduates through start-up and shut-down procedures of various units. Tutored undergraduate courses in chemical engineering.

Professional Affiliations

American Institute of Chemical Engineers

Publications

Chakraborti, S., M. Abashian, J. Rhoderick, and L. Harmon, 1993, "Transportation of DOE Mixed Waste in the U.S.," *Proceedings of the Second International Mixed Waste Symposium*, August 17–20, Baltimore, Maryland, p. 12.4.1.

Chakraborti, S., and T. DeBiase, 1993, "Transportation of Liquid Mixed Waste in the U.S.: Is It Really a Problem?" *Proceedings of the Second International Mixed Waste Symposium*, August 17–20, Baltimore, Maryland, p. 12.3.1.

Chakraborti, S., T. DeBiase, M. Devarakonda, M. Abashian, and J. Bassi, 1993, "Estimation of Initial Costs of DOE Mixed Low-Level Waste Management Options," *Proceedings of the 1993 Incineration Conference*, May 3–7, Knoxville, Tennessee, p. 125.

Caregeorges, M., S. Chakraborti, M. Abashian, and J. Bassi, 1993, "Evaluation of the Regulatory Compliance Impact on DOE Mixed Low-Level Waste Management Options," *Waste Management '93, Proceedings of the Symposium on Waste Management*, Tucson, Arizona, February 28–March 4, p. 1809.

Melvin, J., S. Chakraborti, M. Abashian, and D. Abbott, 1993, "Spent Fuel Storage in the DOE Complex: A Discussion of the Current Status and Unresolved Issues," *Waste Management '93, Proceedings of the Symposium on Waste Management at Tucson, Arizona*, February 28–March 4, p. 877.

Chakraborti, S., T. DeBiase, M. Devarakonda, M. Abashian, and J. Bassi, 1993, "Estimation of Initial Costs of DOE Mixed Low-Level Waste Management Options," *Waste Management '93, Proceedings of the Symposium on Waste Management at Tucson, Arizona*, February 28–March 4, p. 1803.

Chakraborti, S., T. DeBiase, M. Devarakonda, M. Abashian, and J. Bassi, 1992, "Development of a Methodology for Estimation of Initial Costs of DOE Mixed Low-Level Waste Management Options," *Proceedings of the Fourteenth Annual U.S. Department of Energy Low-Level Radioactive Waste Management Conference*, November 18–20, Phoenix, Arizona.

Abashian, M., Chakraborti, S., M. Devarakonda, S. Djordjevic, and J. Bassi, 1992, "A Decision Methodology for the Evaluation of Mixed Low-Level Radioactive Waste Management Options for DOE Sites," *Proceedings of the Fourteenth Annual U.S. Department of Energy Low-Level Radioactive Waste Management Conference*, November 18–20, Phoenix, Arizona, p. 428.

Chakraborti, S., M. Abashian, J. C. Lopez, and R. Batra, 1992, "Review of Alternate Container Materials for TRU Waste: An Expert Panel Evaluation," *Proceedings of the 1992 Incineration Conference*, May 11–15, Albuquerque, New Mexico, p. 657.

Datye, A. K., S. Chakraborti, and E. J. Braunschweig, 1988, "Structure and Reactivity of Small Metal Particles," *Proceedings of the 9th International Congress on Catalysis*, p. 1122.

Chakraborti, S., N. J. Long, and A. K. Datye, 1987, "Oxidation-Reduction Treatment of Rhodium Supported on Nonporous Silica Spheres," *Journal of Catalysis*, Vol. 108, pp. 444–451.

Holt, T., S. Chakraborti, A. D. Logan, and A. K. Datye, 1987, "The Effect of Catalyst Preparation Conditions on the Morphology of MgO Catalyst Supports," *Applied Catalysis*, Vol. 34, p. 199.

Wilkins, E., T. K. Lee, and S. Chakraborti, 1986, "Optimization of the Gel Solar Pond Parameters: Comparison of Analytical Models," *Energy Conversion and Management*, Vol. 26, No. 1, pp. 123–134.

M

Terry A. DeBiase

Professional Qualifications

Mr. DeBiase is a chemical engineer with more than five years of experience in the environmental field. His technical specialties include design, costing, and construction management for remediation systems, development and application of predictive models for engineering design, as well as issues regarding transportation of radioactive mixed waste. Since joining IT, he has provided engineering support to the Los Alamos National Laboratory (LANL) Radioactive Liquid Waste Treatment Facility, U.S. Department of Energy (DOE) mixed low-level waste System Analysis Methodology, New Mexico Environment Department remediation projects, the Hanford site transuranic (TRU) waste management efforts, the Waste Isolation Pilot Plant (WIPP) project dealing with the cost and feasibility of transporting supercompacted TRU waste from the Rocky Flats Plant, and the EG&G Idaho project addressing disposal facility performance assessment for various final wasteforms. He has a strong background in field operations management, technical report preparation, permitting issues, and project and engineering support.

Education

B.S., Chemical Engineering, University of California at Berkeley, California; 1987
Groundwater Pollution and Hydrology, Princeton Short Course, Omni Environmental Corporation; 1990
OSHA Hazardous Waste Operations Training (29 CFR 1910.120, 40 hours); 1989
Management and Supervisor Training (29 CFR 1910.120, 40 hours); 1991
Hazards and Protection (annual refresher) IT Corporation; 1994

Registrations/Certifications

OSHA Engineer in Training, California

Honors and Awards

California State Finalist, Rhodes Scholarship; 1987
Male Scholar-Athlete Award; 1987
Robert Gordon and Ida Sproul Award, Outstanding Junior at University of California at Berkeley
Edmund Kraft Scholarship, Top 100 Freshmen
NCAA Swimming All-American (four-time), NCAA Academic All-American (three-time)

Experience and Background

1992-Present **Chemical Engineer, IT Corporation, Albuquerque, New Mexico.** Provides project and task management and engineering and regulatory support for DOE projects.

- Served as project manager for the technical support to the Radioactive Liquid Waste Section (CST-13) at Los Alamos National Laboratory. Project Work included the 75,000 gallon retrofit study, a tank decontamination plan, and an industrial ventilation standards study.

(M)

- Served as project engineer and task manager for the Lawrence Livermore National Laboratory (LLNL) project addressing proper use of the TRUPACT-II shipping package and associated equipment. Work performed included compilation of site-specific information, field survey for selection of a staging area for TRUPACT-II operations, and preparation of reports and procedures to enable LLNL personnel to use the TRUPACT-II.

- Supervised construction and installation of the remediation system at a site in Albuquerque, New Mexico. Permitted the thermal oxidation unit in Albuquerque. New Mexico, in compliance with Albuquerque-Bernalillo County Air Quality Control Board Regulations.

- Evaluated the effect of engineered soils and other site modifications as on the performance of waste disposal facilities for the National Low-Level Waste Management Program at the Idaho National Engineering Laboratory.

- Provided technical support for the environmental assessment document prepared to satisfy NEPA requirements for the environmental restoration activities planned for Sandia National Laboratories/New Mexico.

- Evaluated the effectiveness of various final waste forms and disposal sites with respect to compliance with the performance objectives in applicable DOE orders for EG&G Idaho.

- Performed an analysis of potential impacts on the Hanford Site TRU waste management efforts from uncertainties associated with the current WIPP Waste Acceptance Criteria. Work performed included compilation and analysis of site-specific information, client interface for the interpretation of relevant information and identification of additional data needs, and report preparation documenting the findings of the study.

- Analyzed U.S. Department of Transportation (DOT) and DOE requirements for transportation of radioactive mixed waste for the development of the DOE mixed low-level waste Systems Analysis Methodology, Published papers in support of this DOE effort, including the development of a cost estimation methodology for mixed low-level waste management options.

- Performed analysis of regulatory and transportation cost issues regarding the disposal of supercompacted Rocky Flats Plant TRU waste forms at the WIPP.

- Provided technical review and database support for the Mixed Waste Inventory Report prepared by DOE in response to the Federal Facility Compliance Act of 1992.

M

1989-1991 **Assistant Engineer, McLaren/Hart, Alameda, California.** Responsible for field operation management, technical report preparation, engineering support.

- Designed and supervised construction of groundwater extraction trench and hydrocarbon reclamation system at a site in Richmond, California, which was subject to the regulations established by the Resource Conservation and Recovery Act (RCRA).

- Provided database programming and maintenance as well as final quality assurance inspection in support of the final feasibility study for a site in Palo Alto, California, which was subject to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

- Wrote Bay Area Air Quality Management District air emission reports and National Pollutant Discharge Elimination System sewer discharge reports for groundwater extraction and treatment systems at RCRA and CERCLA sites.

- Performed operation and maintenance of groundwater extraction and treatment systems at RCRA and CERCLA sites in the San Francisco Bay area.

- Supervised soil sampling to provide final closure for a chemical dilution pit at a CERCLA site in Palo Alto, California.

- Coordinated wastewater discharge permit modifications and sampling plan preparation for a semiconductor manufacturer in Fremont, California.

- Analyzed emission control technologies for various petroleum refinery operations and processes to establish best available control technologies and maximum achievable control technologies for the American Petroleum Institute.

- Wrote a site closure plan in accordance with 40 CFR 265 for a hazardous waste generation facility.

- Coordinated and performed utility clearances for soil borings and well drilling operations.

- Provided engineering support for various projects, such as cost estimation, engineering calculations, and treatment system conceptualization, design, and permitting.

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1989 **Staff Chemical Engineer, Aqua Resources, Inc., Berkeley, California.** Responsible for field investigations and report preparation.

- Performed model development to assess groundwater flow at a CERCLA site in Mountain View, California. Coordinated and conducted water and soil sampling at the site.
- Conducted field surveys and wrote subsequent spill prevention, control, and countermeasure (SPCC) plans to comply with 40 CFR 112 for various United States Naval Bases in San Diego, California.
- Assisted in supervision of the removal of 11 underground storage tanks and subsequent soil and groundwater sampling at an Emeryville, California, site.

Publications/Presentation

Smith, T. H., J. Myers, S. M. Djordjevic, T. A. DeBiase, M. T. Goodrich, D. DeWitt, 1994, "Preliminary Parametric Performance Assessment of Potential Final Waste Forms for Alpha Low-Level Waste at the Idaho National Engineering Laboratory," EEG-WM-11415, Idaho National Engineering Laboratory, EG&G Idaho, Inc., Idaho Falls, Idaho.

Myers, J., S. M. Djordjevic, T. A. DeBiase, M. R. Goodrich, 1994 "Use of Engineered Soils and Other Site Modifications for Low-Level Radioactive Waste Disposal," DOE/LLW-207, National Low-Level Waste Management Program, Idaho National Engineering Laboratory, Idaho Falls, Idaho.

Chakraborti, S., and T. DeBiase, 1993, "Transportation of Liquid Mixed Waste in the U.S.: Is it Really a Problem?" Proceedings of the 2nd International Mixed Waste Symposium, at Baltimore, Maryland.

Chakraborti, S., and T. DeBiase, M. Devarakonda, and M. Abashian, 1993, "Estimation of Initial Costs of Mixed Low-Level Waste Management Option," Proceedings of the Symposium on Waste Management, Tucson, Arizona.

Bassi, J., Chakraborti, S., and T. DeBiase, M. Devarakonda, and M. Abashian, 1992, "Development of a Methodology for Estimation of Initial Costs of DOE Mixed Low-Level Waste Management Options," Proceedings of the 14th Annual U.S. DOE Low-Level Radioactive Waste Management Conference, Phoenix, Arizona.

Andrew A. Dykes

Professional Qualifications

Mr. Dykes is a senior consultant, for PLG, Inc., and has 29 years of relevant experience. He has experience in the application of probabilistic risk assessment (PRA) to nuclear facilities, including waste, spent fuel, and reactor facilities. Skilled at the integration of a variety of analyses into coherent products that address the client's needs. Well versed in a wide variety of analytical techniques, such as Bayesian treatment of evidence, accident analysis, decision analysis, reliability and availability assessment, and human reliability assessment. An expert in the integration of human actions into PRAs and the establishment of risk-based technical specifications.

Ph.D., Nuclear Engineering, Massachusetts Institute of Technology; 1982
M.S., Nuclear Engineering, Massachusetts Institute of Technology; 1971
B.S., United States Military Academy; 1964
Nuclear Plant Engineer Certificate, U.S. Army Power Group; 1971

Registrations/Certifications

Registered Professional Engineer, California and Virginia

Honors and Awards

Treasurer, International Association for Probabilistic Safety Assessment and Management
Chair, Conference Organizing Committee, PSAM-II
Active member of Subcommittee SC-7, Human Factors and Control Facilities, Nuclear Power Engineering Committee, of the IEEE Power Engineering Society
Alpha Nu Sigma
Phi Kappa Phi
Sigma Xi
Member, American Nuclear Society
Member, Institute of Electrical and Electronics Engineers Reliability and Power Engineering Societies
Member, Society for Risk Analysis

Recent Experience and Background

M

Project Manager, PLG, Inc. Handled a variety of projects for the utility industry, and conducted programmatic risk assessments of the options for the removal and interim storage of spent nuclear fuel at Hanford. Project manager and key technical contributor to safety analysis at the Rocky Flats Plant involving criticality safety analysis of plutonium waste drum storage and plutonium holdup material in exhaust ducts of processing lines to support the Safety Analysis Report for Building 707. Conducted the criticality hazards assessment for the preliminary hazards analysis of TA-55, the plutonium processing facility at Los Alamos National Laboratory, to support its FSAR upgrade. The evaluation of administrative controls to minimize human error played an important role in this assessment. Member of the independent safety assessment group for the SP-100 space nuclear reactor.

Completed human factors evaluation for the Final Safety Analysis Report (FSAR) upgrade to DOE Order 5480.23 criteria at the DOE's WIPP. Task leader for human reliability analysis on four full-scope PRAs. Developed a practical approach for eliciting judgment from operations personnel regarding human performance using the success likelihood index methodology. Guided operating crews through an elicitation process to both quantify the likelihood of error and identify potential improvements to operating procedures. This process produced a number of suggestions that were implemented to improve both operations and training. Participating in revisions of IEEE standards in human factors.

Experienced in the analysis of diverse operational and test data to support programmatic planning. As consultant to a U.S. Air Force System Program Office, established a Bayesian-based system for the assessing the flight reliability of the Advanced Cruise Missile. The system consisted of a structured reliability database to organize testing, failure, root cause evaluations, and corrective action effectiveness that provided an efficient communication tool that assisted the organizational decision process. Performed a variety of analyses ranging from the cost of modifications of a nuclear plant to reduce impact on marine life to the risk of cancellation of future projects. Task leader for performance assessment of coal-fired fueled power plants, resulting in a heat rate standard that was accepted by both the utility and the Public Utilities Commission as a fair measure for a rate incentive program.

Principal investigator on an Electric Power Research Institute project to apply risk-based technologies to reduce O&M costs and nuclear power plants. Accomplished studies supporting Technical Specification submissions for a number of utilities. Benefits included consolidation of surveillance procedures, reductions in test-caused failures, and extension of test intervals. Currently, formulating a framework for Technical Specification submissions to build on lessons learned and to speed up the review and approval cycle.

Extensive experience in a wide variety of engineering positions in the U.S. Army Corps of Engineers, including military nuclear power and nuclear weapons effects research and development. As an associate professor at the United States Military Academy, taught courses in nuclear physics, nuclear reactor physics, nuclear systems design, and computer-aided design.

M

Professional Affiliations

Active DOE "Q" Security Clearance
Active DoD "Secret" Security Clearance

Publications

Dykes, A. A., 1994, "Waste Isolation Pilot Plant Human Factors Evaluation," PLG, Inc., prepared for Merrick & Company and The S. M. Stoller Corporation, PLG-1004.

Dykes, R. A., A. A. Dykes, and J. Blodgett, 1994, "Risk Management and Corrective Actions," presented at the PSAM-II Conference, San Diego, California.

Dykes, R. A., A. A. Dykes, and J. Blodgett, 1994, "An Application of Bayes' Theorem to Management Decision Making," presented at the 1994 Annual Reliability and Maintainability Symposium, Anaheim, California.

Ho, V. S., W. T. Loh, A. A. Dykes, G. A. Tinsley, and H. F. Perla, 1994, "Fire and Flooding PSAs Requantification Project," PLG, Inc., prepared for IEA of Japan Co., Ltd., and Institute of Nuclear Safety, Nuclear Power Engineering Corporation, PLG-0967.

Kindinger, J. P., A. A. Dykes, W. G. He, and J. W. Read, 1993, "Decision Analysis to Support TVA Nuclear Generation Planning — Phase 2 Report," PLG, Inc., prepared for Tennessee Valley Authority, PLG-0922.

Dykes, A. A., C. R. Grantom, K. N. Fleming, J. M. Oddo, F. J. Rahn, and D. H. Johnson, "U.S. Nuclear Industry Efforts in Utilizing PSA for Technical Specifications Changes," 1993, presented at IAEA Technical Committee Meeting on Procedures for Use of PSA for Optimizing NPP Operational Limits and Conditions, Barcelona, Spain, September 20-23.

Dykes, A. A., 1993, "Derivation of Routine Human Error Rates Used as Screening Values for the TVA IPE," PLG, Inc., prepared for Tennessee Valley Authority, PLG-0931.

PLG, Inc., 1993, "Short Course — Safety and Risk Assessment of Nuclear and Nonnuclear Facilities," PLG-0927, Newport Beach, California.

PLG, Inc., 1993, "Short Course — Risk Assessment and Risk Management of Nuclear Facilities," PLG-0926, Newport Beach, California.

Dykes, A. A., and T. J. McIntyre, 1993, "Probabilistic Safety Assessment Applications in the U.S. and Canada," PLG, Inc., prepared for Mitsubishi Atomic Power Industries, Inc.

Dykes, A. A., and J. P. Kindinger, 1993, "Rocky Flats Drum Criticality Probabilistic Risk Assessment," PLG, Inc., prepared for EG&G Rocky Flats, Inc., PLG-0838, Rev. 1.

PLG, Inc., 1992, "Browns Ferry Nuclear Plant Unit 2 Probabilistic Risk Assessment Individual Plant Examination," prepared for Tennessee Valley Authority.

PLG, Inc., 1992, "Sequoyah Nuclear Plant Unit 1 Probabilistic Risk Assessment Individual Plant Examination," prepared for Tennessee Valley Authority.

