See pocket 13 for encl

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

11/25/86

To: M.J. Bell

From F.R. Cook

Subj: Alternate Wording for Items in My Oct. 2 1986 Memorandum to Modify Tone; Forwarding of.

Attached per your request of yesterday are the word changes I developed earlier this month per conversation with R.E. Browning.

The alternate wording is highlighted in yellow. I have changed the verbs and adjectives to soften the tone, but have kept the factual content.

FRCook

WM DOCKET CONTROL
CENTER
'86 DEC -1 A10:52

WM Record File 101

WM Project 10
Docket No.
PDR ✓
LPDR ✓

Distribution:
REB w/encl.
Linehan w/encl.
Hildenbrand w/encl.
(Return to WM, 623-SS)

2232

because of the lack of cooperation on DOE/RL part to make contractor personnel and various partially completed records, including parts of the SCP plans, available.

Comments below in item 2b concerning an analogous visit in the rock mechanics/repository design area reflect the DOE's stated determination not to interact with NRC Staff and the significance of this position.

2. Repository Engineering--

a. Additional evaluation of the structural integrity of the exploratory liner design is being conducted after an assessment by the repository design group indicated a high stress could result in the liner as a result of inadequate fitup of the external stiffener rings currently installed on the liner.

The design problem does not appear to affect public health and safety, however, constructability is a concern. The failure of the liner is associated with consideration of buckling deformation during installation and grouting.

Attachment C summarizes the steps RHO is planning to resolve the problem.

b. During the period two NRC staff members and a rock mechanics contractor representative were assigned to this office to review various aspects of repository design. The areas of interest are outlined in Attachment D. The review was marginally useful since DOE and RHO would not permit review of several key records requested by Attachment D. In addition, interactions for review purposes with cognizant RHO personnel was not arranged DOE or RHO.

I stated to DOE (Mecca Olson and Anttonen) that I considered DOE's action not to allow review of the records, some of which were not formally issued by DOE, was inconsistent with Appendix 7 of the DOE/NRC Site Specific Agreement. DOE (Mecca and Olson) indicated that they do not consider that the provisions apply to the personnel assigned to this office on an itinerant basis and that the Yakima Indian Nation (YIN) had indicated a desire to observe any "Appendix 7 visits" by NRC personnel.

The action on DOE's part to not allow the free interaction and review of DOE activities by NRC personnel is inconsistent with the conditions NRC noted were necessary to expeditiously prepare and accomplish licensing activities, including evaluation of the SCP, in NRC letters, Palladino to Rusche of October 24, 1985 and Martin to Coffman of May 12, 1982 (Attachment I). In addition DOE's decision not to provide a copy of the records for retention (for example, the Engineering Study 10, which is the repository conceptual design package prepared by KE/PB and reviewed only in part by Staff) further hinders the Staff's ability to fully evaluate the information in this and other similar extensive records.

The current effect of the DOE decision not to interact is not unlike that referred to in the NRC (Martin) letter cited above. For example, the last effective interchange with staff on a technical matter was in December, 1985. This long period of inaction on the technical issues is similar to pre-1982 DOE/RL--NRC Staff interaction timing.

c1. During the subject period I visited the Lucky Friday silver/zinc/lead mine in Mullen, Idaho. This mine has a history of rock bursts associated with high in-situ stresses. It was noted by the mine crew that operations had been shut down because of the loss of lives associated with rock burst accidents in the last year.

Geotechnical parameters which characterize the in-situ stress and the rock quality--stress ratio and fractures per meter respectively--may be more consistent with stability than the similar parameters associated with the BWIP repository horizon. (Stress ratio was about 2.1:1 and rock fractures averaged about 1 per foot.) Drift stability was a serious problem in the mining operations and led to the current shutdown. It was evident in many locations throughout the mine that actions to stabilize drift and raise surfaces were unsuccessful when local tectonics associated with stress redistribution as a result of mining activities occurred. It was noted that the extent of the tectonics was not restricted to the vicinity of the opening, but could extend tens and possibly hundreds of meters from the surface where rock bursts occurred. A monitoring network using geophones was used by the mine crew to determine the location/ extent of the tectonics.

This phenomena of stress redistribution is not unlike the phenomena reported to occur in deep mines in South Africa (see Attachment F for discussion of these phenomena.) There, also, the extent of the tectonics was considerably beyond the local vicinity of the mined openings. There as in the Idaho mine the stress redistribution is thought to be associated with local geologic structures, including zones of weakness in the rock and faults.

c2. Extensive evidence of spalling of a raise following reaming operations was observed in the Lucky Friday mine. The spalling, similar to the spalling observed in vertical bore holes in the basalt, occurred as reaming operations progressed below the reaming head, which was about 5 feet in diameter, and filled the reamed raise with spalled rock. This spalled rock was thought to be instrumental in prohibiting further spalling by providing mechanical support at the surface. The surface was later stabilized with shotcrete as the spalled rock was removed.

Spalling may be a problem in the boring of the exploratory shaft, since it is not apparent that the drilling mud will provide the encl. to handwritten note dated 11/25/86 to M Bell ~~J. Bunting~~ ~~A Hale~~ from Cook - rec'd 12/1/86

101-WM-Pocket 13

CRYSTALLINE OPTIONS

MAY 13, 1986

TERMINATE CRP NOW

RATIONALE: IF SECOND REPOSITORY IS NEEDED, SITES ARE AVAILABLE FROM FIRST SUITE

PROS:

1. Immediate political relief from CRP States.
2. Possible bargaining chip for MRS proposal.
3. Makes additional funds available for balance of program elements.
4. Makes experienced staff available.

CONS:

1. Obvious political ploy.
2. Severe political backlash from 1st repository States.
3. Graphically demonstrates success mode of resistance.
4. Virtual certain GAO investigation.
5. Loss of utility confidence in total program if crystalline is stopped.
6. The utility cost i.e. 1 mill/kw-hr is based on having a second repository program.
7. High probability of negating all CRP work done to-date.
8. Reduces probability of having sufficient sites for 2nd repository (ref. CRP Strategy Paper).

It would appear that immediately terminating the CRP would give a great deal political benefit to DOE via the CRP States. It may in the very short term . shortly therafter the objections raised by the 1st repository States and utilities would more than offset the gain. To expend all the effort to date and not at least have a regional screening document would be perceived to be program mismanagement.

program mismanagement.

news

Committee on Interior and Insular Affairs
Morris K. Udall, Chairman

House of Representatives
Washington, D.C. 20515

FOR RELEASE: Immediately

CONTACT: Ken Burton 202-225-2844
Sam Fowler 202-225-8331

UDALL, CITING ADMINISTRATION 'POLITICIZING,' ENDS SUPPORT OF DEPARTMENT OF ENERGY NUCLEAR WASTE REPOSITORY SITING PROGRAM

Congressman Morris K. Udall, D-Arizona, chairman of the House Interior Committee, today condemned the Department of Energy's efforts to select sites for the nation's high-level nuclear waste repositories.

Addressing a joint meeting of two industry trade associations, Udall said DOE Secretary John S. Herrington and White House political operatives had "put the election ahead of the safe, long-term storage of nuclear waste."

Udall was one of the principal architects of the Nuclear Waste Policy Act of 1982, which set up the framework for the nation's nuclear waste disposal program. The 1982 law requires DOE to select sites for two high-level nuclear waste repositories.

As chairman of the House committee that oversees implementation of the nuclear waste program, Udall had been one of the most vocal champions of an objective process for selecting the safest and most sensible sites for nuclear waste repositories.

This spring, Udall had defended DOE from mounting public criticism of the Department's effort to screen potential eastern sites for a second nuclear waste repository, and blocked legislative proposals that would have exempted certain eastern sites for political reasons.

However, in a surprise move on May 28, 1986, Secretary Herrington postponed indefinitely site-specific work for a second repository and suspended further consideration of all eastern sites.

On previous occasions, Udall called the Secretary's postponement order a clear violation of the 1982 Act, taken by the Reagan Administration "to protect Republican candidates from the public disapproval of the DOE's selection process during an election year."

Despite Udall's frustration with the DOE's postponement of the second repository program, throughout the summer he had continued to defend the 1982 Act and to oppose legislative efforts to derail the first repository program launched by Members of Congress from both parties. In July, Udall was instrumental in protecting funds for the first repository program from cuts proposed in the House of Representatives.

Now, Udall told the nuclear industry representatives, further revelations of DOE's manipulation of the waste program for political purposes and mounting questions about the absence of technical support for some of DOE's siting decisions has undermined public credibility of the nuclear waste program and hurt the nuclear industry as well.

Udall cautioned that unless the nuclear waste program is put back on track and public confidence restored, other nuclear legislation in the 100th Congress may become irrelevant. "Without a viable high-level waste disposal program, the future of the nuclear option is in doubt," Udall said.

The Chairman's criticism was motivated in part by a May 13, 1986, internal DOE memorandum which outlined options for the department's action in terminating the second repository saying that such a move would bring "immediate political relief from CRP (secondary site) states." Udall noted that several of those states had close Senate and House races.

news

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-30-

APPROACH TO RESTART

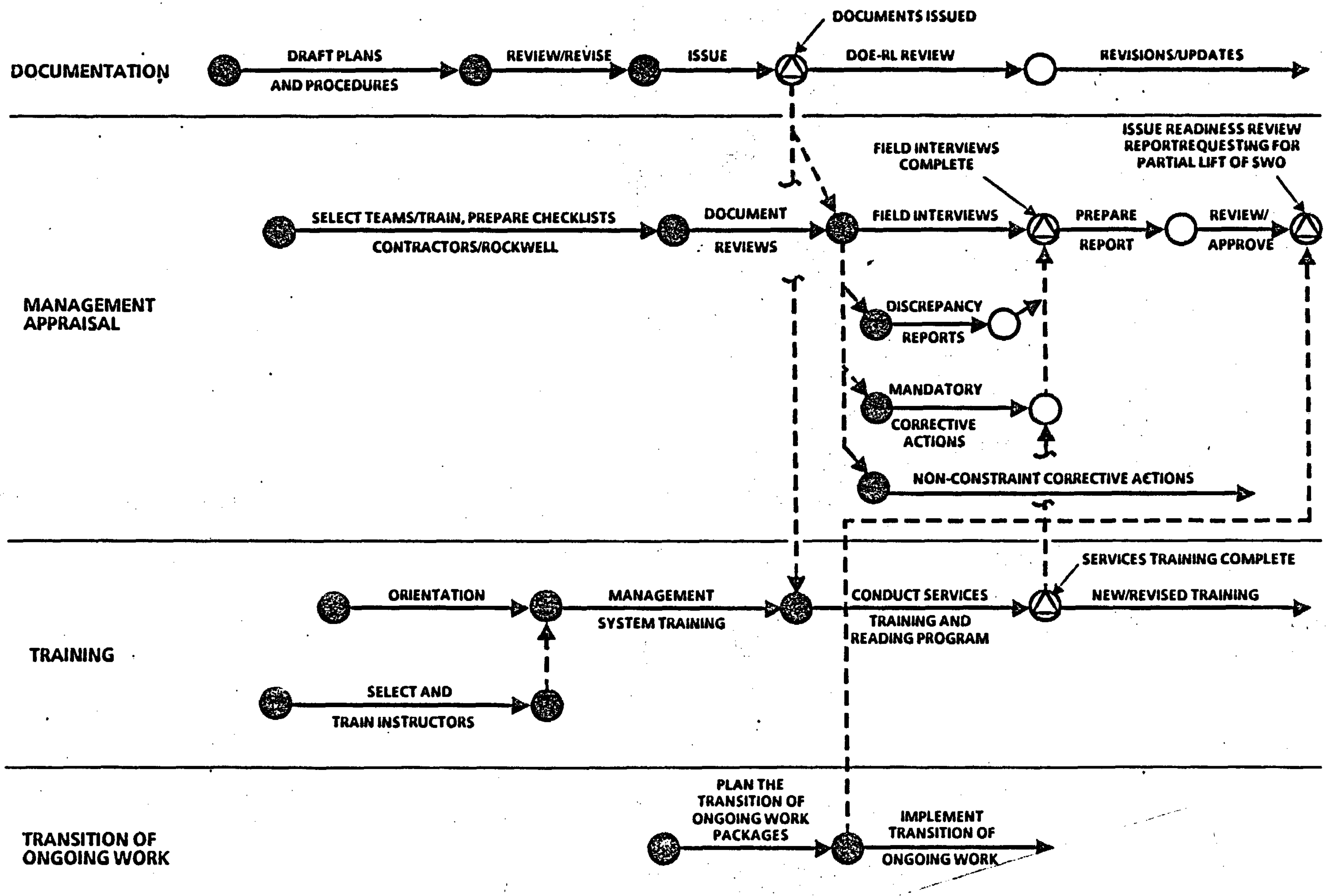
- **Develop management and technical controls**
- **Perform Management Systems analysis**
- **Perform general training**
  - Orientation of all personnel
  - Management Systems training
  - Training of "services" personnel
- **DOE-RL conduct readiness review**