PLG, Inc., 1992, "Watts Bar Nuclear Plant Unit 1 Probabilistic Risk Assessment Individual Plant Examination," prepared for Tennessee Valley Authority.

Dykes, A. A., and E. L. Quinn, 1992, "Methodology for Developing Risk-Based Surveillance Programs for Safety-Related Equipment at San Onofre Nuclear Generating Station Units 2 and 3," PLG, Inc., prepared for Southern California Edison Company, PLG-0575.

PLG, Inc., 1991, "Criticality Risk Assessment of Ductwork Material Holdup in Building 707," prepared for EG&G Rocky Flats, Inc., PLG-0818.

Dykes, A. A., J. A. Mundis, and D. A. Bidwell, 1991, "Application of a Bayesian Aging Model to Predict Steam Generator Plugging Rates," *Proceedings of the International Conference on Probabilistic Safety Assessment and Management*, Beverly Hills, California.

Dykes, A. A., J. W. Read, K. Woodard, and D. R. Buttemer, 1990, "Assessment of Marine Review Committee Recommendations for SONGS Units 2 and 3," PLG, Inc., prepared for Southern California Edison Company, PLG-0805.

M

MICHAEL A. EMERSON

Consultant, PLG, Inc.

8 Years of Relevant Experience

SUMMARY:

Consultant and Manager of PLG's Albuquerque office specializing in the application of risk assessments in the nuclear, chemical, and aerospace industries.

EDUCATION:

M.S., Nuclear Engineering, University of Washington, 1988
B.S., Mechanical Engineering with Distinction, University of New Mexico, 1986

RECENT EXPERIENCE:

Extensive experience in assisting utilities to perform nuclear plant probabilistic risk assessments (PRA), including development of risk models using PLG's RISKMAN® software. Currently participating in the B-52H Nuclear Weapon System Safety Assessment and associated B-52H Electrical Systems Analysis to provide hazard scenario screening and quantification.

Served as manager of computer operations and software development and as project manager for RISKMAN, PLG's most important computer package that provides quantitative risk management capability. Recent RISKMAN development included the addition of new data, spatial, seismic analysis modules, and risk management facilities.

Project manager on the development of programmatic risk assessment software tools.

OTHER EXPERIENCE:

Provided full-time support to Pacific Gas and Electric Company's probabilistic risk assessment (PRA) group in the development of its individual plant examination report for the Diablo Canyon Nuclear Power Plant. Was principal editor of Level 1 and Level 2 portions of the report and produced the executive summary. As part of this support, updated systems analyses, performed an update of the internal flooding analysis, and used the PRA to examine potential changes in plant and procedures. The latter use of the PRA included prioritizing masonry walls for reinforcement on the basis of their potential failure impact on adjacent equipment or mounted conduits carrying important power or control wiring, for justifying continued plant operation under certain degraded systems conditions, and for evaluating the risk of taking specific equipment out of service for maintenance.

Co-authored BARP, a program that provides Bayesian updating of reliability data. Served as a contributor to the development of COPILOT, an expert system that used Bayes' theorem to diagnose nuclear plant transient and accident events. Performed system analyses for boiling water reactor and space station systems.

HONORS AND AWARDS:

Institute of Nuclear Power Operations Fellowship
Tau Beta Pi, Engineering Honor Society
Member, American Society of Mechanical Engineers
Member, American Nuclear Society
Member, Society for Risk Analysis

SECURITY CLEARANCES:

Active DoD "Secret" Security Clearance

RECENT PUBLICATIONS (LAST 5 YEARS):

Kaplan, S., K. M. Naassan, M. A. Emerson, W. R. Fuller, "SBIR Phase 1 Report - Probabilistic Schedule and Cost Risk Analysis for KSC Shuttle Operations," PLG, Inc., prepared for the National Aeronautics and Space Administration, Kennedy Space Center, PLG-0934, July 1993.

Emerson, M. A., K. N. Fleming, D. J. Wakefield, S. A. Epstein, "RISKMAN® - A System for PSA," presented at Probabilistic Safety Assessment, PSA '93, Clearwater Beach, Florida, January 26-29, 1993.

Emerson, M. A., V. S. Ho, D. H. Johnson, C. M. Lankheim, and K. M. Naassan, "Risk Analysis of Environmental Hazards at the High Flux Beam Reactor," Phase 1 Interim Report, PLG, Inc., prepared for Brookhaven National Laboratory, PLG-0884, September 1992.

Contributing Author to:
"Browns Ferry Nuclear Plant Unit 2 Probabilistic Risk Assessment Individual Plant Examination," PLG, Inc., prepared for Tennessee Valley Authority, 1992.

Contributing Author to:
"Sequoyah Nuclear Plant Unit 1 Probabilistic Risk Assessment Individual Plant Examination," PLG, Inc., prepared for Tennessee Valley Authority, 1992.

Contributing Author to:
"Watts Bar Nuclear Plant Unit 1 Probabilistic Risk Assessment Individual Plant Examination, PLG, Inc., prepared for Tennessee Valley Authority, 1992.

Kaplan, S., S. A. Epstein, A. A. Dykes, and M. A. Emerson, "BARP - A PC-Based Bayesian Reliability Program Allowing Engineers to Think in the Language of Probability Curves," *Journal of Reliability Engineering and System Safety*, Vol. 30, pp. 399-408, PLG-0706, 1990.

Kaplan, S., A. Keter, S. A. Epstein, D. C. Bley, and M. A. Emerson, "COPILOT - A PC-Based Expert System for Reactor Operational Assistance Using a Bayesian Diagnostic Module," *Journal of Reliability Engineering and System Safety*, Vol. 30, No. 1-3, pp. 219-237, PLG-0705, 1990.

Fleming, K. N., G. A. Tinsley, M. A. Emerson, D. J. Wakefield, "Risk-Based Equipment Prioritization for Beaver Valley," prepared for Duquesne Light Company, PLG-0770, May 1990.

Kaplan, S., A. Keter, D. G. Lindsay, D. C. Bley, S. A. Epstein, and M. A. Emerson, "Expert Systems for Diagnosis and Decision under Substantial Uncertainty - A Classical (Bayesian) Approach," presented at Forum on Artificial Intelligence in Management, PLG-0761, Monterey, California, May 14-17, 1990.

(M)

Denise C. Gelston

Manager, Air Programs

AREAS OF EXPERTISE

RCRA Compliance and Permitting
Hazardous and Mixed Waste Management
Air Emission Inventories
SARA 312 Reporting
Environmental Auditing

SUMMARY OF QUALIFICATIONS

Ms. Gelston has eight years of experience in environmental compliance and permitting and hazardous and mixed waste management. She ensures regulatory compliance, prepares Air Pollutant Emission Notices (APENs), prepares and reviews RCRA permit applications and closure plans, assists in the preparation of SARA 312 chemical inventory reports, and conducts compliance audits. Ms. Gelston has also assisted in developing a course curriculum for a Clean Air Act Operating Permit course, and has participated in presenting the course.

EXPERIENCE

Manager of Air Programs — **The S.M. Stoller Corporation**
March 1990 - Present — **Boulder, Colorado**

Project manager for the preparation of a RCRA permit application for a hazardous waste landfill. Responsibilities include planning and scheduling for a completed application and overall coordination of various activities that must be completed prior to permit application submittal, including site characterization and facility design. Other responsibilities include interaction with regulators, regulatory interpretation, and preparation of several sections of the permit application.

Project manager of the development of an environmental, health, and safety management system. Ensured that activities were conducted within budget constraints, provided regulatory interpretation, ensured that system components complied with applicable regulations, and assisted in preparation of SARA 312 chemical inventory reporting.

Assisted in preparation of course curriculum for a Clean Air Act Operating Permit course. Designed a process, identified emission points, quantified emissions, determined the applicability of operating permit regulations, and identified pollution prevention and legal options that could be used to assist a facility in avoiding operating permit requirements. Prepared a course segment on enhanced monitoring provisions. Currently assisting in the presentation of the course to various clients.

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Assisted in the preparation of a RCRA closure procedure for a hazardous waste container storage area for a private client. The procedure described activities in sequence for decontaminating secondary containment, equipment, piping, and vaults; disposing of waste generated as a result of closure activities; and sampling to ensure clean closure. Identified methods to minimize waste generated during closure. The procedure was reviewed against the approved RCRA closure plan to ensure that all closure activities are consistent with the closure plan.

Assisted in revising the Rocky Flats Volume Basis Waste Management Cost Analysis, which is an effort to quantify direct labor and material costs associated with managing the principal waste streams at the Rocky Flats Environmental Technology Site. Identified waste management operations and quantified costs associated with those operations.

Served as a member of a multidisciplinary team preparing RCRA permit modification requests for hazardous, low-level mixed, and transuranic-mixed waste storage and treatment units at Rocky Flats. Prepared process flow diagrams, piping and instrumentation diagrams, unit descriptions, and secondary containment calculations for various units in Building 374 at Rocky Flats.

Assisted in preparation of the Rocky Flats Mixed Residues Part B permit modification request. The modification request included hundreds of storage tanks and container storage areas. Interpreted regulations, prepared reports on applicability of RCRA to various units, collected an extensive amount of field information regarding residue characterization and process operations, and prepared process flow diagrams, container storage area layouts, piping and instrumentation diagrams, unit descriptions, and secondary containment calculations for containers and tanks.

Prepared APEN reports for support facilities, storage tanks, and miscellaneous emission sources at Rocky Flats. Estimated airborne emissions of hazardous criteria and toxic pollutants from facilities and storage tanks. The analysis entailed the evaluation of processes and application of engineering judgment to determine source pathways and potential release rates of pollutants.

Assisted in the identification of processes and equipment at Rocky Flats that are subject to RCRA organic air emission regulations and conducted monitoring of equipment subject to the regulations. Demonstrated use of monitoring equipment to facility employees.

Participated in field surveys for the Waste Stream and Residue Identification and Characterization Program for Rocky Flats. Analyzed production and process systems and operations. Characterized both inputs and outputs to processes. Identified RCRA hazardous constituents possibly present in waste streams. Determined chemical reactions occurring during processing. Identified transfer of waste streams to waste management units.

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Assisted in the preparation of a RCRA Part B Permit modification for the Waste System Evaporator in Building 374 at the Rocky Flats Environmental Technology Site. Reviewed engineering drawings, developed process flow diagrams, and wrote sections of the permit modification.

Prepared a Waste Beer Reduction Report for a brewery. Interviewed personnel, reviewed existing data, identified projects and strategies for reducing waste beer generation, calculated VOC emissions, generated a spread sheet, and wrote the final report.

Served as a member of a team assessing the 1993 Operational Readiness Review (ORR) at the Waste Isolation Pilot Plant. Evaluated the performance criteria for the ORR and assessed the adequacy of the facility response to the performance criteria for environmental programs and the RCRA permit application.

Environmental Engineer
August 1986 - March 1990

U.S. Department of Energy
Albuquerque Operations Office
Albuquerque, New Mexico

Provided professional assistance and technical advice to DOE-AL organizations and contractors. Active in nonradioactive hazardous waste and mixed-waste management programs established in support of manufacturing and production technology and national laboratory research activities.

Evaluated DOE treatment, storage, and disposal facilities for compliance with statutes, regulations, and guidelines. Interpreted statutes, regulations, and guidelines to determine applicability to specific situations.

Reviewed and advised on potential impacts from proposed standards, guides, procedures, and regulations in waste management and environmental protection. In particular, provided assistance in determining the impacts of the RCRA Land Disposal Restrictions to mixed wastes at DOE facilities.

Coordinated permit processing in accordance with RCRA. In addition, assisted in the development of RCRA 3008(h) Orders and the response to other compliance orders issued pursuant to RCRA.

EDUCATION

B.S., Chemical Engineering, Rensselaer Polytechnic Institute, 1986

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TRAINING

OSHA 40-Hour Hazardous Waste Health and Safety Training and 8-Hour Refreshers (March 1990, April 1991, and May 1993 Urie Environmental) (May 1992 - Condor Environmental)
Fundamentals of Groundwater and Well Technology, National Water Well Association, 1990
Occupational Environmental Radiation Protection, Harvard School of Public Health, 1988
DOE Environmental Regulations course, Executive Enterprises, November 1989
Nuclear Weapons Orientation, Advanced, U.S. Air Force, June 1987

DAVID J. LECHEL

Fields of Competence

Project management; peer review; environmental impact analysis; NEPA, CERCLA/SARA, RCRA regulatory expertise; design and implementation of environmental sampling programs; regulatory analysis and permit acquisition; strategic planning; environmental audits.

Experience Summary

Twenty one years of experience in project management and preparation of multidisciplinary environmental studies, regulatory analysis, and monitoring in support of remedial actions and construction activities. Responsibilities have included:

- Design, conduct, management, and report preparation of extensive environmental impact documents of U.S. Department of Energy defense facilities, national laboratories, and radioactive/hazardous waste disposal sites; commercial hazardous/toxic waste sites; and proposed coal mines, power plants, and wastewater treatment facilities.

- Regulatory analysis and strategic planning for compliant disposal of transuranic and mixed transuranic waste and byproduct material at U.S. Department of Energy disposal sites.

- Regulatory analysis, and licensing planning and implementation for closure of U.S. Department of Energy byproduct material disposal sites.

Credentials

M.S., Fisheries Biology -- Michigan State University (1974)
B.S., Fisheries Biology -- Michigan State University (1972)

Employment History

1992-Present	LECHEL, Inc.
1982-1992	Roy F. Weston, Inc.
1978-1982	Wapora, Inc.
1975-1978	Ichthyological Associates
1973-1975	Michigan State University

Key Projects

Engineered Alternatives Benefit/Detriment Analysis, Waste Isolation Pilot Plant, Carlsbad, New Mexico, Westinghouse Waste Isolation Division, Technical Consultant (1994-Ongoing). Provides assessment and probabilities of occurrence of potential environmental impacts consequent to each engineered alternative. The benefit/detriment analysis focuses on identifying and quantifying relevant aspects of environmental risk that may be posed by the engineered alternatives considered. The overall analysis requires the evaluation of several waste form modifications and alternative configurations for the repository. The benefits and detriments for which each alternative will be assessed include: short- and long-term environmental consequences, ability of the barrier(s) to retard movement of water and radionuclides, risk to workers from the implementation of the barriers, affect on waste retrieval, risk from transportation, uncertainties in resultant compliance analyses, changes in public confidence in the performance of the disposal system, costs, impacts on other waste disposal systems in the DOE complex, and the effects of mitigating the consequences of human initiated processes and events. The results from the above analysis will be coupled with those of the previous engineered alternatives task force and the current Systems Prioritization Methodology for inclusion in compliance demonstrations.

Peer Review, Tank Waste Remediation System Environmental Impact Statement, Richland, Washington, U.S. Department of Energy, Technical Consultant (1994-Ongoing). Provides independent review of project documents in support of preparation of the tank waste remediation system environmental impact statement (TWRS EIS). The proposed action is subject to the National Environmental Policy Act and the Washington State Environmental Policy Act. The DOE and State of Washington propose to manage, retrieve, treat, immobilize, and dispose or store radioactive, chemical, and mixed waste from 177 underground storage tanks and 1,933 cesium and strontium capsules at the Hanford Site. Remediation of single-shell and double-shell tank wastes will be evaluated by four overall alternatives: Tri-Party Agreement Preferred Alternative, Minimal Pretreatment Alternative, Extensive Pretreatment Alternative, and In-place Stabilization and Disposal Alternative. Alternatives for the long-term disposition of the cesium and strontium capsules include Tri-Party Agreement Storage and Disposal, Tri-Party Agreement Vitrification, and Onsite Stabilization and Disposal. The No Action Alternative is also under consideration. To date, peer reviews of the preliminary Implementation Plan and Chapter 4, Affected Environment have been conducted.

National Environmental Policy Act (NEPA) Support, Office of Civilian Radioactive Waste Management, Washington, D.C., U.S. Department of Energy, Technical Consultant (1994-Ongoing). Provided independent review of DOE and contractor prepared position papers to ascertain whether a Programmatic Environmental Impact Statement (PEIS) should be prepared to address the development of the nuclear waste management system. The DOE had announced in early 1994 that it would prepare multiple environmental impact statements (EISs) for its Proposed Program Approach to dispose of high-level waste and commercial spent nuclear fuel at the Yucca Mountain, Nevada site. EISs are to be prepared for the multi-purpose canister, the

Key Projects (continued)

suitability of Yucca Mountain as a repository site, the proposed rail spur, and possibly the monitored retrievable storage facility. The State of Nevada requested that DOE prepare a Programmatic Environmental Impact Statement (PEIS) because: (1) the multiple EISs will evaluate connected actions, which depend upon a larger action; and (2) the Proposed Program Approach represents but one of many alternatives to the development of the nuclear waste management system. Assessed various topical position papers, and reviewed DOE and the Council of Environmental Quality regulations that implement NEPA and other relevant and related NEPA compliance approaches within DOE. Recommended that DOE prepare multiple and generally expansive EISs that: (1) clearly articulate the types and timing of DOE decisions; (2) ensure that the many actions assessed in the early EISs do not limit future alternatives of subsequent EISs; and (3) build upon the previously established NEPA record as new information becomes available.

Technical Support, Idaho National Engineering Laboratory, Idaho Falls, Idaho, U.S. *Department of Energy, Technical Consultant* (1993-Ongoing). Prepared Summary and Record of Decision for, and provided independent technical review of, DOE's Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Management Programs Environmental Impact Statement (EIS). This two volume EIS evaluates programmatic approaches to management of spent nuclear fuel across the DOE complex, and considers site-specific approaches to the future direction of environmental restoration and waste management programs at INEL. The programmatic EIS evaluated five alternatives to manage existing and projected quantities of spent nuclear fuel, until the year 2035. The analyses focused on impacts to worker safety, public health and the environment, and socioeconomic factors related to transportation, receipt, stabilization and storage of DOE and Naval reactor spent nuclear fuel, as well as special-case commercial fuel. Siting locations for fuel stabilization, and research and development were also assessed. The site-specific EIS addressed five alternatives for management of environmental restoration, waste management, and spent nuclear fuel activities, until the year 2005, at INEL. Potential impacts from facility operations and environmental restoration, including decontamination and decommissioning activities, that would contribute to waste streams and their storage, treatment and disposal were included in the evaluations.