--------------------Partial Lift of Suspension--------------------

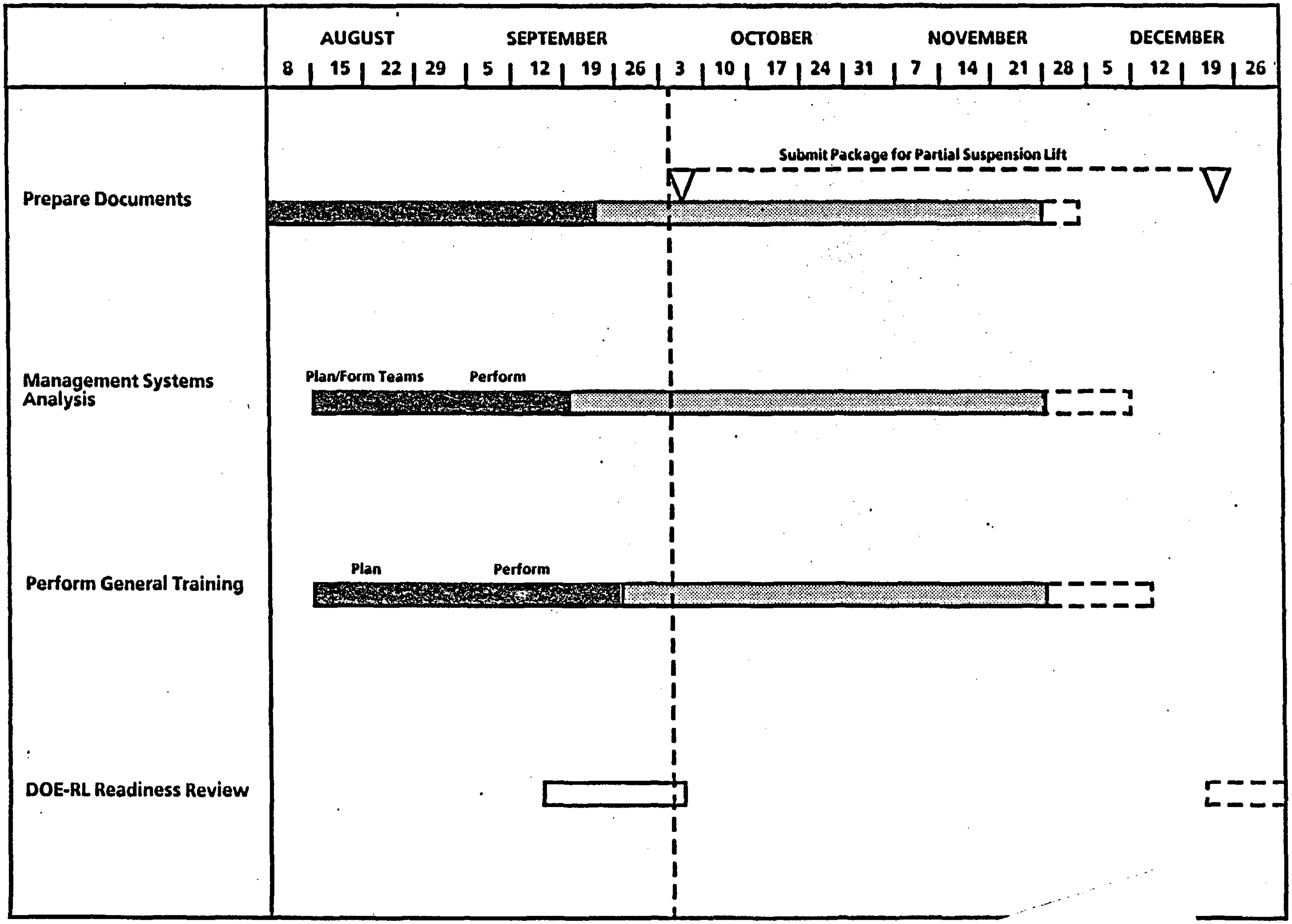
- **Subject blocks of new or stopped work to initiation procedure**
  - Initially DOE, QA, Functional, and Project Management
  - Ultimately Functional Management
- **Subject blocks of ongoing work to transition procedure**
- **DOE-RL audit selected work activities**

Lunchin FYI
AML 11/25/86
Status for restart of activities re
Readiness Review Fre

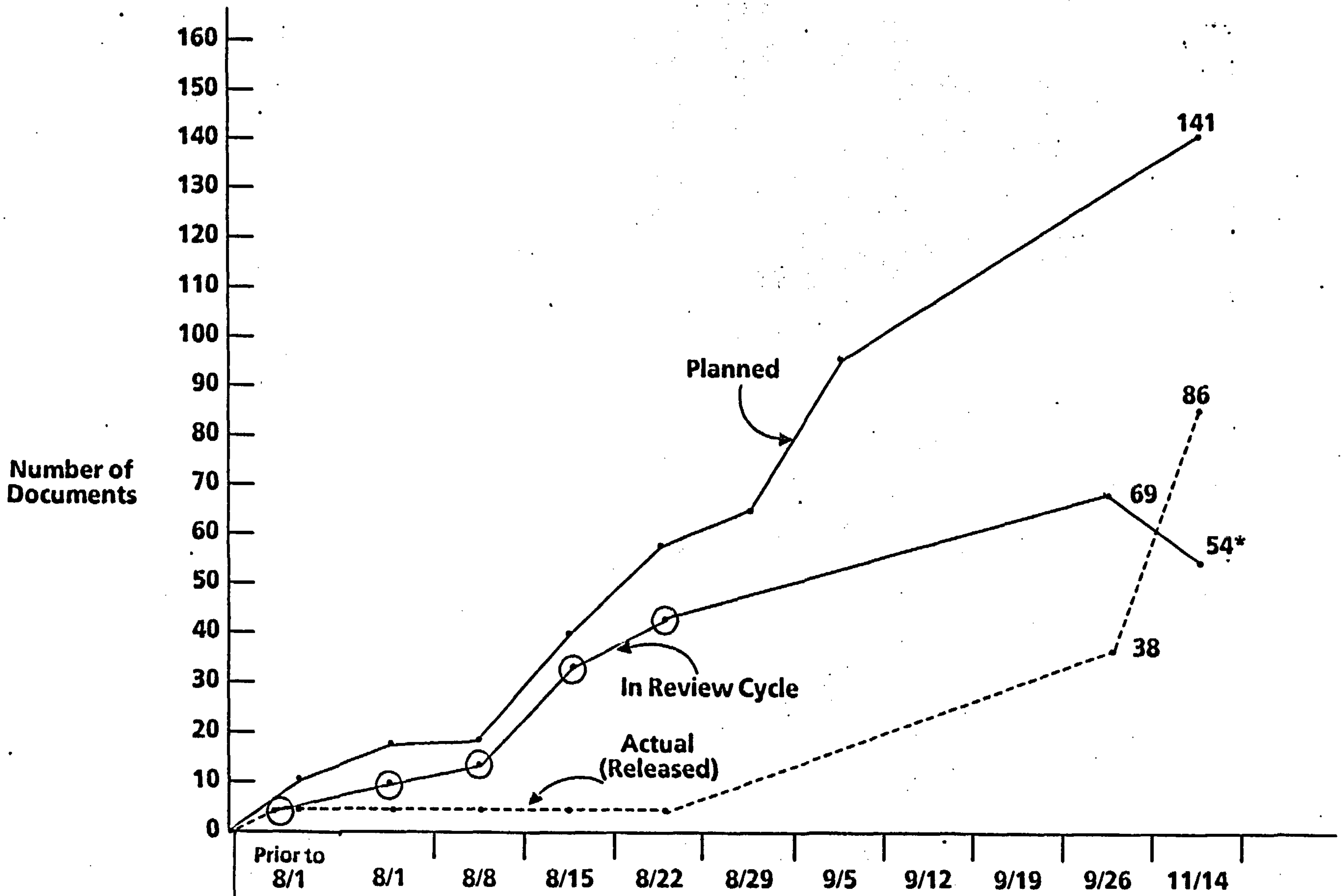
BASALT WASTE ISOLATION PROJECT
INTEGRATED LOGIC FOR PARTIAL LIFTING OF STOP WORK ORDER



GENERAL RESTART PLAN



DOCUMENT PREPARATION TO RESTART WORK AS OF NOVEMBER 14, 1986



*One procedure in preparation. Thirty-six documents are at DOE-RL for review/approval.

TRAINING STATUS

General Employee Orientation

- Complete for all employees

Management System Briefings

- Complete for all employees

TRAINING STATUS

ACTIVITIES FOR PARTIAL LIFTING OF STOP WORK ORDER

Mandatory Reading

- Lists prepared for all employees
- Reading in progress
- Completion possible by December 15, 1986

Training of Service Organization Personnel

- All activities planned
- Estimated completion by December 15, 1986

Documents

- M&IP Section draft complete
- M&IP Annex (Qualification and Training System Plan) in sign-off as an SD Document
- Project Management Procedures complete

APPRAISAL STATUS (November 18, 1986)

- All 19 appraisals initiated
- Includes Rockwell, BCSR, PNL, WHC, M-K, and KE/PB
- Status:

Organization	Deficiencies		Concerns	
	Open	Closed	Open	Closed
PNL	4	2	12	11
WHC	7	3	24	6
M-K	0	0	9	9
KE/PB	11	0	12	0
BCSR	--	--	--	--
Rockwell	27	0	31	0

TRANSITION OF ONGOING WORK TO NEW MANAGEMENT SYSTEM CONTROLS

- Transition of each package scheduled, including:
  - Preparation of work logic network
  - Graded QA evaluation
  - Required procedures availability
  - Training schedule
  - Required hardware/software evaluation.
- Complete transition of work currently estimated for mid-FY 1987.

RESTART READINESS REPORT

- Executive Summary
- Quality Program
- Management System
- Training
- Appraisals
- Restart of Work
- Action Items
- Appendixes

CRITICAL ISSUES

RESTART

Issue	Impacts	Corrective Action
• Late submissions for DOE approval	• DOE staff saturation	• Prioritized review • Schedule improvement • Ten-week look ahead by DOE-RL
• Parallel document preparation	• Inconsistencies • Retraining to revised documents/procedures	• Check for inconsistencies during Appraisal Process • Retrain as required

Linehan/Johnson
See schedule
for SCP and
Readiness Rv's
Status
11/20/86 FRC

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

November 20, 1986

Distribution

BWI DIVISION DIVISION WEEKLY REPORTS

Enclosed for your information is the Basalt Waste Isolation Division Weekly Report for the week ending November 20, 1986.

John H. Anttonen, Assistant Manager
for Commercial Nuclear Waste

Enclosures

Distribution
T. Isaacs, RW-22, HQ
J. Morris, RW-22, HQ
R. Stein, RW-23, HQ
J. Knight, RW-24, HQ
C. Smith, RW-43, HQ
D. Siefkin, Weston
R. Jackson, Weston
W. McClain, Weston
T. Bates, Weston
G. Shaw, Weston
F. R. Cook, NRC

BWI DIVISION WEEKLY REPORT
NOVEMBER 20, 1986

I. Critical Items Status

- At a meeting on November 6, the Readiness Review Board received the General Restart checklist for review/comment. The board also reviewed the Design Basis Study final report and has made its recommendation to the Assistant Manager for Commercial Nuclear Waste.

- A revised draft of the "General Restart Criteria," which is planned to be used as the basis for allowing Rockwell to restart work, was submitted to the Readiness Review Board. The revision was provided on the revised format, and includes both "Action Required" and "Acceptance Criteria."

II. Significant Accomplishments/Information Items

E&C Branch

- The Rockwell Waste Package Program Office completed a review of the Common Canister issues. There is concern that the adoption of a Monitored Retrievable Storage common canister may have significant impact to the Project and the recommendation was made for three site-specific canisters instead of one common canister.

- The preparation of logics to support the drafting of the BWIP Waste Package Strategy Document continues. Members of the Rockwell staff traveled to DOE-HQ to assist in the preparation of this document. The Waste Package Strategy team is currently meeting at HQ and discussions are scheduled to be completed on November 21.

- Calculations for the container lifetime distribution calculations for carbon steel consolidated spent fuel waste packages utilizing a deterministic approach were completed. The calculations were aimed at obtaining container lifetime distributions based on more realistic heat load distributions. The heat load distributions were calculated from the spent fuel thermal receipt characteristics generated by the WASTE II program at PNL.

G&T Branch

- By request from Lynne Fitzpatrick of the Rock Mechanics Subcommittee of the National Academy of Sciences, the December 18-19, 1986, meeting will be deferred until January 1987 (date to be determined). A review of the Rock Mechanics Technical

Plan by Z. T. Bieniawski, Neville Cook, Evert Hoek, and Wilson Blake will be held in Richland on December 18-19.

- The HQ review of Chapter 4, Geochemistry, found it to be of sufficiently high quality to be elevated to a Chapter Review. Following this Chapter Review, and based on HQ review of quality and accuracy, information copies will be forwarded to the States, Indian Tribes, and the NRC.

LES Branch

- SCP Status

Revision 1 of the Licensing Strategies is being prepared. Guidelines from Revision 1 will be provided as well as specific dedicated personnel assignments from various BWIP organizations. A new concept to be used will be an integrating review team to ensure that all strategies reflect the BWIP program. Special emphasis will be placed on performance allocation (particularly on Issues 1.1, 1.4, 1.5, and 1.6).

Incorporation of comments from earlier reviews is continuing for the following chapters/sections:

Chapter 3 - Hydrology
Chapter 6 - Conceptual Design of a Repository
Chapter 7 - Waste Package

Section 8.3.1.1 - Overview
Section 8.3.1.3 - Hydrology
Section 8.3.2 - Repository Program
Section 8.3.3 - Seal System Program
Section 8.3.5 - Performance Assessment Program Plan
Section 8.4 - Planned Site Preparation Activities
Section 8.7 - Decontamination and Decommissioning

Chapter 2, Geoengineering, was revised and turned over to Technical Publications for word processing.

Collection and verification of SCP references is continuing. An "SCP Reference Summary Report" program was developed and is now being used to track progress for all SCP chapters/sections.

Section 8.3.1.2, Geology, was sent out for joint DOE/Rockwell review.

The joint DOE/Rockwell review of the following chapters/sections is continuing. Scheduled Comment Resolution meeting dates are also indicated:

Chapter 1 - Geology	(12-2-86)
Chapter 4 - Geochemistry	(11-18-86)
Section 8.3.4 - Waste Package	(suspended)
Section 8.3.1.2 - Geology	(12-2-86)
Section 8.3.1.4 - Geochemistry	(11-12-86)
Section 8.3.1.6 - Resource Potential	(12-02-86)
Section 8.5 - Schedules	(suspended)
Section 8.6 - Quality Assurance	(11-13-86)

Comment Resolution meetings/workshops for the following chapter/sections were completed on November 5-6, 1986.

Chapter 6 - Conceptual Design
Section 8.3.2 - Repository Design
Section 8.3.3 - Seals

o Finalization of the EMMP and SMMP documents for distribution to the State of Washington and affected Tribes on December 1 is proceeding on schedule. A concurrence draft of the SMMP will be forwarded to HQ on November 21.