Technical and Management Support, Waste Isolation Pilot Plant, Albuquerque, New Mexico, U.S. Department of Energy, Technical Consultant (1992-Ongoing). Provided broad support including planning for the disposal phase supplement EIS, preparation of the Remote Handled Transuranic Waste Disposal Strategy, management and preparation of the WIPP-specific Regulatory Compliance Strategy and Management Plan, peer review of plans to comply with provisions of the WIPP Land Withdrawal Act, and technical peer review of elements of the WIPP regulatory compliance and experimental programs. Authored internal planning recommendations for the scope of the next supplemental EIS, including technical and regulatory content, schedule, and cost reduction. Provided peer review of DOE's Compliance Status

Key Projects (continued)

Report and Project Technical Baseline, and EPA's working draft implementing criteria at 40 CFR 194. Managed the preparation of the Regulatory Compliance Strategy and Management Plan which provided the strategy by which WIPP Program elements are integrated to comply with selected regulations including 40 CFR 191, Environmental Radiation Protection Standards for Management and Disposal of Spent Fuel, High-Level and Transuranic Radioactive Wastes, and RCRA including 40 CFR 264 Subparts G and X and 268 Subparts C and D. Peer-reviewed plans and documents resulting from provisions of the Land Withdrawal Act including the transportation assessment, and the test phase and waste retrieval plans. Provided independent technical review of performance assessment reports for compliance with 40 CFR 191, technical and regulatory reports prepared by Sandia National Laboratories, and other test plans and management plans for radioactive waste tests.

Technical Peer Review Support, Waste Isolation Pilot Plant, Albuquerque, New Mexico, U.S. Department of Energy, Project Manager (1992). Provided technical and regulatory peer review of a variety of test plans, policy and issues papers, decision plans, and technical and regulatory reports. Managed the preparation of a Regulatory Criteria Document that will form the basis of DOE's demonstrations of compliance with 40 CFR 191, Environmental Radiation Protection Standards for Management and Disposal of Spent Fuel, High-Level and Transuranic Radioactive Wastes and RCRA including 40 CFR 264 Subparts G and X and 268 Subparts C and D.

EIS/EIR for Continued Operations of Lawrence Livermore National Laboratory and Sandia National Laboratories, Livermore, Livermore, California, Lawrence Livermore National Laboratory, Project Manager (1991-1992). Managed the preparation of a combined environmental impact statement (EIS) and an environmental impact report (EIR) for the continued operations of the two national laboratories for the U.S. Department of Energy (DOE). The EIS complies with NEPA and the EIR complies with the comparable California law, CEQA. The EIS/EIR examined the current and future (5 to 10 years) operations of the laboratories. Emphasis was placed on waste generation and types, radionuclide/chemical/high explosive inventories, work force growth, occupational and public exposures to routine emissions of radionuclides and chemicals as well as potential exposures during various hypothetical accidents including seismic events. Other elements evaluated included environmental restoration activities, regulatory compliance, socioeconomics, land use, traffic and transportation. As part of this project, multiple libraries and reading rooms were established and maintained and an extensive community relations plan was implemented.

Supplemental EIS, Waste Isolation Pilot Plant, Albuquerque, New Mexico, U.S. DOE, Project Manager (1989-1990). Managed the preparation of the technical and regulatory aspects of a supplement to the EIS for the Waste Isolation Pilot Plant (WIPP). The WIPP is planned as the nation's first repository for disposal of defense-related transuranic waste. The supplement was prepared to report new geologic and hydrologic data (e.g., brine inflow, flow paths, and

Key Projects (continued)

velocity), changes in the waste inventory from ten DOE facilities nationwide, the consideration of hazardous chemical constituents, and changes in the routes and modes of transportation of waste. Responsibilities included the technical management and oversight of eight contractor organizations, preparation of the draft supplement, and response to nearly 20,000 comments in the final supplement.

Technical Support, Waste Isolation Pilot Plant, Albuquerque, New Mexico, U.S. Department of Energy, Project Manager (1990-1991). Provided broad-based technical, policy and regulatory compliance support to the WIPP. Required the development of various position papers regarding the proposed test phase, transuranic waste characterization, and bin-scale tests. Also involved analysis of cost schedule controls and performance monitoring tools, contractor integration, and recommendations for the continued compliance with various DOE orders and regulations.

Uranium Mill Tailings Remedial Action (UMTRA) Project, Albuquerque, New Mexico, Department of Energy (DOE), Manager, Environmental Services (1982-1987). Project Manager (1988-1989). Managed the UMTRA Project to ensure compliance with NEPA, other Federal, state, and local environmental regulations and Nuclear Regulatory Commission (NRC) licensing requirements. Managed a staff to produce EISs and Environmental Assessments (EAs). Prepared Findings of No Significant Impact (FONSI) and Records of Decision, as well as all necessary *Federal Register* notices such as notices of wetlands involvement, public hearings, and related documents. Lead the efforts and was responsible for identification of Federal, state, and local permits and approvals necessary for cleanup of radioactive mill wastes, as well as other ancillary NEPA compliance issues. Managed the preparation of DOE's guidance document for post-remedial action surveillance and maintenance. Also prepared site-specific surveillance and maintenance plans for several UMTRA Project sites, and implemented these activities at four sites. From 1988 through 1989, was Project Manager in support of DOE's UMTRA Project. Provided administrative oversight for technical issues, cost and schedule of remedial design, regulatory compliance, NEPA documentation, quality assurance and other aspects in support of remediation of 24 uranium mill tailings sites in 10 states and 2 tribal reservations.

Environmental Review, Los Angeles, California, Pacific Enterprises, Project Manager (1989). Prepared oral and written testimony for environmental aspects of proposed gas transmission lines. Three pipeline companies proposed the construction of gas pipelines from Wyoming to southern California, and Texas to southern California. Reviewed the environmental aspects of the proposal and prepared oral and written testimony. Testimony focused on cultural resources, flora and fauna, and cumulative impacts.

Environmental Audit, Pantex Plant, Amarillo, Texas, U.S. DOE, Environmental Scientist (1987). Served as member of an audit team at the DOE Pantex Plant. Audit was conducted under the guidance of the Los Alamos National Laboratory (LANL) Environmental Audit Plan

Key Projects (continued)

and the DOE headquarters survey team. Plant was surveyed using 15 different checklists in the major waste areas of radiological mixed wastes, organics, inorganics, asbestos, and polychlorinated biphenyl (PCB). Prepared the report for submittal to DOE and LANL.

Regulatory Analysis, Bear Creek Remedial Project, Oak Ridge, Tennessee, U.S. DOE, Environmental Scientist (1987). Project Scientist associated with a comparative review of the technical requirements of Resource Conservation and Recovery Act (RCRA), NEPA, and CERCLA for the Bear Creek Remedial Action Project. This effort involved a detailed listing of all discipline requirements integral to the remedial investigation/feasibility study (RI/FS) process. A document was prepared for DOE Oak Ridge Operations to serve as the basis for the implementation plan of the Bear Creek remedial program.

Public Health Evaluation, Grand Junction Facility, U.S. DOE, Grand Junction, CO., Project Manager (1986). Managed the preparation of a public health evaluation at DOE's Grand Junction Area office. Required identification of contaminants, pathways of concern, and assessment of effects with major emphasis on arsenic, barium, selenium, and PCBs.

Environmental Assessment and Design Services, SFMP Monticello Site, U.S. DOE, Project Manager (1985-1986). Lead the preparation of an EA and engineering consulting services for DOE's SFMP Monticello site. In addition to preparing the EA for remedial actions, the radon barrier and erosion protection were designed for the stabilized site. A public health evaluation was conducted. Required contaminant identification and migration pathways analysis with focus on arsenic, thorium, and uranium.

Environmental Assessment of Remedial Action at Bruin Lagoon, Philadelphia, Pennsylvania, EPA, Environmental Scientist (1982). Principal Investigator of an EA of cleanup actions at the Bruin Lagoon abandoned hazardous waste site in western Pennsylvania. Compilation and analysis of environmental and other factors led to a finding of no significant impact.

Environmental Review, Fourth Nuclear Power Plant, Taiwan, Washington, D.C., U.S. State Department, Project Manager (1980). Managed and prepared a concise environmental review of the proposed Fourth Nuclear Power Plant, Taiwan. Analyses indicated that initial plant design required additional modifications to prevent site flooding during the monsoon season. Except for an unavoidably high population density, all design features were within NRC standards and IAEA requirements.

Entrainment and Impingement Studies at Various Power Plants, Consumers Power Co., Jackson, Michigan, Detroit Edison, Detroit, Michigan, Project Manager (1979). Project Manager of 316(b) demonstrations for power plants on Western Lake Erie, the Detroit River, and the St. Clair River. The 316(b) demonstrations for the Lake Erie and St. Clair River plants

Key Projects (continued)

were the second required at the plants by the Michigan DNR because of incorrect initial assessments. All of the second demonstrations were promptly accepted by the DNR and EPA Region V.

Site Assessment, PCB Contamination, Philadelphia, Pennsylvania, SEPTA, Project Manager (1980). Project Director of a site assessment of railroad car shops contaminated with PCBs. Historical "housekeeping" practices and vertical/horizontal migrations of PCBs on and offsite were examined.

Areawide EA for New Source Coal Mines, Philadelphia, Pennsylvania, EPA, Peer Reviewer (1981). Technical administrator of area-wide assessments of new source coal mining in West Virginia and Kentucky. Extensive compilation and assessment of West Virginia and Kentucky human resources (socioeconomics, land use), natural resources (aquatic and terrestrial biota), and earth resources (coal, soils) information in support of NPDES permitting requirements.

EIS, New Source Coal Mine, Philadelphia, Pennsylvania, EPA, Project Manager (1981-1982). EIS of a new source coal mine in West Virginia. Factors of significance included the potential for the production of acid mine drainage and subsequent adverse impacts on sensitive receiving streams and the positive benefits derived from enhanced employment and induced socioeconomic effects.

Effluent Control Practices, Philadelphia, Pennsylvania, EPA, Peer Reviewer (1981). Project Director of an assessment of effluent control practices in the hard rock mining industry. Heavy metal effluent, acid mine drainage, and sediment control techniques were examined at 10 mines in the west and south. Developed a conceptual approach for further effluent abatement at one mine site in the arid southwest.

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John N. McFee

Professional Qualifications

Mr. McFee is a Registered Professional Engineer with 28 years of experience in chemical syntheses, energy recovery, waste management process design research and development, regulatory permitting, and characterization of hazardous and radioactive wastes. His technical expertise includes DOE waste treatment activities and technologies; design of incineration systems for hazardous and radioactive wastes; and developing systems for mixed waste processing. As Director of Engineering and Assessment of the IT-Albuquerque office, he supervises a staff of more than 40 environmental scientists and engineers with technical specialties in fate and transport modeling, mixed waste treatment technologies, and risk assessment. Mr. McFee is a member of IT's Technical Associate program.

Education

Nuclear Power Engineering School, Idaho National Engineering Laboratory; Idaho Falls, Idaho; 1974

B.S., Chemical Engineering, Clarkson College of Technology, Potsdam, New York; 1965

Registrations/Certifications

DOE Q Clearance, Active

Registered Professional Engineer, Idaho

Experience and Background

1988–Present *Manager, Engineering and Assessment, IT, Albuquerque, New Mexico.* Provides overall technical direction to IT's Albuquerque sections in remedial engineering, waste management engineering, risk assessment, and pathways modeling.

- Senior technical leader, titled Technical Area Leader for waste destruction and stabilization, supporting the DOE Office of Technology Development Mixed Waste Integrated Program. Responsibilities include review of DOE waste destruction research initiatives, technical oversight of waste destruction development programs, and consultation on DOE innovative waste treatment activities.

- Project Manager for the identification and characterization of technology improvements to the Waste Isolation Pilot Plant (WIPP). Participated in the WIPP Engineered Alternatives Task Force (EATF) project which was formed to identify and evaluate alternatives to the WIPP repository design and/or waste forms to enhance compliance with long-term performance standards (EPA 40 CFR 191). Assisted in developing an alternatives analysis technique to reduce the large number of possible alternatives to a manageable number of feasible alternatives. The preliminary screening was accomplished using an ordered decision logic system which quantified the decision criteria. Recommendations were developed for the number of treatment facilities and preferred locations.

- Participated in the DOE Mixed Waste Working Group as a WIPP representative. The Working Group assembled waste generation data and reviewed regulatory alternatives for compliance with the EPA's Land Disposal Restrictions. These efforts resulted in a two-year variance for radioactive mixed waste compliance.

- Member of the Technical Resource Team, supporting the DOE Mixed Waste Focus Area. Responsible for providing DOE with information and expert opinion on innovative and conventional technology application to treatment of mixed waste streams. Specific areas of expertise are thermal and nonthermal waste destruction technologies.

- Project Manager for a study of remediation technologies for removing soil contaminated with radioactive and mixed waste at the 100 Area of the DOE Hanford site. The study involved "macroengineering" technologies to determine available large-scale equipment remediation alternatives Developed a screening technique to reduce the large number of alternatives to a single feasible recommendation.

- Provided senior technical guidance and review of DOE site treatment plans for Nevada Test Site, Los Alamos National Laboratory, Sandia National Laboratories, Pantex Plant, and the Weldon Spring site.

- Senior technical contributor and project manager for a conceptual design study of alternatives addressing retrieval and processing of buried radioactive waste at the DOE's Idaho National Engineering Laboratory (INEL). Conceptual designs, cost estimates, and technology status information were developed on three incineration alternatives for waste processing.

- Project Manager for IT's contribution to the EG&G Idaho System Design Study. Numerous process flow schemes were developed to address the problem of retrieving and processing buried waste at the Idaho National Engineering Laboratory (INEL). Conceptual designs and cost estimates were prepared for the most promising schemes. Information prepared by IT staff included functional and operational requirements documents, mass balance diagrams, layout drawings, an assessment of the research necessary for successful application of the concept, and a system cost estimate.

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- Participant in the DOE-Headquarters T/S/D Workshop considering treatment/storage/disposal capabilities in the overall DOE system. This expert panel was created to develop a waste generation/waste treatment data base for all DOE facilities. Mr. McFee is a contributor in the specialties of transuranic waste and waste treatment.

- Project Manager for the RCRA waste stream characterization project of all Los Alamos National Laboratory facilities and On-Site Surveyor for a TA-55, the CMR Building, and the Sigma Complex where special nuclear materials are processed. The information is being used to document the Laboratory's waste generation activities pursuant to the requirements of the Laboratory's hazardous waste operating permit, to design wastewater treatment systems, and in NPDES permit applications. In several instances, recommendations were made for solvent substitution or waste segregation to minimize mixed waste generation.

- Project Manager of the EG&G Idaho master subcontract for hazardous waste management support at INEL.

- Supervised development of an information base of the existing waste treatment technologies currently in use in DOE facilities in support of DOE's application for regulatory relief from EPA's waste treatment requirements for mixed wastes subject to the Land Disposal Restrictions.

1985–1988 ***Senior Program Specialist, EG&G Idaho, Inc., Idaho Falls, Idaho.*** Mr. McFee's three years of experience with EG&G Idaho provided a broad background and understanding of INEL's waste management system. Specific activities included:

- Managed the RCRA Trial Burn for the INEL's low level waste incinerator. This included responsibilities for development of the waste characterization, evaluation of the trial burn plan strategies, preparation of the trial burn plan documentation, negotiation with EPA Region X for trial burn plan acceptance, subcontracting the sampling and analysis firm, and management of the trial burn. The trial burn was successful in two of the three selected test burns. U.S. DOE management presented a citation for excellent performance in the trial burn.

- Developed the design and cost estimate for a mixed waste liquid feed system for the WERF controlled air incinerator. Supervised development and execution of the RCRA trial burn plan and participated in meetings with EPA Region X on the permit application. Provided the bases and calculational methodology for the environmental assessment and safety analysis of the incinerator in the modified configuration.

- At the PREPP rotary kiln incinerator for retrieved TRU waste, responsibilities included preparing start-up test plans to evaluate the incinerator and off-gas system performance, and then serving as the test engineer to supervise the tests. After data were reduced, recommendations were made for system modifications which would enhance performance and operations.

- Principal technical representative in the development of the RCRA trial burn and state compliance test for PREPP. Served as the lead technical representative in discussions of the permit application with EPA Region X.

- Supervised the process design and cost study of alternatives for disposal of spent scrub solution from the PREPP incinerator off-gas clean-up system.

- Reviewed the Title I and Title II design package for an enriched uranium incinerator scheduled for installation at a DOE facility.

1984–1985 ***Director, Engineering and Technology, Waste-Tech Services, Inc., Idaho Falls, Idaho.*** As a Director of this Energy Incorporated spin-off company, responsibilities included the design and development of mobile fluidized bed hazardous waste incineration systems to be provided by this new company. The major tasks included supervising the design effort and preparing test plans and EPA permit applications.

- Directed the initial design efforts for a packaged hazardous waste incinerator system for destruction of chlorinated materials using a fluidized bed incinerator.

- Developed numerous designs for fluidized bed destruction systems addressing client waste problems including waste films, chemical process wastes, animal wastes, and contaminated soils. Most designs were based on pilot plant tests carried out to develop the design data.

- Directed a test program to demonstrate chlorinated organic compound destruction in a fluidized bed pilot plant. The destruction efficiencies were in compliance with RCRA standards, but at temperatures less than normally used for incineration of these compounds.

- Designed, developed, and demonstrated a prototype radioactive waste volume reduction system for nuclear power plant applications. The system was based on use of a single fluidized bed for calcining aqueous wastes and the incineration of combustible materials.

1975–1984 ***Group Manager, Fluidized Bed Applications, Energy Incorporated, Idaho Falls, Idaho.*** Directed the Energy Incorporated fluidized bed development laboratory. Specific activities included:

- Directed the company's development program on hazardous waste incineration. The program was concluded successfully having demonstrated fluidized bed capabilities in meeting EPA requirements for destruction efficiency and provided design parameters for commercial systems. Following successful development, an extensive marketing program was carried out in conjunction with the corporate marketing division.

- Developed test plans and directed numerous fluidized bed pilot plant tests to demonstrate energy recovery from various materials including: rubber tires, anthracite culm, waste hydrocarbon films, and production plant wastes.

- As Project Engineer and, subsequently, as Program Manager on the development program for the RWR-1, a commercial radioactive waste fluidized bed volume reduction system, a concept was designed, tested, and ultimately licensed by the NRC. Engineering responsibilities included: developing the concept, designing the prototype to meet regulatory and market needs, supervising the test program to develop design data, preparing the Licensing Topical Report with the appropriate safety assessment, and designing the deliverable system.

- As Senior Chemical Engineer, performed numerous process design tasks and incineration tests on fluidized bed programs.

1974–1975 ***Engineer, Westinghouse Electric Corporation, Idaho National Engineering Laboratory, Idaho Falls, Idaho.*** Graduated from a six-month, full-time Nuclear Power Engineering School for Naval Nuclear Power.

1973–1974 ***Engineer, Westinghouse Electric Corporation, Bettis Atomic Power Laboratory, West Mifflin, Pennsylvania.*** Participated in the hydraulic analysis and design of a Naval Nuclear Core.

1966–1972 ***Engineer, Hooker Chemical Corporation, Niagara Falls, New York.*** Process engineer in development, design, and startup at chemical production facilities.

Patents Granted

"Method of Recovering Hazardous Waste from the Phenolic Resin Filters," D. H. M. Krantz, G. L. Bourne, J. N. McFee, B. G. Burdge, J. W. McConnell, U.S. Patent No. 4,995,916.

Professional Acknowledgments

Invited Instructor for the 1988 and 1989 Incineration Conference Basics Short Course
Director 1990 through 1994. Incineration Conference Basics Short Course
Invited Instructor for the 1989 and 1990 ASME Radioactive Waste Management Course

Professional Affiliations

American Institute of Chemical Engineers

Publications

McFee, J. N., W. E. Schwinkendorf, and P. W. Hart, 1995, "Evaluation of Alternatives to Incineration for DOE Mixed Waste," Waste Management '95, *Proceedings of the Symposium on Waste Management*, Tucson, Arizona.

McFee, J. N., and J. Berry, 1995, "Mixed Waste Integrated Program: Waste Destruction/Stabilization Technical Area Program Highlights," Waste Management '95, *Proceedings of the Symposium on Waste Management*, Tucson, Arizona.

McFee, J. N., P. W. Hart, D. J. Kuchynka, and W. E. Schwinkendorf, 1994, "Innovative Low-Temperature Waste Destruction Processes for U.S. Department of Energy Mixed Waste Treatment," *Emerging Technologies in Hazardous Waste Management VI*, Vol. I, D. William Tedder, American Chemical Society, Atlanta, Georgia.

McFee, J. N., and L. G. Gale, 1988, "Testing of the PREPP Rotary Kiln for Waste Incineration," *Proceedings of International Conference on Incineration of Hazardous, Radioactive, and Mixed Wastes: 1987*, San Francisco, California.

McFee, J. N., H. Bohrer, and D. Dalton, 1987, "Status Report on the INEL RCRA Permit for Incineration of Hazardous Waste," *Proceedings of Incineration of Low-Level and Mixed Waste*, St. Charles, Illinois.

Steverson, E. M., and J. N. McFee, 1987, "The Incineration of Absorbed Liquid Wastes in the INEL's WERF Incinerator," *Waste Management '95, Proceedings of the Symposium on Waste Management*, Tucson, Arizona.

McFee, J. N., and R. L. Gillins, 1986, "Low-Level Radioactive Waste Incineration at the Idaho National Engineering Laboratory During 1986," *Waste Management '86, Proceedings of the Symposium on Waste Management*, Tucson, Arizona.

Steverson, E. M., D. P. Clark, and J. N. McFee, 1986, "Addition of Liquid Waste Incineration Capability to the INEL's Low-Level Waste Incinerator," *Waste Management '86, Proceedings of the Symposium on Waste Management*, Tucson, Arizona.

McFee, J. N., G. P. Rasmussen, and C. M. Young, 1985, "The Design and Demonstration of a Fluidized Bed for the Destruction of Hazardous Organic Materials in Soils," *Journal of Hazardous Waste*.

Rasmussen, G. P., and J. N. McFee, 1983, "Fluidized Bed Incineration Systems for the Ultimate Disposal of Toxic and Hazardous Materials," *Proceedings of the First Hazardous Materials Management Conference*, Philadelphia, Pennsylvania.

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M

Jonathan Myers

Professional Qualifications

Dr. Myers holds a Ph.D. in Geochemistry and has twelve years of professional experience. His specialty involves the application of computer modeling techniques for designing waste isolation systems; predicting interactions between contaminants, soil, rock, and groundwater; and predicting the fate of hazardous, transuranic (TRU), low-level (LLW), mixed, and high-level radioactive substances released into the environment. He has been actively involved in waste characterization, site characterization, and long-term performance modeling for several nuclear waste disposal projects including the Waste Isolation Pilot Plant (WIPP), the Yucca Mountain Project (YMP), the Basalt Waste Isolation Project (BWIP), the Salt Repository Project, and the Swedish and Canadian high-level nuclear waste disposal programs. He has provided extensive support to the WIPP project for over eight years. He has also been active in LLW performance assessment projects including an assessment of treatment and disposal option for mixed LLW at the INEL, and an assessment of the effectiveness of engineered barriers for isolating commercial LLW.

He has also been active in applying computer modeling techniques for developing contaminant source terms and sorption coefficients for several mixed LLW operable units as part of the Fernald, INEL, Nevada Test Site, and Los Alamos Environmental Restoration Programs. For these projects he has developed novel computer simulation techniques to predict the limits on contaminant concentrations in leachate that may migrate from the operable units.

Other related activities include the development and use of a cement degradation model to predict the long-term performance of various cement formulations proposed for use as engineered barriers in the Yucca Mountain and Swedish high-level nuclear waste disposal programs.

Dr. Myers has also pioneered the use of computer simulation techniques to design and evaluate waste treatment processes. He has used these techniques to predict the performance of proposed air stripper systems at Mather Air Force Base, optimized the design of a lime treatment system for heavy metal waste streams, and predicted the mass and composition of sludge resulting from heavy metal and radionuclide precipitation processes.

Dr. Myers is a member of IT's Senior Technical Associate program and has published over thirty technical papers in his field of expertise. He has made many presentations to the National Academy of Sciences, the most recent being "Recommendations of the Engineered Alternatives Task Force on Improving the Long-Term Performance of WIPP." He is currently manager of the IT-Albuquerque Hydrologic and Geochemical Assessment Group with technical oversight, cost and schedule, and technical staff supervision responsibilities.

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Education

Ph.D., Geochemistry, University of Wyoming, Laramie, Wyoming; 1982
M.S., Geology, University of Wyoming, Laramie, Wyoming; 1978
B.S., Geology, City University of New York, New York, New York; 1974

Experience and Background

1991-
Present

Manager, Hydrologic and Geochemical Assessment Group, International Technology Corporation (IT), Albuquerque, New Mexico. Dr. Myers manages a group of eight scientists and engineers who specialize in geochemistry, hydrology, and contaminant flow and transport. The group serves as a technical resource for clients and the company by performing computer simulations in support of site characterization, remedial investigations, feasibility and treatability studies, disposal system designs, risk assessments, and long-term performance predictions. The group has considerable experience in performing groundwater flow and contaminant transport modeling, calculation of radionuclide and heavy metal source terms, and estimation of adsorption coefficients for contaminants. His specific responsibilities have included:

- Contributing author of the WIPP Test Phase Plan. This work included the development of a methodology to address RCRA concerns for the mixed TRU waste inventory, and a definition of the testing required to provide the data necessary to evaluate compliance with the No-Migration provisions of RCRA.

- Project manager for a 1.1 million dollar contract to provide geotechnical support for the WIPP project. Tasks have included conducting computer simulations of creep closure to evaluate alternative repository configurations for extending the useful life of storage rooms and increasing the safety of underground operations.

- Project manager and technical director for a LLW performance assessment investigation for EG&G-Idaho in which the long-term performance of six waste forms proposed for the treatment of retrievably-stored mixed LLW at the INEL, and three sites proposed for disposal were evaluated. A total of thirty simulations were performed, each of which calculated a maximum annual effective dose equivalent for both undisturbed long-term performance and inadvertent human intruder scenarios. Work included the development of conceptual models, selection of numerical codes, defining site and wasteform properties, performing simulations, and interpreting results.

- Project manager and technical director for a commercial LLW performance assessment investigation for the DOE National Low-Level Waste Management Program. The work involved assessing the benefits of engineered barriers in improving the long-term performance of commercial LLW disposal facilities. Various facility designs incorporating combinations of barriers such as concrete overpacks, concrete vaults, sloped soil covers, sorptive backfill, and sorptive underlying layers were defined. Designs were evaluated by calculating a long-term dose reduction factor for each facility design relative to a reference facility design that did not incorporate engineered barriers.

- Technical director for a project to develop and use numerical models to assess the long-term performance of various mixed low-level radioactive waste (LLW) waste forms and disposal sites with respect to the performance requirements of DOE Order 5820.2A and 10 CFR 61 in support of the DOE-Headquarters Mixed LLW Management Program. Work involved the development of conceptual models, selection and modification of source-term, flow, transport, and dose assessment modules, linkage of modules, verification, benchmarking, and performing simulations.

- Proposed and evaluated options for the pump-and-treat remediation of groundwater contaminated with hexavalent chromium at sites in West Texas and Northern California. The evaluations utilized computer modeling techniques to quantify the effects of redox and pH adjustment on chromium precipitation and effluent composition. Recommendations resulting from the simulations were successfully implemented.

- Performed simulations of the deep injection well disposal of hazardous waste to predict the mobility of hazardous constituents at a site in West Texas. Analyses included the mixing of waste fluid and formation fluid at elevated temperatures in the presence of host rock mineralogy.

- Developed americium and plutonium source-terms for use in a risk assessment at a disposal pit at INEL. Source-terms were developed by performing waste/groundwater interaction simulations.

- Contributing author of several work plans developed for the Nevada Test Site ER program. This work included defining analytical parameters and detection limits for deep groundwater samples to support groundwater flow, contaminant transport, and risk assessment studies.

- Performed computer simulations of waste/groundwater interactions to calculate radionuclide and heavy metal leachate compositions at the central Los Alamos radioactive waste disposal facility for use in risk assessments.

- Performed simulations of the interactions that will occur at elevated temperatures between groundwater and several cement formulations proposed for seal materials at Yucca Mountain. The simulations provided estimates of the long-term seal performance.

- Used computer simulation techniques to optimize the design of a lime treatment system for the removal of radionuclides and heavy metals from aqueous waste streams. The simulations provided very cost-effective analyses of proposed designs.

- Evaluated the potential for mineral precipitation to reduce the effectiveness of air stripper systems proposed for use at Mather Air Force Base to remove VOCs from groundwater.

- Performed computer simulations to determine the factors affecting the pH of power plant fly-ash at a commercial generation facility in Northern California. Results of analyses are being used to control process parameters to avoid the generation of hazardous by-products.

1985 - 1991

Section Manager, Geochemical Analysis, International Technology Corporation, Albuquerque, New Mexico. Dr. Myers managed technical staff involved in projects for the Geochemical Analysis specialty in Albuquerque. His specific responsibilities have included:

- In support of the WIPP Engineered Alternatives Task Force (EATF), which was created by the DOE to identify and evaluate alternatives that could enhance the WIPP facility's compliance with long-term performance standards (EPA 40 CFR 191), Dr. Myers directed the development and use of a Design Analysis Model to predict the relative improvements that could be realized from both alternative repository designs and waste forms. The model predicts the 10,000-year cumulative releases of each radionuclide while considering the coupled interactions between brine inflow, creep closure, and gas generation.

- Chaired an expert panel for the WIPP EATF to evaluate potential applications of cementitious materials as waste forms, backfill, and container materials to immobilize TRU waste.

- Evaluated the long-term performance of the WIPP in terms of EPA 40 CFR 191 and the RCRA no-migration requirements contained in 40 CFR 268.6. Analyses included the effects of processing waste forms on migration rates of radioactive and RCRA-listed contaminants.

- Served as contributing author to the "Draft Final Plan for the Waste Isolation Pilot Plant Test Phase: Performance Assessment," a five-year plan which defines all of the waste characterization, site characterization, and computer modeling activities necessary to evaluate compliance with EPA regulations (RCRA and 40 CFR 191).

- Served as principal author of the "Panel One Test Plan for the Waste Isolation Pilot Plant" which outlined the procedures for conducting underground tests for measuring gas generation rates using actual waste in the WIPP repository.

- Provided input to the WIPP No-Migration Variance Petition under 40 CFR 268.6 by developing contaminant source terms for modeling releases of RCRA-listed hazardous components from the WIPP disposal system.

- For the WIPP Brine Sampling and Evaluation Program, performed geochemical characterization of the repository environment, including brine chemistry and brine/rock interactions, and a geochemical characterization of potential sources of intruding water, including Castile and Salado brines. This information was subsequently used to develop source terms for performance assessment activities in support of 40 CFR 191.

- Developed the Water Quality Sampling Plan for the WIPP site which involved the repeated sampling and analysis of groundwater from approximately 20 wells in the vicinity of the repository to determine groundwater characteristics. Data from the program were subsequently used to predict radionuclide migration rates through the overlying aquifers.

- Served as Project Manager during 1985 and 1986 for integrating hydrological and geochemical modeling tasks with the overall WIPP performance assessment program to determine regulatory compliance for the WIPP site. Activities included developing conceptual models and computer codes so that coupled processes could be realistically simulated. Conducted code verification and validation to ensure integrity of the results.

- Developed and used innovative geochemical modeling techniques to optimize the removal of uranium from contaminated groundwater by pH adjustment and anion exchange processes in support of the Fernald CERCLA feasibility study.

- Developed modeling techniques to estimate uranium, thorium, and heavy metal solubilities and sorption coefficients to provide input into the fate and transport modeling for CERCLA RI/FS at the Fernald site.

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- For the Yucca Mountain Project and the Swedish repository high-level nuclear waste programs, modeled the long-term performance of cementitious seals using the EQ3/EQ6 computer code.

- For the YMP, analyzed geochemical interactions between cementitious seal materials and groundwater to evaluate the longevity of shaft sealing components. The results of these studies were subsequently published and presented at Waste Management '89 and the Sixth International Water/Rock Interactions Conference.

- Served as contributing author to the "Field Sampling and Laboratory Procedure Plan for the Fernald Geochemical Program" which defined the number, location, and types of analyses to be performed on soil, rock, and groundwater samples at the Fernald site.

1982 - 1985 ***Senior Geochemist, Basalt Waste Isolation Project, Rockwell International, Richland, Washington***. While at Rockwell International, Dr. Myers was involved in the following activities in the field of high-level nuclear waste management and disposal:

- Served as Principal Technical Director for a large experimental test program designed to determine the interactions which occur between actual high-level nuclear waste, barrier materials, host rock, and groundwater at elevated temperatures and pressures. Duties included providing technical guidance for long-term experiments performed in a radiation environment.

- Evaluated the performance of the Basalt Waste Isolation Project repository design in terms of the regulatory requirements as defined in NRC 10 CFR 60 and EPA 40 CFR 191 governing the long-term performance of a high-level nuclear waste repository. Specific analyses included interactions between radionuclides, groundwater, and rock to predict contaminant migration rates.

- Directed a project to develop Eh and pH sensor systems which will operate at temperatures up to 300°C and pressures up to 300 Atmospheres.

- Planned and conducted an experimental test program to determine the effects of alpha and gamma radiation on water/rock interactions.

- Responsible for negotiating technical statements of work and contract terms on several subcontracts placed with organizations including Westinghouse, Battelle, University of Colorado, Arizona State University, and Temple University.

Professional Affiliations

American Geophysical Union
Geochemical Society
International Association of Geochemistry and Cosmochemistry
Mineralogical Society of America
American Institute of Physics

Publications

Smith, T. H., J. Myers, S. M. Djordjevic, T. A. DeBiase, M. T. Goodrich, D. DeWitt, 1994, "Preliminary Parametric Performance Assessment of Potential Final Waste Forms for Alpha Low-Level Waste at the Idaho National Engineering Laboratory," EGG-WM-11415, Idaho National Engineering Laboratory, EG&G Idaho, Inc., Idaho Falls, Idaho.

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Myers, J., P. Drez, and P. James, 1991, "The Redox State of the Culebra Member of the Rustler Formation," in "Hydrogeochemical Studies of the Rustler Formation and Related Rocks in the WIPP Area, Southeastern New Mexico," *SAND88-0196*, M. D. Siegel, S. J. Lambert, and K. L. Robinson, eds., Sandia National Laboratories, Albuquerque, New Mexico.

Siegel, M. D., K. L. Robinson, J. Myers, 1991, "Solute Relationships in Groundwaters from the Culebra Dolomite and Related Rocks in the Waste Isolation Pilot Plant Area, Southeastern New Mexico," in "Hydrogeochemical Studies of the Rustler Formation and Related Rocks in the Waste Isolation Pilot Plant Area, Southeastern New Mexico," *SAND88-0196*, M. D. Siegel, S. J. Lambert, and K. L. Robinson, eds., Sandia National Laboratories, Albuquerque, New Mexico.

Myers, J., S. Djordjevic, M. Adams, R. Spangler, J. Valdez, D. Vetter, and P. Drez, 1991, "Design Analysis of Engineered Alternatives for the Waste Isolation Pilot Plant", *Waste Management '91, Proceedings of the Symposium on Waste Management.*

Abitz, R., J. Myers, P. Drez, and D. Deal, 1990, "Geochemistry of Salado Formation Brines Recovered From the Waste Isolation Pilot Plant Repository," in *Waste Management '90, Proceedings of the Symposium on Waste Management.*

Ulmer, G. C., D. E. Grandstaff, and J. Myers, 1990, "A New Hydrothermal Technique for Redox Sensing Using Buffer Capsules," *Fluid-Mineral Interactions: A Tribute to H. P. Eugster*, R. J. Spencer and I-Ming Chou, eds., The Geochemical Society, Special Publication No. 2.

Alcorn, S. R., J. Myers, M. A. Gardiner, and C. A. Givens, 1989, "Chemical Modeling of Cementitious Grout Materials Alteration in HLW Repositories," in *Waste Management '89, Proceedings of the Symposium on Waste Management*, Tucson, Arizona, February 26–March 3.

Gardiner, M. A., S. R. Alcorn, J. Myers, and C. A. Givens, 1989, "Modeling Simple Cement-Water Systems Using the Speciation/Solubility/Reaction Path Computer Codes EQ3NR/EQ6, With Specific Application to Nuclear Waste Repositories," *Proceedings of the Sixth International Water-Rock Interaction Conference*, Grand Malvern, England, August, pp. 235–238.