Other

o Briefings and tours covering BWIP activities and facilities were provided to County Commissioners from Benton, Franklin, and Grant Counties, State of Washington, and Area Emergency Management representatives on November 20.

III. Upcoming Events

See attached pages.

SF Dahlem for

J. J. Keating, Director
Basalt Waste Isolation Division

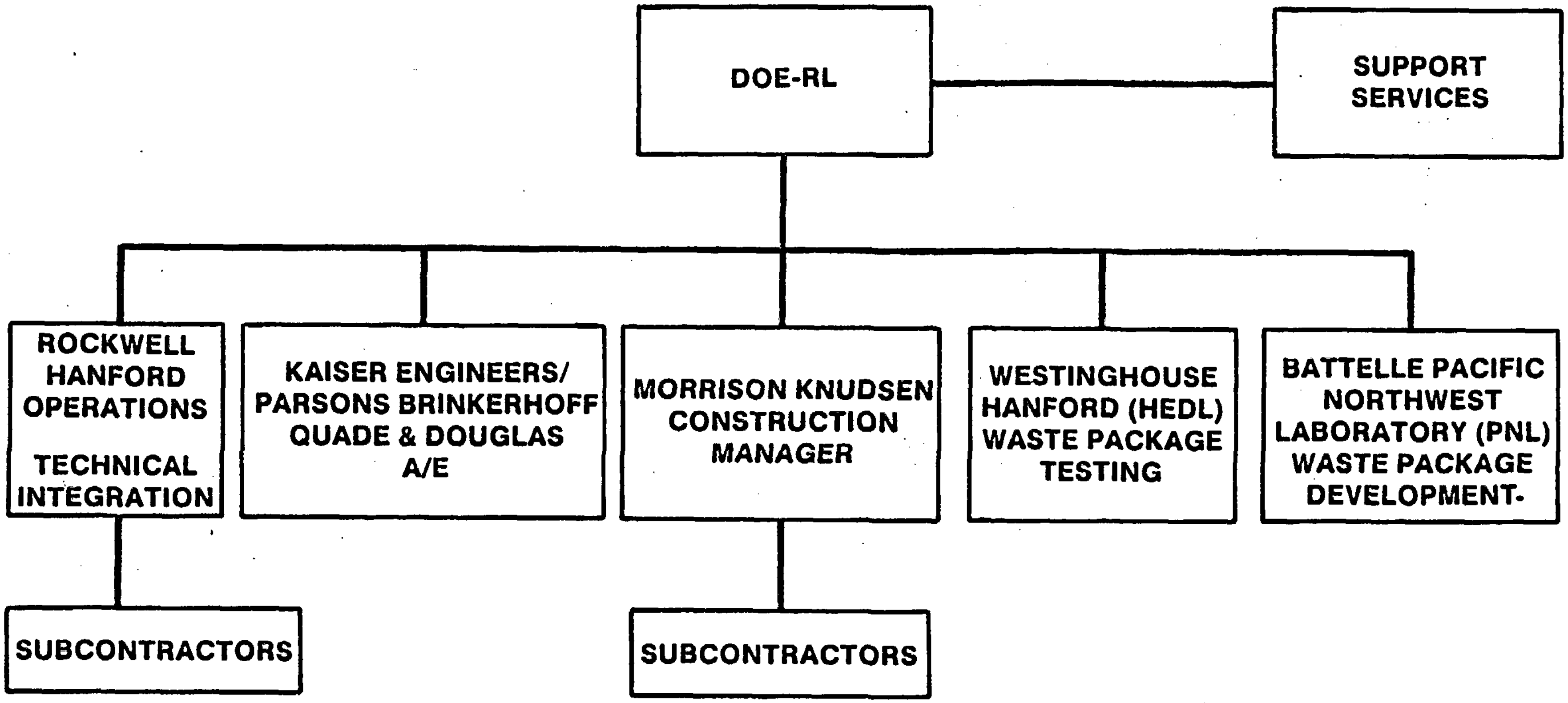
BWI UPCOMING EVENTS
NOVEMBER 20, 1986

Date	Event	Location	Contact
HQ Meetings			
November 13-21	Waste Package Strategy Workshop	HQ	LaMont
November 25	ES Design Basis Study Restart	Richland	Anttonen
December 15	Geohydrology Task Force Meeting	HQ	Dahlem
TBD	Review of BWIP Systems Integration Activities	Richland	Petrie
Coordinating Group Meetings			
January 12-13	Geoscience Coordinating Group	HQ	Dahlem
State/Indian/Public Interaction			
November 24	City of Pasco briefing	Pasco	Squires
November 24	State of Washington Representative-Elect Jim Jesernig	Richland	Anttonen/ Squires
December 6-7	ISCG Meeting	Las Vegas	Whitfield/Powell
December 11	Christine Masters, State of Washington Department of Transportation	Richland	Squires
February 1987	ASQC	Las Vegas	Dahlem
April 19-21, 1987	Western Regional Energy Conference	Richland	Dahlem
Internal Project Meetings			
November	SCP Reviews	Richland	Dahlem/Staff
November 25	Monthly Project Review	Richland	Anttonen
December 2-4	GAO Discussions covering BWIP	Richland	Olson
December 3-5	Geohydrology Workshop	Richland	Dahlem/S

Date	Event	Location	Contact
January 1987	Rock Mechanics Committee - NAS	Richland	Lassila
January 1987	Hydrology/Geochemistry Meeting with the USGS	TBD	Furman/Thompson
NRC Interactions			
December 2-5	Hydrology Data Review	Richland	Thompson/Dahlem Mecca
TBD	Repository Design (workshop)	Richland	Nicoll/Kovacs
TBD	NRC meeting to discuss SCP Issues, Hierarchy, Resolution Strategy, Data Needs	HQ	Mecca/Dahlem
International			
February 27, 1987	NEA Tour and Briefing	Richland	Squires
April 1987	IAEA Natural Analog Meeting	HQ	Dahlem

J. Kennelly

BWIP
MAJOR CONTRACTORS



OFFICE OF ASSISTANT MANAGER FOR COMMERCIAL NUCLEAR WASTE (AMC)

Assistant Manager — Anttonen*
Deputy - Olson
Inst. Liaison - Powell
Oper. Admin. - Turner
Cost Control Spec. - Higgins
Secretary - Wagnild

BASALT WASTE ISOLATION DIVISION (BWI)

Director - Keating
Secretary - Vale

Engineering and Construction Branch

Chief - Holten
Secretary - Hickman
Mining Engineer - Boileau
Project Engineer - Rokkan
Project Engineer - Nicoll
Project Engineer - Petrie
Project Engineer - Smith
Project Engineer - LaMont

Geoscience & Technology Branch

Chief - Dahlem
Secretary - Maclaren
Geochemist - Furman
Geologist - Marjaniemi
Hydrologist - Knepp
Hydrologist - Thompson
Project Engineer - Lassila
Project Engineer - Squires