Deal, D. E., J. B. Case, R. M. Deshler, P. E. Drez, J. Myers, and J. R. Tyburski, 1987, "Brine Sampling and Evaluation Program Phase II Report," *DOE-WIPP-87-010*, prepared for U.S. Department of Energy, Waste Isolation Pilot Plant, Carlsbad, New Mexico.

Gunter, W. D., J. Myers, and S. Girsperger, 1987, "Hydrogen: Metal Membranes" in *Hydrothermal Experimental Techniques*, G. C. Ulmer and H. L. Barnes, eds., John Wiley & Sons, New York.

Myers, J., and I. D. Colton, 1986, "The Geochemical Environment of the Culebra Dolomite," *Transactions of the American Geophysical Union*, Vol. 67, No. 16, p. 408 (abstract).

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Early, T. O., J. Myers, and E. A. Jenne, 1985, "Applications of Geochemical Modeling to High-Level Nuclear Waste Disposal at the Hanford Site, Washington," *Proceedings of the Conference on the Application of Geochemical Models to High-Level Nuclear Waste Repository Assessment*, G. K. Jacobs and S. K. Watley, eds., NUREG-CP-0062, pp. 104-108.

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Myers, J., G. C. Ulmer, D. E. Grandstaff, R. Brozdowski, M. J. Danielson, and O. H. Koski, 1984, "Developments in the Monitoring and Control of Eh and pH Conditions in Hydrothermal Experiments," *Geochemical Behavior of Disposed Radioactive Waste, American Chemical Society Symposium Series*, Vol. 246, pp. 197-216.

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Apted, M. J., and J. Myers, 1982, "Comparison of the Hydrothermal Stability of Simulated Spent Fuel and Borosilicate Glass in a Basaltic Environment," *RHO-BW-ST-38*, Rockwell Hanford Operations, Richland, Washington.

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Myers, J., and W. D. Gunter, 1979, "Measurement of the Oxygen Fugacity of the Cobalt-Cobalt Oxide Buffer Assemblage," *American Mineralogist*, Vol. 64, pp. 224-228.

Rodney A. Palanca

Mr. Palanca holds a B.S. in Chemical Engineering from the University of Washington. He served 20 years in the U.S. Nuclear Navy, retiring with the rank of Lieutenant Commander. Mr. Palanca began his Westinghouse career at the DOE's Fast Flux Test Facility, Hanford, Washington and trained as a Chief Operator. He transferred to the Waste Isolation Pilot Plant in 1986 to work on the WIPP waste acceptance criteria. Since then, he has worked in several areas of TRU waste management and waste handling operations including startup testing and writing operating procedures for the waste handling equipment, developing Operational Safety Requirements, and conducting operational readiness reviews. He has served as the WID representative on the TRU Waste Integrated Working Group (formerly the National TRU Waste Task Force) and contributed to the development of a national TRU waste strategy for the DOE. He was the WIPP waste handling representative on the Engineered Alternatives Task Force. He is currently assigned as the cognizant engineer for all waste handling systems and is preparing plans for restoring the RH TRU waste handling systems to a ready condition.

M

David C. Palmer

Manager, Health Physics

22 Years of Relevant Experience

SUMMARY: Mr. Palmer has more than 22 years of professional management experience in health physics and environmental monitoring and analysis. He has been involved in management of radioactive protection and environmental monitoring programs for both mixed radioactive waste sites and the nuclear power industry, National Environmental Policy Act (NEPA) documentation, and exposure pathway analysis, including personnel exposure and risk analysis, for both radioactive material and hazardous chemicals. He was in charge of the health physics programs at one nuclear power reactor plant where he directed the environmental monitoring program and was responsible for the plant health physics program during preparations for decommissioning the reactor. Included in this task was removal and shipment of all reactor fuel assemblies to Europe for reprocessing, removal, and disposal of all irradiated reactor control rods, and other general activities to prepare for the complete dismantling of the nuclear supply system.

EDUCATION: M.S., Environmental Health Sciences (Radiological Health), University of Michigan, 1969

B.S., Engineering Physics, University of Michigan, 1967

RELEVANT EXPERIENCE:

Principal contributor for a study evaluating all onsite and offsite transportation risks associated with full production operations at the Rocky Flats Plant. The resulting document was designed to serve as a technical resource to evaluate transportation impacts in the proposed Site-Wide Environmental Impact Statement (SWEIS). The risk assessment involved pathway and exposure analysis and dispersion modeling of radiological and hazardous materials.

Provided the operational health physics portion of the pre-operational quality assurance audit of the health physics program at the Waste Isolation Pilot Plant (WIPP). This included audits of the operational plans and practices, as well as a general assessment of the health physics program to identify those elements of the program requiring supplementation or improvement when compared to program requirements, applicable standards, good health physics practices, and actions that might be taken to limit the potential for future legal challenges.

Project manager and principal contributor for preparation of the Action Description Memorandum (ADM) and EA to comply with NEPA requirements and risk assessment documentation to comply with CERCLA requirements for the Rocky Flats Plant remedial actions at the 903 Pad, Mound, and East Trenches areas. Environmental and public health analyses were provided for each selected alternative action to aid in the selection of the proposed remedial action.

Project manager for the analysis of injury and fatality frequency rates to be applied to the transportation of wastes from the U.S. EPA Denver Radium Superfund Site to the appropriate disposal site. Calculated estimates of the number of injuries and fatalities for various transportation modes and routes, including truck and rail transportation combinations.

Project manager and principal contributor for preparation of a comparison between the U.S. EPA "Interim Recommendations on Doses to Persons Exposed to Transuranium Elements in the General Environment" with the Colorado Department of Health plutonium in soil standard. The study included a multiple pathway analysis of the risk to persons living in a hypothetical residential development on soil contaminated to the levels proposed in the two standards.

Supported the assessment of radiological risks associated with transportation accidents included in the Supplemental Environmental Impact Statement (SEIS) for WIPP.

Principal contributor to the preparation of an EA of the Supercompactor and Repackaging Facility (SARF) and the TRU Waste Shredder (TWS) at the Rocky Flats Plant, with specific responsibilities including evaluation of radiological exposures to workers and the public from routine operations and potential accidents.

Wrote the procedure for operation and calibration of a field instrument to detect low energy radiation (FIDLER) for WIPP. The instrument is designed to detect low-level surface contamination by alpha emitters and uses a microcomputer-based, portable radiation survey instrument with digital readout and data logging capabilities. The procedure included set-up, operation, and both full geometry and single point calibrations aided by a special computer program incorporated into the procedure.

Project manager for the peer review of Section 8 (Alternatives to the Proposed Action) of the Engineering and Emissions Data Base (EEDB) for the Recovery Modification Project (RMP) for the recovery of plutonium from residues at Rocky Flats. The EEDB was to be written as a reference document to be used by the Oak Ridge National Laboratory (ORNL) to prepare an Environmental Impact Statement (EIS) for the RMP. The task involved reviewing the document to assure that all feasible alternatives had been addressed, suggesting possible alternatives, and reviewing the description and evaluation of eight alternatives included in the draft EEDB.

M

Principal contributor to the Safety Evaluation for the Supercompactor and Repackaging Facility (SARF) at the Rocky Flats Plant. Responsibilities included identification of potential radiological and toxicological hazards, development of methodologies for analysis of the hazards, including failure mode and effects analysis, and evaluation of the probability of occurrence and potential consequences of the hazards identified.

OTHER EXPERIENCE:

Served as the Radiation Protection Manager of the Indiana & Michigan Electric Company facility, beginning at the plant's very early stages of construction. Responsible for the design and implementation of the entire Health Physics program at the plant, including writing the original Radiation Protection Manual.

Designed and administered of the radiological assessment portion and control portions of the emergency response plan for the Indiana and Michigan Electric Company facility. Included were the writing and implementation of all radiation protection related emergency procedures, development of both manual and computerized decisional aids for use by plant operations personnel and health physics technical personnel, formation and direction of all onsite and offsite radiological assessment teams, and formulation and distribution of recommendations for offsite protective actions to the appropriate federal and state agencies during the course of an emergency. Served as the primary contact with all state and federal agency personnel for all matters of radiological or environmental matters during formation of the emergency plan and during numerous drills and exercises.

At Elk River, directed the environmental monitoring program and was responsible for the plant health physics program during preparations for decommissioning the reactor. Included in this task were removal and disposal of all irradiated reactor control rods and other general activities to prepare for the complete dismantling of the nuclear supply system.

M

JAMES E. WARD

SUMMARY OF QUALIFICATIONS

Mr. Ward has over four years of professional experience in engineering with an emphasis on nuclear facility operations, design, and project engineering. His experience associated with the nuclear operations has included a sealed source fabrication program, a remote facility restoration, various regulatory compliance, and hazardous chemical and waste transportation. This experience has included positions of research and development engineer and project engineer. Currently, Mr. Ward supports project engineering for an engineering and architecture company.

PROFESSIONAL EXPERIENCE

Merrick and Company, Carlsbad Area Office, Carlsbad, New Mexico

- **Project Engineer.** Project Technical Baseline document. Project engineer on the preparation and submittal of a document that provides the bases of the WIPP project, technical parameters, description, design, safety and operation to the project. Responsible for the timely preparation of the document that is technically correct within a limited time schedule.

- **Project Engineer.** HVAC load calculation for Waste Isolation Pilot Plant (WIPP) Support and Waste Handling Building. Project lead on the heating and cooling load calculations for two buildings at WIPP. The project included the load calculations, a cooling load assessment of the existing system, and a technical report. Responsible for the budget, manpower allocation, and schedule of the project.

- **Project Engineer.** Final Safety Analysis Report (WIPP) upgrade to meet DOE Order 5480.23. This project included development of revisions to be incorporated in the existing WIPP FSAR to meet the issuance of a new departmental order on nuclear safety analysis reports. Responsible for client interface, project controls, project reporting, and technical revisions concerning the principal health and safety criteria. The upgrade included five subtasks that specifically targeted: Hazard analysis and classification, Principal health and safety criteria, Human Factors analysis and evaluation, Analysis of abnormal, normal, and accident conditions, and Demonstrated compliance with DOE Order 4330.4A, "Maintenance Management Program".

Battelle, Pacific Northwest Laboratories, Richland, Washington

- **Development Engineer.** Waste Management Section. Responsible for characterization, packaging, and DOT, EPA, and DOE compliance for all hazardous material and waste transportation shipments Responsibilities included staff training, packaging certification and development, procedure development, and program development.

- **Research and Development Engineer.** Nuclear Engineering and Testing Section. Selected accomplishments include the following: Feasibility study for waste management of Greater-Than-Class-C (GTCC) radioactive sealed sources, remote system and component designs for conducting research operations, perform shielding calculations and data collection for remote system designs and for reducing occupational exposure during operations, supervise operations for a medical radio-isotope program and a remote radioactive research facility restoration program, develop and implement training, and capital equipment procurement. Responsibilities

James E. Ward cont'd

included leading research, supervising staff, procedure development, and training.

Transportation Manufacturing Corporation, Roswell, New Mexico

- **Liaison Engineer.** Liaison for design engineering that facilitated the primary interface to procurement, manufacturing, quality, and test programs. Principle accomplishments included: heads-up design changes, engineering change orders, change control management, and company wide interface.

EDUCATION AND TRAINING

B.S.	Mechanical Engineering, University of New Mexico	1989

Previously Radiation worker II trained, MSA and SCBA respirator, OSHA 40-hour Hazardous Waste Worker, previous DOE "Q" and "L" clearance, DOT HM-181 shippers training. Functional knowledge of radioisotopes (radiochemistry, radiophysics, material degradation, shielding, and containment).

Computer skills include: AUTOCAD release 12 with AME, MICROSHIELD (a radioactive shielding program), COSMOS/M (finite element modeling/analysis), WordPerfect 6.0, Microsoft (WINDOWS, EXCEL), LOTUS, MATHCAD, ELITE HVAC analysis.

PROFESSIONAL EXPERIENCE

12/93 to present	**Project Engineer.** Merrick & Company, Carlsbad area office, Carlsbad, New Mexico. Engineering and Architecture firm that provides a full range of services.
1/91 - 12/93	**Research and Development Engineer.** Battelle Pacific Northwest Laboratory, Richland, Washington. Not for profit research and development institute.
5/90 - 12/90	**Liaison Engineer.** Design Engineering Group, Transportation Manufacturing Corporation, Roswell, New Mexico. Manufacturing facility for intercity mass transit buses.
1/89 - 8/89	**Manufacturing Engineering CO-OP.** Advanced Composites Group, GE Aircraft Engines, Albuquerque, New Mexico. Methods engineer for development of advanced graphite composites for aircraft components.
1/88 - 8/88	**Environmental Engineering CO-OP.** Human Resources Group, GE Aircraft Engines, Albuquerque, New Mexico. Environmental staff engineer to maintain local, state, and federal environmental compliance. Direct oversight in hazardous waste shipments, and effluent emission compliance.

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James D. Waters

Project Manager

20 Years of Relevant Experience

SUMMARY:

Mr. Waters has a broad range of experience in the management and operation of complex mineral facilities including 17 years experience in the potash mining district. He has completed several different projects involving ore reserve studies, minerals recovery, and budget planning to meet market conditions. He has held high level engineering and management positions at 3 of the 5 area mines. Mr. Waters is familiar with BLM and New Mexico State Land Use rules and their resource recovery regulations.

Mr. Waters has been involved in a number of efforts to support WIPP operations. He was involved in the development of the Project Technical Baseline, the Final Safety Analysis Report Upgrade, and various other regulatory compliance projects.

Mr. Waters is an accomplished process engineer with over 25 years of experience in the design construction and start up of complex chemical and mineral flowsheets. Mr. Waters has been involved in worker safety in a variety of positions and has successfully installed employee oriented safety programs at two different mining operations.

EDUCATION:

M.B.A., Western New Mexico University, 1974
B.S., Metallurgical Engineering, University of Texas at El Paso, 1968

RELEVANT EXPERIENCE:

Performed a detailed investigation on the borehole penetrations into known mining areas in the Carlsbad area and identified those boreholes available for observation in the mines. This project was performed to develop background information for future WIPP compliance permitting applications.

Assisted with development of the WIPP Project Technical Baseline. Prepared facility description, site description, and post closure sections. Performed an updated geological survey of data on the Los Medanos area and the Gnome Project and developed a resource book on geology of Project Gnome. Team member on the FSAR Upgrade project. Performed several plant walk downs to inventory hazardous chemicals and also helped develop the Hazardous Assessment criteria for the FSAR Upgrade. Reviewed the WIPP Maintenance program and wrote a new maintenance section for the WIPP FSAR. Assisted the DOE technical assistance contractor in developing a National TRU Program Manager.

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Assisted Mining Services group with the development of a comprehensive reclamation plan on the remediation of the Horizon Potash mine facility.

Performed a detailed analysis of Eddy and Horizon potash mine ore reserves. Evaluated best current process technology and developed production costs based upon current mine operating costs. This information was used to develop a plan to combine the two operations into one profitable unit. A detailed proposal was developed to accomplish this plan.

Performed a preliminary environmental site assessment of Eddy Potash Mine and submitted a report and draft reclamation plan to top management.

Managed all surface operations including production, maintenance, utilities, and engineering for the largest potash facility in the United States. Performed continuous evaluations of mine reserves and mineral recovery to meet production goals.

Served as the last Project Manager for two major expansion studies involving adjacent ore reserves. Study to acquire National Potash involved fairly detailed analysis of most potash reserves located in the northern section of the potash basin.

Administered the operation and maintenance programs of the large chemical potash refinery, loading dock (600,000 tons per year shipped, and a granulation plant located about 5 miles from the main surface facility. Planned and developed short-term and long-term operational cost budgets and capital expenditure programs. Directly supervised the process engineering group, maintenance engineering group, and environmental group.

Obtained an air quality permit for National Potash plant site.

OTHER EXPERIENCE:

As Refinery Superintendent, supervised operation of a 9,000-tons-per-day refinery including crushing, grinding, flotation, and chemical refinery. Scheduled major maintenance projects and directed refinery mechanics. Supervised 10 to 12 salaried and 66 hourly employees.

Evaluated new process technologies and their application to Kennecott Copper Corporation. Acted as a consultant to five major mining divisions in fields of mineral processing and copper smelting. Assisted exploration group with conceptual plant design and cost estimates of proposed projects. Worked in the field at several divisions on a wide variety of engineering projects, usually as project engineer.

Margaret S. Wood

Manager, Institutional Programs

18 Years of Relevant Experience

SUMMARY: Ms. Wood currently serves as Stoller's Manager for Institutional Programs. She has 18 years of experience working in intergovernmental and public affairs, safeguards and security, personnel, industrial relations, and emergency preparedness at DOE facilities throughout the United States. She has worked at the DOE's Albuquerque Field Office, Kansas City Plant, Pinellas Plant, and Los Alamos National Laboratory, and is specifically informed about the technical and public perception issues associated with the environmental restoration and waste management programs at the Weapons Complex facilities.

EDUCATION: B.A., Public Justice, St. Mary's University, 1974

RELEVANT EXPERIENCE:

Developed a Community Relations Plan for the General Electric Corporation in St. Petersburg, Florida in accordance with Resource Conservation and Recovery Act, State of Florida, and federal requirements. Work products included development and production of a work plan, a Public Involvement Meeting and Hearing Guide, a Community Interview Plan, and a Community Relations Plan. Significant work accomplishments include identifying and developing site-specific methods for improving internal and external communication programs and public involvement in the facility's waste management and environmental restoration programs.

Developed public outreach strategies, prepared public outreach materials, and developed hearing plans and procedures for an Environmental Impact Statement prepared by the U.S. Department of Energy's (DOE) Plutonium Recovery Modification Project, Project Office. Identified the potentially affected public, applicable public involvement regulatory issues and requirements, and technical project issues that could generate public concern. Developed and produced public outreach materials, press releases, display advertisements, briefing materials, and scoping meeting and information meeting plans (including opening statements and rules of conduct), and assisted in speaker preparation. Outreach materials included design and development of fact sheets on various technical and management aspects of the project.

Project manager for the development of briefing materials and speaker preparation for the proposed Special Nuclear Materials Laboratory at the Los Alamos National Laboratory.

Project manager for the review and assessment of public outreach fact sheets being developed for the Weapons Complex Reconfiguration Programmatic Environmental Impact Statement.

Developed and produced management charters, management plans, strategic plans, work plans, and management presentations for Westinghouse, Waste Isolation Division, at the Waste Isolation Pilot Plant. The management plan serves as the superior DOE Waste Isolation Pilot Plant (WIPP) Project Site Office document in the hierarchy of management documents.

Developed and produced a Management Information Handbook for the DOE WIPP Project Site Office. The handbook presented information on DOE organizations, procedures, and directives as well as information to assist DOE personnel with interagency, intergovernmental, and contractor interactions.

Identified methods used to treat, handle, and dispose specific waste streams and the associated cost of performing this work as a part of a Volume-Based Cost Analysis that was performed for all waste streams at the Rocky Flats Plant.

Principal contributor to a Safety Analysis Report that is being developed on Pondcrete Storage for the Rocky Flats Plant.

Developed strategies to improve communication with federal, state, and local agencies, Tribal Governments, special interest groups, media, and the general public and expand public participation in major projects such as the Waste Isolation Pilot Plant (WIPP) and Uranium Mill Tailing Remedial Action projects at locations such as Riverton, Grand Junction, Ambrosia Lake, Rifle, Gunnison, and Falls City.

Participated in the preparation of public outreach materials, congressional briefings, public meetings, and public hearings for the Draft Supplement to the Environmental Impact Statement for WIPP.

Developed and presented briefings to local, state, and federal officials on issues such as WIPP and federal employment issues.

OTHER EXPERIENCE:

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As Chief of Safeguards and Security for the DOE Rocky Flats Office, directly supervised a staff of seven employees, including chemists, engineers, and security specialists. Monitored and inspected all aspects of the contractor's safeguards, security, and emergency preparedness programs to ensure adequacy and compliance with all applicable federal requirements. Developed and approved building and site security plans, approved security procedures and plans for anti-nuclear demonstrations, and conducted facility threat analyses.

PUBLICATIONS:

DOE/AL, *Security Planning Guide*, Co-author
DOE/AL, *Personnel Security Handbook*, Principal Author
DOE/AL, *Engineering Analysis - Material Surveillance Task Force*, Co-author

Initial Engineered Alternatives Screening Candidates

The individual Engineered Alternatives (EA) found in the 1991 Engineered Alternatives Task Force Final Report (EATF), #1 through #64

1 Compact Waste
2 Incinerate and Cement
3 Incinerate and Vitrify
4 Wet Oxidation
5 Shred and Bituminize
6 Shred and Compact
7 Shred and Cement
8 Shred and Polymer Encapsulation
9 Shred add Salt and Compact
10 Plasma Processing
11 Melt Metals
12 Add Salt Backfill
13 Add other Sorbents
14 Add Gas Suppressant
15 Shred and Add Bentonite
16 Acid Digestion
17 Sterilization
18 Add Copper Sulfate
19 Add Gas Getters
20 Add Fillers
21 Segregate Waste Forms
22 Decontaminate Metals
23 Change Waste Generation Process
24 Add Anti-Bacterial Material
25 Accelerate Waste Digestion Process
26 Alter Corrosion Environment
27 Alter Bacterial Environment in WIPP
28 Transmutation of Radionuclides
29 Vitrify Sludges
30 Salt Backfill Only
31 Salt Backfill Plus Gas Getters
32 Compact Backfill
33 Salt Plus Brine Sorbents

Initial Engineered Alternatives Screening Candidates

34 Preformed Compacted Backfill
35 Grout Backfill
36 Bitumen Backfill
37 Add Gas Suppressant
38 Minimize Space Around Waste Stack
39 Segregate Waste in WIPP
40 Decrease Amount of Waste per Room
41 Emplace Waste and Backfill Simultaneously
42 Selected Vegetive Uptake
43 Brine Isolating Dykes
44 Raise Waste Above the Floor
45 Brine Sump and Drains
46 Gas Expansion Volume
47 Seal Repository Room Walls
48 Vent Facility
49 Ventilate Facility
50 Add floor of Brine Sorbents
51 Change Mine Extraction Ratio
52 Change Room Configurations
53 Seal Individual Rooms
54 Two Level Repository
55 Monument Forest Over Repository
56 Monument Covering the Entire Repository
57 Buried Steel Plate Over the Repository
58 Artificial Surface layer Over the Repository
59 Add Marker Dye to Strata
60 Drain Castile Reservoir
61 Grout Culebra Foundation
62 Increase Land Withdrawal Area
63 Change Waste Container Shape
64 Change Waste Container Material

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The EATF Combination EAs, #65 through #79

65 EATF Baseline - As received with salt backfill.
66 EATF Alternative 1 - Shred and cement organics and inorganics only, salt backfill.

Initial Engineered Alternatives Screening Candidates

The Systems Prioritization Methodology - 2 (SPM-2) original EAs, #80 through #99 (from 1/19/95 list)

80 SPM-Baseline
81 SPM-A Salt backfill 50% filling efficiency
82 SPM-B Salt/Bentonite backfill 50-50 mix, 50% filling efficiency
83 SPM-C Salt/pH buffer backfill some amount of CaO
84 SPM-D Cement grout backfill 100% filling efficiency
85 SPM-E Salt/Grout backfill 100% efficiency
86 SPM IT-1 Shred and cement organics and inorganics, salt backfill 50% filling efficiency
87 SPM IT-2 Cement sludges, shred and cement orgainics and inorganics, salt backfill 50% filling efficiency, nickel alloy container.
88 SPM IT-3 Cement sludges, shred and cement orginics and inorganics, cement grout 100% filling efficiency.
89 SPM IT-4 Cement sludges, shred and cement organics and inorganics, salt/pH buffer backfill with some amount of CaO.
90 SPM IT-5 Cement sludges, shred and compact orgainics and inorganics, salt backfill with 50% filling efficiency, 200 drum monolayer, 6x33x300 room.
91 SPM IT-6 Cement sludges, shred and compact organics and inorganics, cement grout backfill 100% filling efficiency, 2000 drum monolayer, 6x33x300 room.
92 SPM IT-7 Cement sludges, compact organics and inorganics, salt/pH buffer backfill with some amount of CaO, 2000 drums monolayer, 6x33x300 room.
93 SPM IT-8 Cement sludges, shred and add bentonite to orgainics and inorganics, salt backfill 50% filling efficiency.
94 SPM IT-9 Cement sludges, shred and add bentonite to organics and inorganics, cement grout backfill 100% efficiency.
95 SPM IT-10 Decontaminate metals, nickel alloy container, cement grout backfill 100% filling efficiency.
96 SPM EATF-8 Vitrify sludges, incinerate and vitrify organics, melt metals with glass/glass frit, radionuclides partitioned into slag and metals are eliminated from the WIPP inventory, salt backfill, non-ferrous container.
97 SPM EATF-9 Vitrify sludges, incinerate and vitrify organics, melt metals with glass/glass frit, radionuclides partitioned into slag and metals are eliminated from the WIPP inventory, grout backfill, non-ferrous container.

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Initial Engineered Alternatives Screening Candidates

98 SPM DOE-1 Passive markers- no specific scenario given reduce human intrusion probability parameters.
99 SPM DOE-2 Compartmentalization of waste - various unspecified scenarios.

The individual EAs found in 40 CFR Part 194, #100 through #109

100 194- Cementation
101 194- Shredding
102 194- Supercompaction
103 194- Incineration
104 194- Vitrification
105 194- Improved waste containers
106 194- Grout and bentonite backfill
107 194- Metal Melting
108 194- Alternative configuration of waste emplacement
109 194- Alternative disposal system dimensions

Engineered Alternatives
Definitions

The following is a list of definitions for the discrete technology EAs, # 1 through # 64. The Engineered Alternatives Screening Working Group (EASWG) reviewed the original 1991 Engineered alternatives Task Force (EATF) definitions and modified them where necessary. Those taken directly from the EATF are noted as such.

Title Description

1 Compact Waste
All wastes except sludges are processed by first pre-compacting the waste into 35 gallon drums, the "pucks" are then supercompacted at forces in excess of 2200 tons and packed for disposal in 55 gallon drums. The volume reduction is approximately 3:1.

2 Incinerate and Cement
Solid organics are incinerated and the resulting ash is cemented into an ash/cement matrix.

3 Incinerate and Vitrify
Solid organics are incinerated and fused into a glass matrix by vitrifying. Vitrification melts/fuses the waste; silica may be added prior to melting.

4a Wet Oxidation and Cement
Solid organics are oxidized into an ash residue. Wet oxidation involves the accelerated oxidation of waste in the presence of heated water vapor or steam, with the intent to chemically degraded the waste. The ash residue is cemented into an ash/cement matrix.

4b Wet Oxidation and Vitrify
Solid organics are oxidized into an ash residue. Wet oxidation involves the accelerated oxidation of waste in the presence of heated water vapor or steam, with the intent to chemically degrade the waste. The ash residue is vitrified into a fused glass. Silica may be added to the residue prior to melting/fusing.

5 Shred and Bituminize
All waste except sludges are mechanically shred. A volume reduction ratio of 1.2:1 is assumed for shredding only. Bitumen is mixed into the waste, filling the void space in the waste drum.

Engineered Alternatives
Definitions

6 Shred and Compact
All waste except sludges are mechanically shred. A volume reduction ratio of 1.2:1 is assumed for shredding only. The shredded waste is compacted in the drum. Supercompaction is not used.

7 Shred and Cement
All waste except sludges are mechanically shred. A volume reduction ratio of 1.2:1 is assumed for shredding only. "Wet" Cement is added to the waste creating a solid homogeneous waste/cement matrix.

8 *Shred and Polymer Encapsulation*
All waste except sludges are mechanically shred. A volume reduction ratio of 1.2:1 is assumed for shredding only. The shredded waste is encapsulated with a polymer.

9 Shred, add Salt, and Compact
All waste except sludges are mechanically shred. A volume reduction ratio of 1.2:1 is assumed for shredding only. Shredded waste is mixed with crushed salt and compacted in the drum. Supercompaction is not used.

10 Plasma Processing
All waste is subjected to a high temperature plasma eliminating organics and melting metals and sludges into a solid form. The products of this process are vitrified glasses and solid metals.

11a Melt Metals
All metals are melted (sludges and combustibles are excluded) into an ingot and disposed at WIPP. The size and weight of the final product are within transportation limits.

11b Melt Metals - Partition Actinides with Frit
All metals are melted (Sludges and combustibles are excluded). Glass Frit is added to the molten metal partitioning the radionuclides within the slag. The slag is removed, solidified, and disposed at the Waste Isolation Pilot Plant (WIPP). The metal is cast into ingots and disposed as Low Level Waste (LLW) at a LLW facility. The size and weight of the ingot are within transportation limits.

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Engineered Alternatives
Definitions

12 Add Salt Backfill
A crushed salt backfill is placed around and between the waste containers, filling the void space within the rooms. A 50% filling efficiency is assumed.

13 Add Other Sorbents (EATF definition)
Evaluation of sorbents in addition to or other than bentonite may lead to improved waste characteristics of permeability and porosity. These sorbents are intended to sorb brine and radionuclides.

14 Add Gas Suppressant (EATF definition)
Adding materials to the waste that could reduce gas generation rates, such as materials that raise the pH of the brine that comes in contact with the waste, could prove beneficial in reducing gas pressure buildup in the waste disposal rooms.

15 Shred and Add Clay
All waste except sludges are mechanically shred. A volume reduction ratio of 1.2:1 is assumed for shredding only. Engineered clay grout is added to the shredded waste removing the void space within the waste drum. Two forms of clays are considered, swelling (smectites) and non-swelling (illite/kaolinite).

16a Acid Digestion and Cement
Solid organics are dissolved in a strong acidic solution that is subsequently neutralized and precipitated, resulting in a reduced volume sludge waste form, which is solidified into a cement/precipitate matrix.

16b Acid Digestion and Vitrify
Solid organics are dissolved in a strongly acidic solution that is subsequently neutralized and precipitated, resulting in a reduced volume sludge waste form, which is vitrified into a fused glass. Silica may be added prior to vitrification.

17 Sterilization (EATF definition)
Prior to emplacement of the waste in WIPP, sterilize the contents of each waste package to eliminate or reduce microbial gas generation. To be sufficiently effective, this alternative would probably have to be used in conjunction with sterilization of the entire underground waste disposal area, which is not considered a credible alternative.

Engineered Alternatives
Definitions

18 Add Copper Sulfate (EATF definition)
The addition of copper sulfate to the waste is expected to reduce the generation of gasses resulting from anoxic corrosion of iron based metals. The copper sulfate reacts with iron, forming ferrous sulfate and preventing the production of free hydrogen gas.

19 Add Lime
Lime (CaO) is added to solid organics within a drum.

20 Add Fillers (EATF definition)
Adding filler materials to the waste in order to reduce the initial void volume will reduce the waste's permeability and can reduce brine inflow during room reconsolidation.

21 Segregate Waste Forms (EATF definition)
This alternative refers to isolating each major waste form (i.e., sludges, combustibles, etc.) from one another. By segregating the various waste forms that are now intermingled within the waste packages, several engineered alternatives could be applied to smaller waste quantities, thereby possibly reducing costs and overall schedule.

22 Decontaminate Metals
Metals are sorted and decontaminated using freon or carbon dioxide. Filters are used to collect the radionuclides and are disposed as TRU waste. Decontaminated metals are recycled or disposed of as LLW.

23 Change Waste Generation Process (EATF definition)
Since two-thirds of the waste that will ultimately be emplaced in WIPP has not been generated, an opportunity exists to change the processes that generate the remaining waste to minimize waste porosity, permeability, and gas generation. Some progress has already been made in reducing waste generation Volume, and compaction of waste at generator sites is an example of a process that reduces porosity and permeability.

Engineered Alternatives Definitions

24 Add Anti-Bacterial Material (EATF definition)
The addition of an anti-bacterial material to the waste could alleviate some gas production if such a material does not pose a greater challenge than the gas itself. The material must has an estimated effective lifetime sufficient to prevent those microbes already present in the repository from eventually overtaking its effectiveness.

25 Accelerate the Waste Digestion Process (EATF definition)
This alternative suggests that the gas generation process might be accelerated so that gas generation is minimized after decommissioning of the repository. This requires the addition of appropriate bacterial agents to hasten waste digestion, which would have to be essentially complete before decommissioning.

26 Alter Corrosion Environment in WIPP (EATF definition)
The use of copper sulfate has already been identified as an engineered alternative that might modify the corrosion process to generate less gas. Other alternatives may alter the chemical environment of the waste storage rooms, such as assuring dryness or maintaining a pH buffer, so that corrosion is minimized.

27 Alter Bacterial Environment in WIPP (EATF definition)
This alternative is analogous to "Alter Corrosion Environment in WIPP." By changing the chemistry of the waste, microbial gas generation rates may be reduced to acceptable levels.

28 Transmutation (EATF definition)
This alternative considers transmutation of long-lived radionuclides to short-lived nuclides, eliminating the need for long-term disposal.

29 Vitrify Sludges
Sludge waste is melted/fused into a fused glass. Silica may be added prior to vitrification.

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Engineered Alternatives
Definitions

30 Salt Backfill Only (EATF definition)
This is the basic backfill material being considered to reduce void volume around the waste and to hasten room closure. The material results from mining the disposal rooms and drifts, and can be processed by crushing or pulverizing to enhance backfilling operations. Unless the salt is preformed into compact shape(s), it has significant initial porosity and permeability, but will rapidly reconsolidate as a result of creep closure.

31 Salt Backfill Plus Gas Getters (EATF definition)
The addition of gas getters with the salt backfill may be advantageous for preventing buildup of unacceptable gas Volume. A potential disadvantage of applying gas getters in this matter is that salt reconsolidation takes place fairly quickly. If reconsolidation prevents interaction of gases with the gas getters in the salt matrix, it could prove ineffective. An added advantage of certain gas getters (e.g. CaO) is they will act as pH buffers thereby minimizing corrosion and radionuclide solubility in brine.

32 Compact Backfill (EATF definition)
Compacting backfill in place could reduce its permeability sufficiently to prevent significant brine mobility. Such a procedure would probably require more storage space than currently planned to permit equipment access between and around the waste packages.

33 Salt Plus Clay Backfill
Crushed salt is mixed with approximately 30% clay. The salt/clay backfill is placed around the drums filling the void space within the rooms. A 50% filling efficiency is assumed.

34 Preformed Compacted Backfill (EATF definition)
Preforming backfill into dense compacted modules, such as bricks or blocks, or shapes that can be inserted between waste packages, may reduce the overall permeability of the waste disposal rooms, thereby reducing the potential for brine contact with the waste. Compacted backfill reduces the time required for room closure and the amount of brine that can migrate into the room from the surrounding salt.

Engineered Alternatives
Definitions

35 Salt Aggregate Grout Backfill
Crushed salt is sifted and used as an aggregate in a brine based grout backfill (properties of Type 10 grout are assumed). The grout is pumped into the rooms, filling the void spaces within the rooms. A high filling efficiency is assumed.

36 Bitumen Backfill
Bitumen is placed around the waste drums filling the void space within the disposal rooms.

37 Add gas Suppressants (EATF definition) [backfill alternative]
This alternative is analogous to that described for the waste form (same name) but the suppressing material would be mixed with the backfill.

38 Minimize Space Around Waste Stack
This alternative reduces the room dimensions to minimized space around the waste containers. Only minimal space around the waste containers is assumed after emplacement.

39 Segregate Waste in WIPP (EATF definition)
The segregation of different waste forms in or among waste disposal rooms could prove beneficial. For instance, the segregation of permeable metal waste in small amounts within more easily compacted or previously compacted waste could "encapsulate" the metals with other waste that is less permeable. The segregation of high gas-generation waste from more benign waste would focus the solution on a smaller area of WIPP. There may also be an advantage in segregating sludges that contain nitrates, from combustible wastes to prevent nitrate reducing bacteria from generating nitrogen gas.

40 Decrease the Amount of Waste per Room (EATF definition)
By leaving the room size the same as currently designed, but emplacing less waste volume per room, sufficient space may be gained around the waste stack to isolate the stack from the surrounding host salt. This would be accomplished by creating a waste stack that is as compacted as practicable, surrounded by relatively "plastic" backfill containing sorbents and gas getters that would act as a secondary encapsulation medium. The host salt would, of course, remain the primary barrier.

Engineered Alternatives
Definitions

41 Emplace Waste and Backfill Simultaneously (EATF definition)
The intent of this alternative is to emplace backfill more efficiently so that its effect is maximized. This alternative would be used in conjunction with compacting in place or using precompacted (and preformed if necessary) backfill.