Licensing/Environmental/Safety Branch

Chief - Mecca
Secretary - Jacobs
Licensing Specialist - Bell
Licensing Engineer - Kovacs
Project Engineer - Krupar
Environmental Scientist - Whitfield

QUALITY SYSTEMS DIVISION (QSD)

Director - Saget
QA Engineer - Davies
QA Engineer - Kasch
QA Engineer - Litz
QA Engineer - Subramanian
QA Specialist - Newby

STORAGE AND TRANSPORTATION DIVISION (STD)

Director - Izatt
Secretary - Thompson
Program Engineer - Crouter
Program Engineer - Langstaff
Program Engineer - Goranson
Program Engineer - Collins
Traffic Manager - Peterson
Trans. Engineer - Kenyon
Traff. Mgmt. Spec. - Jarrell

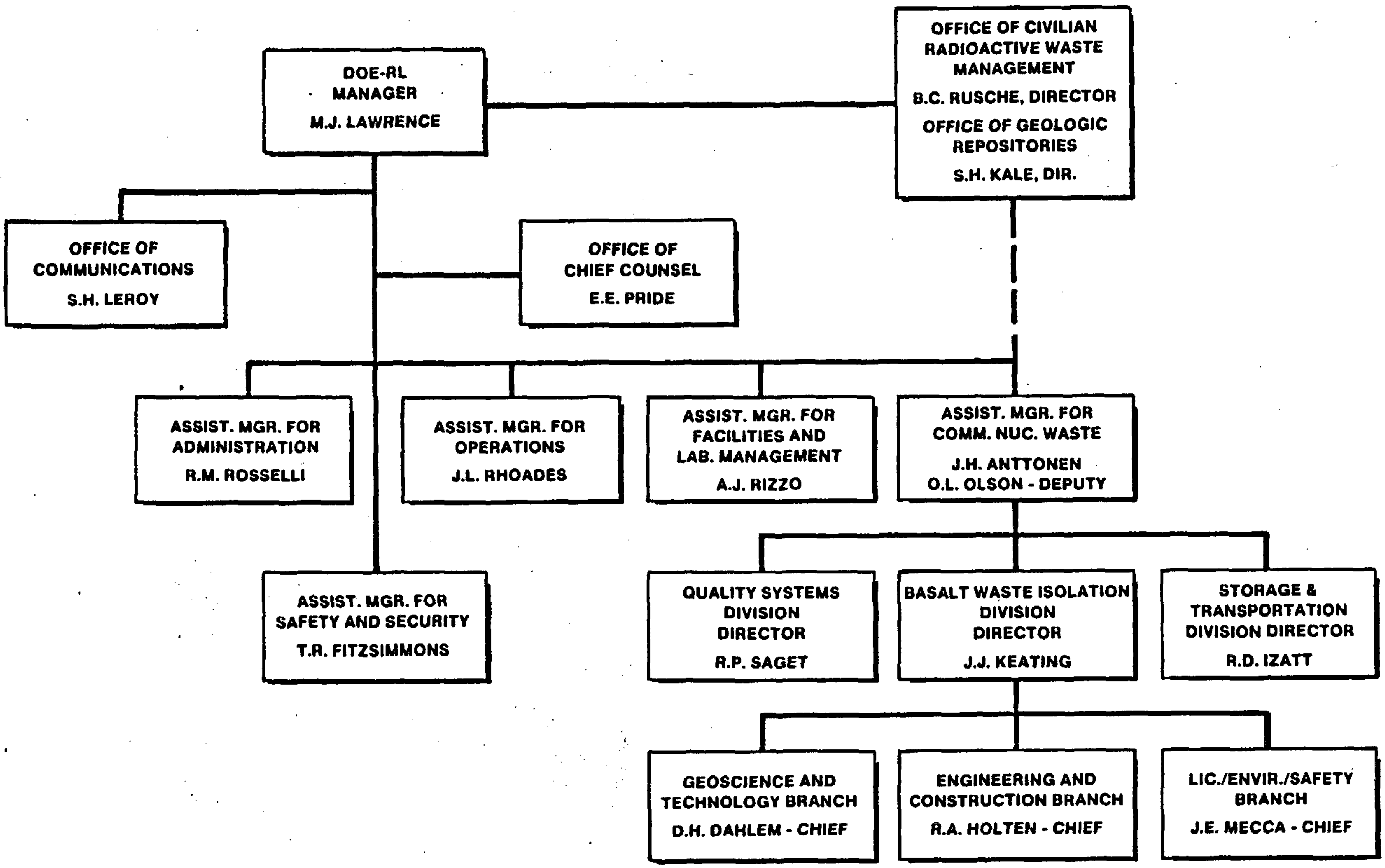
OFFICE OF THE ASSISTANT MANAGER FOR COMMERCIAL NUCLEAR WASTE (AMC)

* PROJECT MANAGER FOR BASALT WASTE ISOLATION PROJECT

(11/1/86)