42 Selective Vegetative Uptake (EATF definition)
Using the vegetative uptake of certain plants to concentrate radionuclides has been proposed. Some work has been done demonstrating the vegetative concentration of heavy metals.

43 Brine Isolating Dikes (EATF definition)
Brine dikes can consist of partial or full-height walls of material that segregate waste quantities to reduce the amount of waste accessed by inflowing brine or a driller's circulating mud.

44 Raise Waste Above Floor (EATF definition)
If it can be postulated that Salado brine will collect on the waste disposal room floor, then isolating the waste from the floor may be beneficial. If it can be further postulated that humidity generated by brine can be isolated from the waste, than this alternative may reduce the amount of corrosion-induced gas generation.

45 Brine Sumps and Drains (EATF definition)
By properly sloping the floor of waste disposal rooms toward collection sumps, it may be possible to isolate inflowing brine from the waste. Isolating the brine during room closure and designing the sumps so that they become "encapsulated" after closure, may result in reduced corrosion-induced gas generation.

46 Gas Expansion Volume (EATF definition)
This alternative refers to the mining of recesses within the repository to allow free expansion of the gases generated and thus reduce gas pressure.

47 Seal Repository Room Walls (EATF definition)
This alternative refers to a flexible, impermeable seal applied to the walls of each room such that closure does not break the seal. The intent is to prevent contact between the waste stack and interstitial brine.

Engineered Alternatives
Definitions

48 Vent Facility (EATF definition)
If gas generation results in the potential for overpressurizing waste disposal rooms, providing small engineered vents could alleviate this condition.

49 Ventilate the Facility (EATF definition)
Continuous ventilation of the waste disposal rooms until complete closure has taken place would eliminate concerns about brine from the surrounding Salado Formation collecting in the repository.

50 Add Floor of Brine Sorbent (EATF definition)
The intent of this alternative is to prevent free brine from contacting the waste stack, thereby reducing the potential for corrosion induced gas generation.

51 Change Mined Extraction Ratio
The mined extraction ratio is increased to increase the closure rate or the disposal rooms (i.e., leaving less supportive salt around the mined waste disposal rooms).

52 Change Room Configuration (EATF definition)
This alternative involves several possibilities. Stacking the waste tightly against the walls would eliminate initial void volume and enhance closure time. Another option involves increasing room size, which would also increase the extraction ratio, making room for a buffer of sorbents and gas getters completely surrounding the waste stack. A third option involves increasing room height and stacking the waste higher to reduce the overall footprint of the repository.

53 Seal Individual Rooms
Individual rooms are sealed instead of only sealing the panels. Communication between the rooms during an intrusion scenario is significantly reduced (gas, brine, and radionuclides).

Engineered Alternatives
Definitions

54 Two Level Repository (EATF definition)
A two level repository refers to decreasing the facility's surface footprint by placing half the waste disposal area above the other, creating a two level facility. Although reduction of the facility footprint will reduce the probability of human intrusion into the underground disposal area, the consequences could double of the intrusion event penetrates both levels of the repository.

55 Monument Forest over Repository (EATF definition)
The use of closely spaced surface markers, consisting of long-lasting materials, can be used to alert potential intruders about the existence of the repository. These monuments could be mass produced and include other designations describing the location and content of the disposal area. Each marker would be deeply anchored in bedrock.

56 Monument Covering the Entire Repository (EATF definition)
The waste disposal area of the WIPP consists of approximately 100 acres. A monument 2,100 feet on a side, consisting of natural and/or man-made materials, could provide adequate warning to potential intruders as well as adding to the difficulty of drilling into the repository. The alternative could consist of a single "pyramid" or multiple contiguous monuments.

57 Buried Steel Plate Over the Repository (EATF definition)
The action of a drill bit makes it difficult to penetrate non-friable materials. Burying a relatively thick steel or other metal plate at some distance below the surface over the repository could alert an intruder that this is an unusual site. The plate would probably have to be sandwiched between corrosion inhibitors to assure longevity. Additionally, site exploration and evaluation prior to drilling would alert geologists that further exploration is needed.

58 Artificial Surface Layer Over Repository (EATF definition)
Replacing the natural surface material over the repository with a layer of artificial or sterile material to a reasonable depth is another way of alerting potential intruders to explore further before taking any action.

Engineered Alternatives
Definitions

59 Add Marker Dye to Strata (EATF definition)
The use of marker dye that is sufficiently strong to discolor the driller's mud pond may alert the intruder that some further evaluation is necessary.

60 Depressurize Castile Reservoir
This alternative removes brine from the Castile Formation in sufficient quantities to remove the motive force that transports waste from the repository to the accessible environment in an intrusion event involving the Castile Formation.

61 Grout Culebra Formation (EATF definition)
The Culebra is a potential conduit for releasing radionuclides to the accessible environment. Grouting the Culebra above the repository may reduce the pathway.

62 Increase Land Withdrawal (EATF definition)
Currently planned land withdrawal boundaries do not extend to the boundaries of 40 CFR Part 191. Extending the land withdrawal boundaries to coincide with the permitted regulatory boundaries would provide longer radionuclide transit times before reaching the boundaries used to calculate repository performance.

EASWG note: This definition was not modified even though the LWA has been enacted since this definition was generated in the EATF. The EASWG used the intent of the definition to extend the boundaries in determining the validity of this alternative.

63 Change Waste Container Shape (EATF definition)
Square waste or hexagonal packages are used to decrease the void space within the disposal room.

64 Change Waste Container Material
Materials other than ferrous materials are used to construct the waste package..
Materials shall be selected after reviewing previous material studies (further refinement at a later date).

Engineered Alternatives
Definitions

110 Enhanced Solidification of Sludges
Cementation of Sludges is performed to provided a waste from with improved properties over non-cemented sludges.

111 Clay Based Backfill
Clay based backfill is placed around the drum, filling the void spaces within the room to hasten room closure and isolate the waste with a low permeability barrier. Two forms of clays are considered, swelling (smectites) and non-swelling (illite/kaolinite). Clay may be placed dry or water may be added and the material pumped into the rooms.

Engineered Alternatives Pass List with Comments

The following is a listing of Engineered Alternatives (EA) that passed the screening process, a brief description of the Engineered Alternatives Screening Working Groups (EASWG) conclusion is provided.

1 Supercompact Everything Except Sludges (formerly "Compact Waste")
The EASWG concluded that this EA met the definition and would be considered further. Off-The Shelf technology is available. Widely used for low level waste (LLW). Transuranic (TRU) waste supercompacted at Rocky Flats Project (RFP). Permitting in interim status at RFP - Resource Conservation and Recovery Act (RCRA) Part B.

2 Incinerate and Cement Solid Organics (formerly "Incinerate and Cement")
The EASWG concluded that this EA met the definition and would be considered further. Technology mature for hazardous constituents some engineering instill required for TRU. Commonly used for LLW - Japan, France, USA. No TRU waste incinerator operating. Permitted incinerators at Los Alamos National Laboratories (LANL) for hazardous materials, moratorium on new hazardous materials incinerators, major effort required to permit future incinerators.

3 Shred and Vitrify Solid Organic Waste (formerly "Incinerate and Vitrify")
The EASWG changed the title from "Incinerate and Vitrify" to "Shred and Vitrify" because the current vitrification technology does not require incineration, only shredding. The EASWG also concluded that this EA met the EA definition and would be considered further. Various vitrification technologies have been demonstrated; related to plasma melting. Frances (Marcoule Facility) currently making radioactive glass logs. Not yet permitted for TRU waste.

4a Wet Oxidation and Cement Solid Organics Waste (formerly "Wet Oxidation")
The EASWG concluded that wet oxidation alone did not meet the definition because the resulting waste must be solidified to meet the Waste Acceptance Criteria (WAC). The two common solidification techniques were added to this EA to meet the definition. Wet Oxidation technology demonstrated at bench scale, questions exist regarding ability to handle all organic wastes. Currently used to treat non-rad organics in water. Technology never permitted but believed possible.

Engineered Alternatives Pass List with Comments

4b Wet Oxidation and Vitrify Solid Organic Waste (formerly "Wet Oxidation")
The EASWG concluded that wet oxidation alone did not meet the definition because the resulting waste must be solidified to meet the WAC. The two common solidification techniques were added to this EA to meet the definition. Same Technical and Regulatory feasibility comments as 4a.

5 Shred and Bituminize Everything Except Sludges (formerly "Shred and Bituminize")
The EASWG concluded that this EA met the definition and would be considered further. Technology is mature but not applied to TRU waste, development work required. Used in Japan for radioactive resins and sludges. This technology has not been permitted however, the EASWG believes obtaining a permit is possible.

6 Shred and Compact Everything Except Sludges (formerly "Shred and Compact")
The EASWG concluded that this EA met the definition and would be considered further. (Not Supercompaction - low pressure compaction) Commercial nuclear plants routinely use compaction technology for LLW. Not currently being done for TRU nor demonstrated. Off-the-shelf equipment available. Permitted for LLW but not TRU, highly probable permit obtainable.

7 Shred and Cement Everything Except Sludges (formerly "Shred and Cement")
The EASWG concluded that this EA met the definition and would be considered further. Grouting technology demonstrated at Hanford, believed used in German application for TRU type waste. Permitting of cementation of TRU sludges under interim status at DOE facilities. Permitting problems not expected by EASWG.

8 Shred and Cold Polymer Encapsulate Everything Except Sludges (formerly "Shred and Polymer Encapsulation")
The EASWG concluded that this EA met the definition and would be considered further. Commercial technology in use that polymerizes LLW. Not demonstrated for TRU waste. Technology is available off-the-shelf. Permitting problems are not expected by the EASWG.

Engineered Alternatives Pass List with Comments

9 Shred, Add Salt, and Compact Everything Except Sludges (formerly "Shred add Salt and Compact")
The EASWG concluded that this EA met the definition and would be considered further. Technology is available off-the -shelf however process not in use for TRU waste. Compaction of LLW currently permitted and performed. Permitting problems not expected by the EASWG.

10 Plasma Processing of All Waste (formerly "Plasma Processing")
The EASWG concluded that this EA met the definition and would be considered further. Centrifical (molten maytag) and Fixed Hearth technologies demonstrated with non-TRU materials, Centrifical technology used to extract exotic metals in industrial applications. Pilot test completed for pit nine, INEL application with simulated waste. Design of a full-scale unit is approximately 90% complete at INEL (Lockheed) Research and Development (R&D) permitted. Not permitted for TRU waste. EASWG expects permit obtainable.

11a Melt Metals into TRU Waste Ingots (formerly "Melt Metals")
The EASWG decided to separate this EA into two categories: a) melt metals and emplace all at WIPP and b) melt metals, partition radionuclides in slag and remove, cast metal, and dispose as LLW. The EASWG determined that this separation allows for greater flexibilities in the analysis. The EASWG concluded that both EAs met the definition and would be considered further. Technology is mature but not applied to TRU wastes, development work required. EASWG believes technology is transferable to TRU waste uses. Technology not permitted for TRU waste, EASWG expects permits are obtainable.

11b Melt Metals with Frit to Partition Actinides (formerly "Melt Metals")
The EASWG decided to separate this EA into two categories: a) melt metals and emplace all at WIPP and b) melt metals, partition radionuclides in slag and remove, cast metal, and dispose as LLW. The EASWG determined that this separation allows for greater flexibilities in the analysis. The EASWG concluded that both EAs met the definition and would be considered further. Technology is mature but not applied to TRU wastes, development work required. EASWG believes technology is transferable to TRU waste uses. Potential to recycle waste containers/container materials. Technology not permitted for TRU waste, impacts LLW disposal. facilities.

Engineered Alternatives Pass List with Comments

12 Salt Backfill Around Drums and Waste Stack (formerly "Add Salt Backfill")
The EASWG concluded that this EA met the definition and would be considered further. The technology of pneumatic backfilling was demonstrated at WIPP. Can also be as simple as a pile of salt and a shovel. No regulatory concerns were noted. EASWG believes no permit is required for this technology.

15 Shred, Add Clay Based Material to Everything (formerly "Shred and Add Bentonite")
The EASWG decided to change the title of this EA to allow for various types of clays to be considered in the analysis. The EASWG concluded that this EA met the definition and would be considered further. Process is not being done for TRU waste. Equipment is available off-the-shelf. EASWG believes permits are obtainable.

16a Acid Digestion and Cementation of Solid Organics (formerly "Acid Digestion ")
The EASWG concluded that Acid Digestion alone was not an EA; acid digestion must be followed by a stabilization process. Acid digestion was deleted and acid digestion with solidification was added. The EASWG determined that this EA meet the definition and should be considered further. This Technology was used to process approximately 5,000 Kg TRU
waste between 1972 and 1980 at Handford using sulfuric acid. Current bench-scale technology at Savanna River Site uses an acid process at 180°C and 15 psig. Belgium recovers Pu with sulfuric acid. Development of processes waste and residue stabilization systems, spent acid treatment, off-gas systems, is required. Cementation of resulting sludge has not been demonstrated. Technology not permitted. Permit issues associated with disposition of hazardous constituents. EASWG believed the technology may be permitted however not enough information is available to justify rejection.

16b Acid Digestion and Vitrify of Solid Organics (formerly "Acid Digestion")
The EASWG concluded that Acid Digestion alone was not an EA; acid digestion must be followed by a stabilization process. Acid digestion was deleted and acid digestion with solidification was added. The EASWG determined that this EA met the definition and should be considered further. The Technology and regulatory feasibility is identical to #16a with vitrification consideration #3.

M

Engineered Alternatives Pass List with Comments

19 Add Lime to Solid Organic Waste (formerly "Add Gas Getters")
The EASWG changed the title of this EA from "Add Gas Getters" to "Add Lime to Solid Organic Waste". The new title was changed to better describe the EA. The EASWG concluded that this EA met the definition and would be considered further. This EA is a material handling process, no treatment technology is involved. Aluminum would have to be removed from the waste prior to the addition of lime. The EASWG concluded that a permit may not be required for this EA but potential WAC and TRUPACT II certification issues may be involved in implementing this EA.

22 Decontaminate Surface of Metallic Wastes for LLW Disposal (formerly "Decontaminate Metals")
The EASWG concluded that this EA met the definition and would be considered further. The EASWG concluded that this technology was mature and off-the-shelf technology is available. This technology was commonly used for alpha contaminated materials. The EASWG expects that a permit is obtainable if required.

29 Microwave Melt Sludges (formerly "Vitrify Sludges")
The EASWG changed the title from "Vitrify Sludges" to "Microwave Melt Sludges" to better define the EA. The EASWG concluded that this EA met the definition and would be considered further. The microwave technology has been demonstrated for radioactive waste, however the entire waste handling process has not been demonstrated. Completed systems with feed and off-gas processes must still be designed. Problems are expected with obtaining a permit because this is a thermal process however the EASWG believes a permit is obtainable.

33 Salt Plus Clay Backfill (formerly "Salt Plus Brine Sorbents")
The EASWG determined that this EA met the definition of an EA and that it would be kept for further consideration. The EASWG changed the title to "Salt plus Clay Backfill" and described the alternative as a crushed salt backfill containing 30% clay. The technical and regulatory feasibility is identical to #12.

Engineered Alternatives Pass List with Comments

35 Salt Aggregate Grout Backfill Around Drums (formerly "Grout Backfill"

The EASWG changed the title to specify a salt aggregate grout. The EASWG concluded that this EA met the definition and would be considered further. The technology is mature. Brine saturated grouts are commonly used in the petroleum and mining industries. Questions on gas generation potential may limit the effectiveness of this alternatives. The EASWG believed a permit would not be required, only DOE requirements need to be satisfied.

36 Bitumen Backfill

The EASWG concluded that this EA met the definition and would be considered further. Material handling technology is mature. Bitumen backfill used in Germany. Off-the-shelf technology is available. May impact the no-migration permit; possible large increase in hazardous materials. Uncertainty in safety requirements due to combustible nature. The EASWG concluded that there is a large uncertainty in regulatory feasibility, however not enough information is available to justify rejection.

38 Reduce Room Dimensions to Minimize Space Around the Waste Stack (formerly "Minimize Space Around Waste Stack")

The EASWG concluded that this EA met the definition and would be considered further. The technology used to initially mine the rooms and panels can be used, the technology is mature. Equipments is available at the site and the operations required to implement the EA is understood. Regulatory issues include, site design validation process considerations with the State of New Mexico, the Consultation and Cooperation Agreement and other coordination concerns with the state.

51 Change Mine Extraction Ratio

The EASWG concluded that this EA met the definition and would be considered further. The EASWG concluded that this technology is mature and understood. Equipment is available. Mayor analysis would be required to determine the design and the overall impact on the disposal system. Regulatory concerns include: mayor considerations with respect to the site design validation process, State of New Mexico agreements and MSHA requirements. The EASWG concluded that no permit is required to implement this EA.

Engineered Alternatives Pass List with Comments

53 Seal Individual Rooms
The EASWG concluded that this EA met the definition and would be considered further. Technology is available off-the-shelf. Major analysis is required to determine seal design and performance parameters. No permitting problems were envisioned by the working group.

60 Depressurize the Castile Reservoir (formerly "Drain the Castile Formation")
The EASWG determined this EA met the definition of an EA and should be considered further. The EASWG changed the title from "drain" to "Depressurize" stating that drain was not technically correct and was misleading. Technology is a standard oil industry practices (per Nelson Munsey of Yates Petroleum). Must dispose of brine - many options for disposal available. Technology has been permitted, minimal permitting problems anticipated. State permit required.

63 Change Waste Container Shape
The EASWG concluded that this EA met the definition and would be considered further. Technology is mature and available. Off-the-shelf containers of different various shapes are available and may meet existing TRU waste container requirements. NRC TRUPACT II certification modification required, DOT certification required. These certifications have been obtained for TRU waste containers previously. Permits can be obtained.

64 Change Waste Container Material
The EASWG concluded that this EA met the definition and would be considered further. The technology is mature and available. Depending on the specific material, waste containers made of non-ferrous materials are available off-the-shelf that may meet the current TRU waste container requirements. Same regulatory feasibility comments as #63.

83 SPM-C Salt backfill with CaO
The EASWG concluded that this EA met the definition and would be considered further.

M

Engineered Alternatives Pass List with Comments

110 Enhanced Solidification of Sludges
The EASWG determined that this EA met the definition and would be considered further. Technology of cementing sludges has been demonstrated. RFP has matured this technology. Some development work may be required. The regulatory issues include, satisfying DOE requirements and RCRA permit or modification to permit.