BASALT WASTE ISOLATION PROJECT

PROJECT MANAGEMENT ORGANIZATION



BWIP QA PROGRAM OVERVIEW

WASHINGTON STATE NUCLEAR WASTE BOARD MEETING

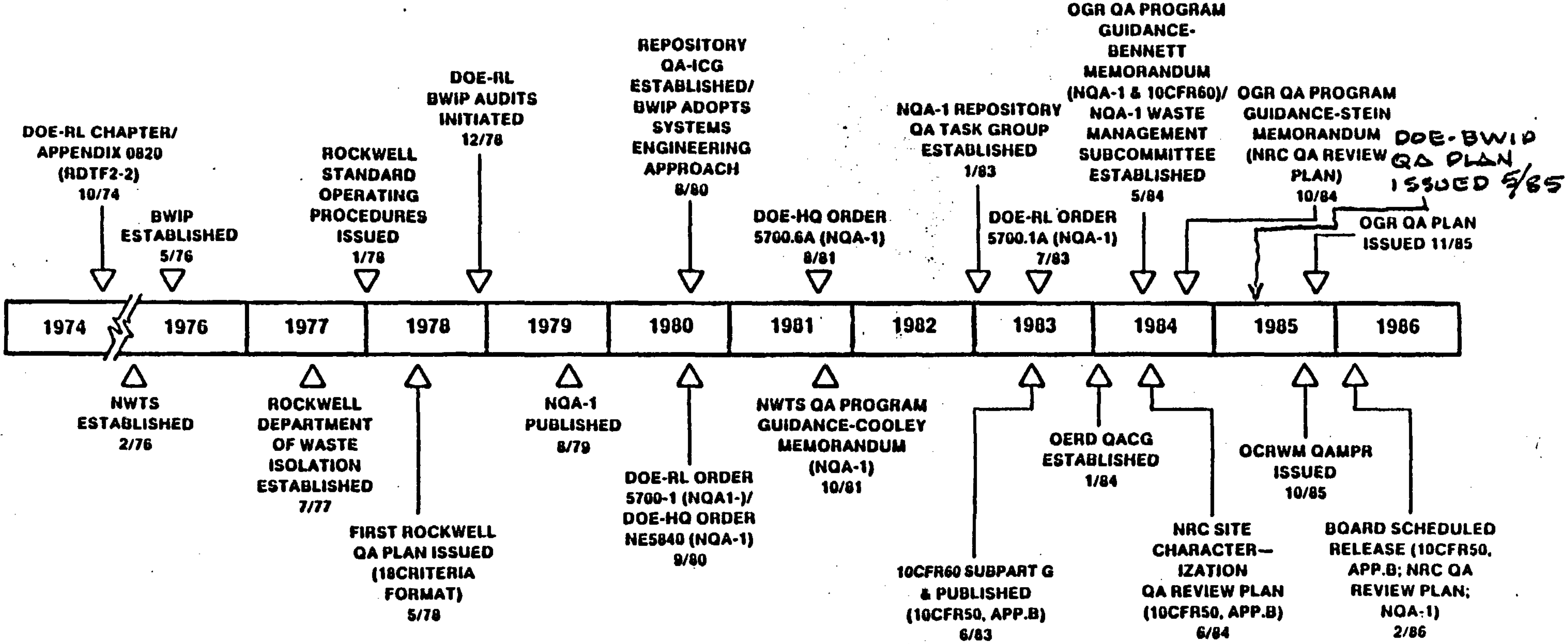
AT

OLYMPIA, WASHINGTON
NOVEMBER 21, 1986

BY

R. P. SAGET, DIRECTOR
QUALITY SYSTEMS DIVISION
U.S. DEPARTMENT OF ENERGY
RICHLAND, WASHINGTON

CHRONOLOGY OF BWIP
QA PROGRAM DEVELOPMENT



ACRONYMS:

DOE-RL: DEPARTMENT OF ENERGY RICHLAND OPERATIONS OFFICE
RDT: REACTOR DEVELOPMENT TECHNOLOGY
NWTS: NUCLEAR WASTE TERMINAL STORAGE PROGRAM
BWIP: BASALT WASTE ISOLATION PROJECT
NQA: NUCLEAR QUALITY ASSURANCE
QA-ICE: QUALITY ASSURANCE INTERFACE COORDINATION GROUP
NE: NUCLEAR ENERGY
OGRD: OFFICE OF GEOLOGIC REPOSITORY DEPLOYMENT
QACG: QUALITY ASSURANCE COORDINATION GROUP
NRC: NUCLEAR REGULATORY COMMISSION
OGR: OFFICE OF GEOLOGIC REPOSITORIES
OCRWM: OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT
QAMPR: QUALITY ASSURANCE MANAGEMENT POLICIES AND REQUIREMENTS
BQARD: BASALT QUALITY ASSURANCE REQUIREMENTS DOCUMENT

PREPARED BY: M.F. NICOL
2/14/86 6-8456

SOURCE OF QUALITY ASSURANCE PROGRAM CRITERIA

- 10 CFR 60, SUBPART G
- 10 CFR 50, APPENDIX B
- U.S. NUCLEAR REGULATORY COMMISSION REVIEW PLAN FOR SITE CHARACTERIZATION
- ANSI/ASME NQA-1

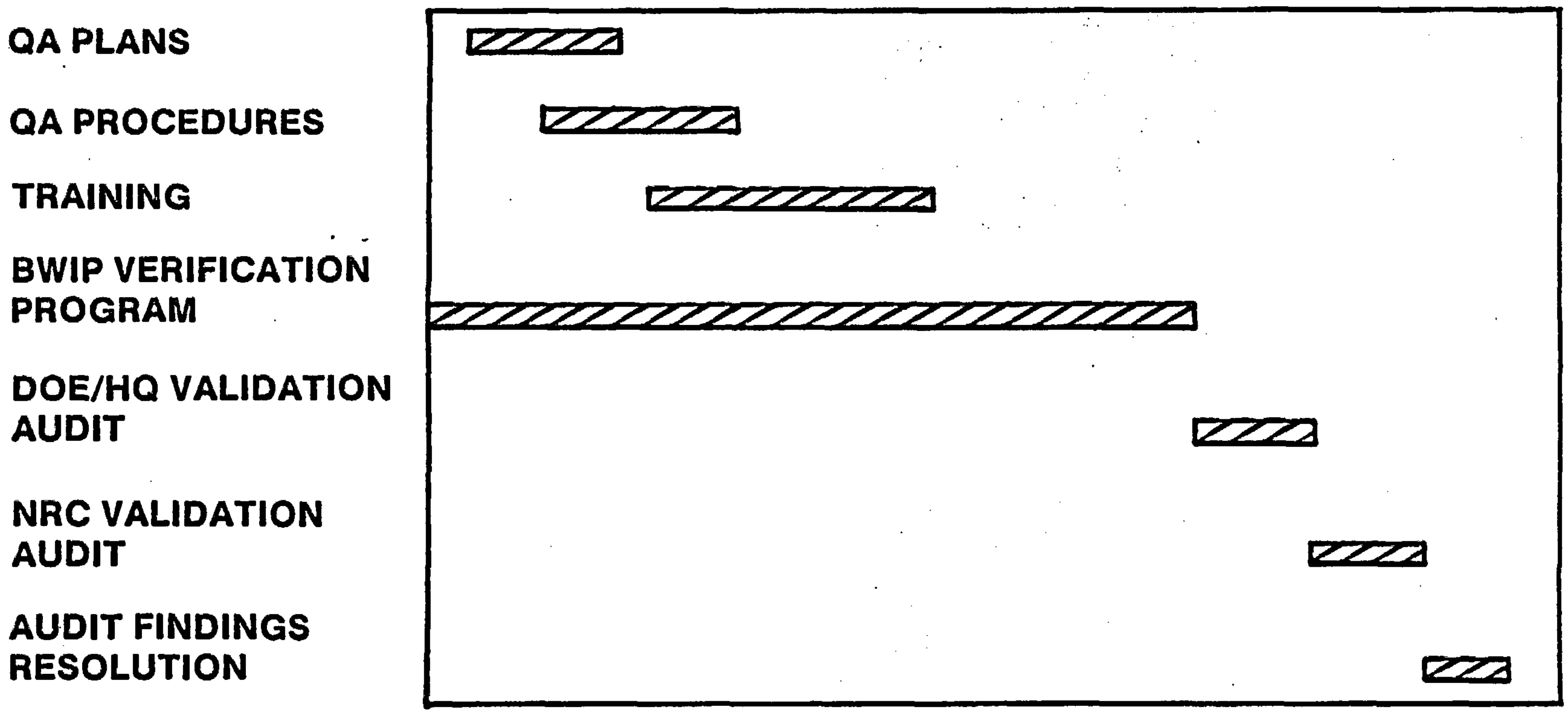
APPLICABLE DEPARTMENT OF ENERGY QUALITY ASSURANCE PLANS AND REQUIREMENTS DOCUMENTS

- DOE ORDER 5700.6A, "QUALITY ASSURANCE"
- DOE/RL ORDER 5700.1A, "QUALITY ASSURANCE"
- OFFICE OF CIVILIAN RADIOACTIVE WASTE MANAGEMENT "QUALITY MANAGEMENT POLICIES AND REQUIREMENTS"
- OFFICE OF GEOLOGIC REPOSITORIES "QUALITY ASSURANCE PLAN FOR SITING AND SITE CHARACTERIZATION," OGR/B-3
- BASALT QUALITY ASSURANCE REQUIREMENTS DOCUMENT (BQARD), ~~DRAFT~~