111 Clay Based Backfill
The EASWG determined that this EA met the definition and would be considered further. The Technology is mature for moist and dry clay emplacement. The EASWG believes that no permits are required and only DOE requirements must be met.

Note:
The Combination EAs were derived from those used in the EATF report and SPM program. The titles/descriptions have been changed to match the title of the discrete technologies. For example, the title "Nickel Alloy Container" was changed to "Change Waste Containers Material, #64" and "Rectangular Containers" was changed to "Change Waste Container Shape, #63". This was done to provide consistency throughout the analysis.

66 EATF Alternative 1 - Shred and cement organics and inorganics only, salt backfill.
The EASWG concluded that this EA met the definition and would be considered further.

67 EATF Alternative 2 - Enhanced cement sludges, shred and cement organics and inorganics, salt backfill.
The EASWG concluded that this EA met the definition and would be considered further.

68 EATF Alternative 3 - Enhanced cement sludges, shred and cement organics and inorganics, salt aggregate grout backfill.
The EASWG concluded that this EA met the definition and would be considered further.

Engineered Alternatives Pass List with Comments

69 EATF Alternative 4 - Enhanced cement sludges, incinerate and cement organics, shred and cement inorganics, salt backfill.
The EASWG concluded that this EA met the definition and would be considered further.

70 EATF Alternative 5 - Enhanced cement sludges, incinerate and cement organics, shred and cement inorganics, salt aggregate grout backfill.
The EASWG concluded that this EA met the definition and would be considered further.

71 EATF Alternative 6 - Vitrify sludges, shred and vitrify organics, melt metals into TRU waste ingots, salt backfill.
The EASWG concluded that this EA met the definition and would be considered further.

72 EATF Alternative 7 - Vitrify sludges, shred and vitrify organics, melt metals into TRU waste ingots, salt aggregate grout backfill.
The EASWG concluded that this EA met the definition and would be considered further.

73 EATF Alternative 8 - Vitrify sludges, shred and vitrify organics, melt metals with frit to partition actinides (metals are eliminated from the WIPP inventory), salt backfill, change waste container material.
The EASWG concluded that this EA met the definition and would be considered further.

74 EATF Alternative 9 - Vitrify sludges, shred and vitrify organics, melt metals with frit to partition actinides (metals are eliminated from the WIPP inventory), salt aggregate grout backfill, change waste container material.
The EASWG concluded that this EA met the definition and would be considered further.

75 EATF Alternative 10 - Decontaminate surface of metallic waste for LLW disposal, no backfill, change container material and shape, 10x31x188 rooms.
The EASWG concluded that this EA met the definition and would be considered further.

Engineered Alternatives Pass List with Comments

76 EATF Alternative 11 - Supercompact organics and inorganics, salt backfill, monolayer of 2,000 drums in a 6x33x300 room.
The EASWG concluded that this EA met the definition and would be considered further.

77 EATF Alternative 12 - Supercompact orgainics and inorganics, salt aggregate grout backfill, monolayer of 2,000 drums, in a 6x33x300 room.
The EASWG concluded that this EA met the definition and would be considered further.

78 EATF Alternative 13 - Vitrify slugdes, shred and vitrify orgainics, melt metals with frit to partition actinides (metals are eliminated from the WIPP), no backfill, change waste container material and shape, minimize space around waste stack in a 10x31x188 room.
The EAWG concluded that this EA met the definition and would be considered further.

79 EATF Alternative 14 - Supercompact organics, and inorganics, salt backfill, seal individual rooms, 2,000 drums per room.
The EASWG concluded that this EA met the definition and would be considered further.

87 SPM IT-2 Enhanced cement sludges, shred and cement orgainics and inorganics, salt backfill, change waste container material.
The EASWG concluded that this EA met the definition and would be considered further.

88 SPM IT-3 Enhanced cement sludges, shred and cement organics and inorganics, salt aggregate grout backfill.
The EASWG concluded that this EA is a duplicate of #68, "EATF Alternative 3".

89 SPM IT-4 Enhanced cement sludges, shred and cement organics and inorganics, salt backfill with CaO.
The EASWG concluded that this EA met the definition and would be considered further.

Engineered Alternatives Pass List with Comments

90 SPM IT-5 Enhanced cement sludges, shred and compact orgainics and inorganics, salt backfill, 2,000 drum monolayer, 6x33x300 room.
The EASWG concluded that this EA met the definition and would be considered further.

92 SPM IT-7 Enhanced cement sludges, compact organics and inorganics, salt backfill with CaO, 2,000 drums monolayer, 6x33x300 room.
The EASWG concluded that this EA met the definition and would be considered further.

93 SPM IT-8 Enhanced cement sludges, shred and add clay based material to organics and inorganics, salt backfill.
The EASWG concluded that this EA met the definition and would be considered further.

94 SPM IT-9 Enhanced cement sludges, shred and add clay based materials to organics and inorganics, salt aggregate grout backfill.
The EASWG concluded that this EA met the definition and would be considered further.

95 SPM IT-10 Decontaminate surface of metallic waste for LLW disposal, change waste container material, salt aggregate grout backfill.
The EASWG concluded that this EA met the definition and would be considered further.

110 Enhanced Cementation of Sludges - Accepted
The EASWG concluded that this EA met the definition and would be considered further.

111 Clay Based Backfill
The EASWG concluded that this EA met the definition and would be considered further.

Engineered Alternatives Rejection List with Justifications

The following is a listing of Engineered Alternatives (EA) that failed the screening process, a brief description of the Engineered Alternatives Screening Working Groups (EASWG) rejection justifications are provided.

4 Wet Oxidation
Wet Oxidation alone was not considered an EA and was deleted. The EASWG determined that wet oxidation must be followed by a stabilization process to be an EA so #4 Wet Oxidation was changed to wet oxidation plus two separate solidifiers, #4a and #4b.

11 Melt Metals
The EASWG decided to delete this EA and separate it into two categories: #11a - melt metals and emplace all at WIPP and #11b - melt metals, partition radionuclides in slag and remove, cast metal and dispose as LLW. The EASWG determined that this separations allows for greater flexibilities in the analysis.

13 Add other Sorbents
The EASWG determined that this EA is a duplicate of #15.

14 Add Gas Suppressant
The EASWG concluded that this EA is a duplicate of #19.

16 Acid Digestion
The EASWG concluded that Acid Digestion alone was not considered an EA. Acid digestion must be followed by a stabilization process to be an EA so #16, Acid Digestion, was changed to include two separate solidifiers, #16a and #16b.

17 Sterilization
The EASWG determined that the original EATF rejection justification was still valid and that this EA would be rejected. The EATF rejection justification states, "Not feasible to maintain long-term effectiveness."

Engineered Alternatives Rejection List with Justifications

18 Add Copper Sulfate
The EASWG determined that the original EATF rejection justification was still valid and that this EA would be rejected. The EATF rejection justification states, "Potential for hydrogen generation by galvanic coupling of deposited copper."

20 Add Fillers
The EASWG concluded that this EA was not specific enough to evaluate and is considered by other more specific alternatives (#7,9,13,14,15,18 & 19).

21 Segregate Waste Forms
The EASWG concluded that this EA did not meet the definition of an EA and was inherent with most waste processing EAs. This EA was not considered for further evaluation.

23 Change Waste Generation Process
The EASWG could not define this alternative and rejected it from further consideration. The EASWG determined the original EATF rejection justification was still valid. The EATF rejection justification states, "Scope too broad to be evaluated."

24 Add Anti-Bacterial Material
The EASWG determined that the original EATF rejection justification was still valid and that this EA would be rejected. Adding mercury was discussed and rejected due to the health hazards. The EASWG stated that adding hazardous materials to increase the safety of the repository was self defeating. The EATF rejection justification states, "Unable to identify a long-term, anti-bacterial material."

25 Accelerate Waste Digestion Process
The EASWG determined that the original EATF rejection justification was still valid and that this EA would be rejected. The EASWG discussed the experimental results for culturing digestive materials. The working group was not convinced that the WIPP environment could be controlled to the extent required by the digestion process. The EATF rejection justification states, "Technology for fast waste digestion not demonstrated."

M

Engineered Alternatives Rejection List with Justifications

26 Alter Corrosion Environment
The EASWG concluded that this EA was not specific enough to evaluate. The technology was less than bench scale and has not been demonstrated. This concept is considered under other alternatives.

27 Alter Bacterial Environment in WIPP
The EASWG concluded that this EA is a duplicate of #24 which was deleted.

28 Transmutation of Radionuclides
The EASWG concluded that transmutation technologies are not feasible for TRU wastes, the process requires the segregation of the pure isotopes from the waste. If waste was placed directly in the reactor, activated (radioactive) materials would be generated. The EATF rejection justification states, "Technology not demonstrated for large amounts."

30 Salt Backfill Only
The EASWG concluded that this EA is a duplicate of #12.

31 Salt Backfill Plus Gas Getters
The EASWG concluded that this EA is a duplicate of #83.

32 Compact Backfill
The EASWG determined that this EA was considered under EA #12 and would not be evaluated further.

34 Preformed Compacted Backfill
The EASWG concluded that this alternative is considered under the salt backfill alternative and would not be evaluated further.

37 Add Gas Suppressant
The EASWG concluded that the original EATF rejection justification was still valid. The EATF rejection justification states, "This alternative was considered together with the 'Salt Plus Gas Getters' alternative, and therefore was not subject to separate evaluation."

Engineered Alternatives Rejection List with Justifications

39 Segregate Waste in WIPP
The EASWG concluded that this EA was part of the baseline repository design. Load management is considered in the compliance documentation. The EASWG concluded that this EA does not meet the definition of an EA.

40 Decrease Amount of Waste per Room
The EASWG concluded that the original EATF rejection justification was still valid. The EATF rejection justification states, "This alternative was considered together with some of the backfill alternatives, and hence not evaluated separately."

41 Emplace Waste and Backfill Simultaneously
The EASWG concluded that this alternative is a subset of other backfill alternatives and was not evaluated separately.

42 Selected Vegetative Uptake
The EASWG determined that the process for vegetative uptake would not allow for proper containment of the alpha emitters. This process would require the waste to be placed in soil with plants. The EASWG determined the original EATF rejection was still valid. The EATF rejection justification states, "Not been laboratory demonstrated for TRU waste."

43 Brine Isolating Dykes
The EASWG determined that the isolation dykes configuration must be maintained to be effective. Room consolidation would alter the configuration and the EA would not be effective. The EA was not considered further.

44 Raise Waste Above the Floor
The EASWG determined that this is a short-term fix for along-term problem. The EA would provide no benefit and therefore would not be considered further. The EASWG also concluded that the original EATF rejection justification was still valid.

Engineered Alternatives Rejection List with Justifications

45 Brine Sump and Drains

The EASWG concluded that this EA is not effective since the required configuration cannot be maintained due to creep closure and rock mechanics of the repository. The EASWG also concluded that the original EATF rejection was still valid. The EATF rejection justification states, "This alternative was deleted because the EAMP (Engineered Alternatives Multidisciplinary Panel) believed that the flow paths leading to the sumps would not remain open long enough to allow substantial amounts of brine to be isolated from the waste."

46 Gas Expansion Volume

The EASWG concluded that this EA was detrimental to repository performance because the extra void volume allows for more stored energy and greater consequences during human intrusion scenarios. The EA was not considered further.

47 Seal Repository Room Walls

The EASWG determined that the rock mechanics of the repository precluded sealing. The technology has not been proven. Creep closure and interaction with the waste would be detrimental to the seal. The EASWG determined the original EATF rejection was still valid. The EATF rejection justification states, "The technology has not been demonstrated."

48 Vent Facility

The EASWG reviewed past data from the EATF data and the Design Analysis Model and determined that higher peak pressures would result for a vented facility. The EAMP also determined the original EATF rejection justification was still valid. The EATF rejection justification states, "Not regulatory feasible after institutional control" (period).

Engineered Alternatives Rejection List with Justifications

49 Ventilate Facility

The EASWG reviewed data from the EATF and concluded that this alternative was not feasible due to both regulatory and technical concerns. Quoting the original EATF, "...regulatory concerns about maintaining active facility controls for such a long period (100 years), the difficulty of assuring continuous ventilation in all spaces, and the potential for rupturing the waste containers during the ventilation period. The difficulty of safely sealing the rooms and panels of the facility, after so many years of creep closure has taken place, was also considered. Also, ventilation might violate the RCRA "no migration" variance proposed for the WIPP." The EASWG concluded that this EA would not be evaluated further.

50 Add floor of Brine Sorbents

The EASWG determined that this EA is a duplicate of #44 which was deleted.

52 Change Room Configurations

The EASWG determined that this EA did not meet the definition of an EA and may be detrimental to the performance of the repository during a human intrusion scenario.

54 Two Level Repository

The EASWG determined that this EA did not meet the definition of an EA and may be detrimental to the performance of the repository during a human intrusion scenario.

55 Monument Forest Over Repository

The EASWG concluded that this EA is a marker and not a barrier and does not meet the definition of an EA because it does not increase the performance or reduce the uncertainty in the performance calculations.

56 Monument Covering the Entire Repository

The EASWG concluded that this EA is a marker and not a barrier and does not meet the definition of an EA because it does not increase the performance or reduce the uncertainty in the performance calculations.

Engineered Alternatives Rejection List with Justifications

57 Buried Steel Plate Over the Repository
The EASWG concluded that this EA is a marker and not a barrier and does not meet the definition of an EA because it does not increase the performance or reduce the uncertainty in the performance calculations.

58 Artificial Surface Layer Over the Repository
The EASWG concluded that this EA is a marker and not a barrier and does not meet the definition of an EA because it does not increase the performance or reduce the uncertainty in the performance calculations.

59 Add Marker Dye to Strata
The EASWG concluded that this EA is a marker and not a barrier and does not meet the definition of an EA because it does not increase the performance or reduce the uncertainty in the performance calculations.

61 Grout Culebra Foundation
The EASWG concluded that grouting the Culebra could be detrimental to the performance of the repository. Technology was not considered feasible in part because the technology has not been demonstrated for this application, verification of the effectiveness is problematic, may create alternative pathways within the Culebre formation, and the long-term effectivity is unknown.

62 Increase Land Withdrawal Area
The EASWG concluded that increasing the area does not reduce the consequences of releases or increase the performance of the repository. Regulatory restriction on resource recovery within the new area would be problematic (resource lease acquisition).

65 EATF Baseline - As Received with Salt Backfill
The EASWG determined that this EA is a duplicate of #12, "Add Salt Backfill".

80 SPM-Baseline
The EASWG determined that the SPM baseline is the current repository baseline. The baseline case is not an alternative and is inherent in the analysis.

Engineered Alternatives Rejection List with Justifications

81 SPM-A Salt backfill
The EASWG concluded that this EA is a duplicate of #12, "Add Salt Backfill".

82 SPM-B Salt/Bentonite backfill 50-50 mix, 50% filling efficiency
The EASWG concluded that this EA is a duplicate of #22, "Salt Plus Clay Backfill".

84 SPM-D Cement grout backfill
The EASWG concluded that this EA is a duplicate of #35, "Salt Aggregate Grout Backfill".

85 SPM-E Salt/Grout backfill
The EASWG concluded that this EA is a duplicate of #35, "Salt Aggregate Grout Backfill".

86 SPM IT-1 Shred and cement organics and inorganics, salt backfill
The EASWG concluded that this EA is a duplicate of #66, "EATF Alternative 1".

88 SPM IT-3 Enhanced cement sludges, shred and cement organics and inorganics, salt aggregate grout backfill.
The EASWG concluded that this EA is a duplicate of #68, "EATF Alternative 3".

91 SPM IT-6 Enhanced cement sludges, shred and compact organics and inorganics, salt aggregate grout backfill, 2,000 drum monolayer, 6x33x300 room.
The EASWG concluded that this EA is a duplicate of #77, "EATF Alternative 12".

96 SPM EATF-8 Vitrify sludges, shred and vitrify organics, melt metals with frit to partition actinides (metals are eliminated from the WIPP inventory), salt backfill, change waste container material.
The EASWG concluded that this EA is a duplicate of #73, "EATF Alternative 8".

97 SPM EATF-9 Vitrify sludges, shred and vitrify organics, melt metals with frit to partition actinides (metals are eliminated from the WIPP inventory), salt aggregate grout backfill, change waste container material.
The EASWG concluded that this EA is a duplicate of # 74, "EATF Alternative 9".

Engineered Alternatives Rejection List with Justifications

98 SPM DOE-1 Passive markers - no specific scenario given to reduce human intrusion probability parameters.
The EASWG concluded that this EA dos not meet the definition of an alternative. The proposed alternative is a marker and not a barrier. This alternative does not increase the performance nor reduce the uncertainty in performance assessment.

99 SPM DOE-2 Compartmentalization of waste - various unspecified scenarios.
The EASWG determined that this EA is inherent in several EAs and does not require further consideration in the analysis.

100 194- Cementation
The EASWG determined that this EA is inherent in several EAs and does not require further consideration in the analysis.

101 194- Shredding
The EASWG determined that this EA is inherent in several EAs and does not require further consideration in the analysis.

102 194- Supercompaction
The EASWG concluded that this EA is a duplicate of #1, "Compact Waste."

103 194- Incineration
The EASWG concluded that this EA is inherent in #2, "Incinerate and Cement" because incineration is not an EA alone. Incineration must be followed by a form of solidification to meet the particulate restriction in the a WAC.

104 194- Vitrification
The EASWG concluded that this EA is a duplicate of #3, "Shred and Vitrify Waste."

105 194- Improved Waste Containers
The EASWG concluded that this EA is a duplicate of #63, "Change Waste Container Shape" and #64, "Change Waste Container Material."

106 194- Grout and Bentonite Backfill
The EASWG determined that this EA is inherent in several EAs (#33 and #35) and does not require further consideration in the analysis.

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Engineered Alternatives Rejection List with Justifications

107 194- Metal Melting
The EASWG concluded that this EA is a duplicate of #11a and 11b, "Melt Metals."

108 194- Alternative Configuration of Waste Emplacement
The EASWG concluded that this EA is inherent in several other EAs and does not require further consideration in the analysis.

109 194- Alternative Disposal System Dimensions
The EASWG concluded that this EA is inherent to several other EAs and does not require further consideration in the analysis.

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