BQARD

- COMBINES BASE REQUIREMENTS FOR QUALITY LEVEL 1 ITEMS INTO A SINGLE DOCUMENT
- INSURES CONSISTENT IMPLEMENTATION OF REQUIREMENTS AMONG PROJECT PARTICIPANTS
- PROVIDES BASIS FOR "FULLY QUALIFIED" QA PROGRAM
- USES 18 CRITERIA FORMAT

PROGRAM LOGIC



BWIP QA PLANS STATUS REPORT

AS OF QUARTER ENDING 9/30/86

MAJOR PARTICIPANT	DOCUMENT IDENTIFICATION	REV. NO.	STATUS*	APPROVAL DATE	REMARKS
RHO	RHO-QA-MA-3	2	5	8/4/86	
KE/PB	BWIP PROCEDURES MANUAL	2	4	NONE	KE/PB INCORPORATING COMMENTS FROM INTERNAL REVIEW
M-K	BWIP QA MANUAL	1	4	10/16/86**	**DOE-RL PREPARING TO APPROVE WITH COMMENTS
PNL	QA MANUAL FOR LICENSING RELATED PROGRAMS (PNL-MA-60)	1	5	9/5/86	
WHC	QA MANUAL MG-197	N/A	5	8/6/86	
DOE-RL	BOARD DOE-RL QA PLAN	1 1	5 5	6/6/86 8/14/86	

*STATUS LEGEND:

1 - PLANNED
2 - UNDER PREPARATION
3 - FOR COMMENT RESOLUTION
4 - FOR PROJECT APPROVAL
5 - ISSUED FOR IMPLEMENTATION

QA PROCEDURES DEVELOPMENT SUMMARY

AS OF 9/30/86

PROCEDURES SATUS	MAJOR PARTICIPANTS DOE-RL	RHO	KE/PB	M-K	PNL	WHC	PROJECT TOTALS	REMARKS
TOTAL REQUIRED	36	32*	48	26	80	68	290	*TO BE ISSUED AS QAPP'S IN RHO-BW-MA-17
ISSUED FOR IMPLEMEN-TATION	33	0	0	0	80	68	181	
APPROVED BY DOE-RL	35	0*	0	**	NA***	NA***	35	*10 SUMBITTED TO DOE-RL **M-K R.1 IMPLEMENTING PROCEDURES TRANSMITTED TO DOE-RL FOR APPROVAL ***APPROVED BY ROCKWELL
UNDER REVIEW OR COMMENT	9*	31	48**	26***	—	—	114	*7 OF 9 ARE REVISIONS TO PREVIOUSLY APPROVED PROCEDURES **INTERNAL REVIEW BY KE/PB ***DOE PREPARING TO APPROVE WITH COMMENTS (10/16)
UNDER PREPARATION	0	1	—	—	—	—	1	
NOT YET STARTED	1	0	—	—	—	—	1	

DOE/RL BWI TRAINING PROGRAM

INITIAL PROCEDURE ORIENTATION	COMPLETE	07-05-86
PROJECT ORIENTATION	COMPLETE	09-15-86
ADVANCED AUDIT TRAINING	COMPLETE	08-27-86
AUDITS AND SURVEILLANCE FOR THE TECHNICAL PARTICIPANTS	COMPLETE	09-25-86
PERFORMANCE-BASED TRAINING SYSTEM	ADOPTED	08-23-86
- TRAINING MATRIX DEVELOPMENT	COMPLETE	09-05-86
- JOB FUNCTION IDENTIFICATION	UNDERWAY	12-01-86
- LESSON PLAN DEVELOPMENT (25 COURSES)	UNDERWAY	FEBRUARY
INSTRUCTOR TRAINING	COMPLETE	10-22-86
DETAILED TRAINING AND ORIENTATION FOR IDENTIFIED JOB FUNCTIONS	TARGETED	MID-OCT. THRU NOV., 1986

BWIP FY 86 QA AUDIT STATUS REPORT

AS OF QUARTER ENDING 9/30/86

INITIATING ORGANIZATION	AUDITS			AUDIT FINDINGS					REMARKS
	FISCAL YEAR		QUARTER	FISCALYEAR			QUARTER		
	PL	CO	CO	IS	CL	OP	IS	CL	
RHO	11	9	3	29	25	23	3	8	
KE/PB	6	1	0	13	11	2	0	0	
M-K	2	2	0	4	4	0	0	1	
PNL	17	17	5	13	13	0	1	1	
WHC	2	1	0	1	1	0	0	1	
DOE-RL	8	8	0	27	1	37	0	0	

LEGEND:

PL = PLANNED
CO = COMPLETED

IS = ISSUED
CL = CLOSED

OP = STILL OPEN

BWIP FY 86 SURVEILLANCE STATUS REPORT

AS OF QUARTER ENDING 9/30/86

INITIATING ORGANIZATION	AUDITS FISCAL YEAR PL	AUDITS FISCAL YEAR CO	AUDITS QUARTER CO	AUDIT FINDINGS FISCAL YEAR IS	AUDIT FINDINGS FISCAL YEAR CL	AUDIT FINDINGS FISCAL YEAR OP	AUDIT FINDINGS QUARTER IS	AUDIT FINDINGS QUARTER CL	REMARKS
RHO	395	443	141	443	422	37	141	130	
KE/PB	398	398	65	398	381	17	65	59	
M-K	0	0	0	0	0	0	0	0	NO ACTIVITIES TO SURVEIL
PNL	156	156	32	156	151	5	32	32	
WHC	12	11	2	11	10	1	2	1	
DOE-RL	44	29	10	29	20	9	10	4	RHO = 21 WHC = 6 PNL = 1, KE/PB = 1

LEGEND:

PL = PLANNED
CO = COMPLETED

IS = ISSUED
CL = CLOSED

OP = STILL OPEN

QA STAFFING STATUS REPORT

AS OF QUARTER ENDING 9/30/86

FUNCTIONAL ACTIVITY	MAJOR PARTICIPANTS												REMARKS
	DOE-RL		RHO		KE/PB		M-K		PNL		WHC		
	EX	REQ	EX	REQ	EX	REQ	EX	REQ	EX	REQ	EX	REQ	
ADMINISTRATION/ MANAGEMENT	1	1	11	11	1	1	2	1.5*	1	1	2	2	*QC SUPERVISOR 9/29/86
PROGRAM DEVELOPMENT	3	3	7	7	1	1	1	1.5	3	4.25	4	2	
PROGRAM VERIFICATION	2	2	25	25	0	0	1	2	5	6.5	1	3	
CONSULTANTS	17	17	0	0	0	0	0	0	2	4	0	0	
OTHERS	0	0	11	11	0	0	0	0	0	0	0	0	
TOTALS	23	23	54	54	2	2	4	5	11	15.75	7	7	

EX = EXISTING STAFF
REQ = STAFFING REQUESTED FOR THE FY

HISTORY

- BWI AUDIT/SURVEILLANCE PROGRAM
  - LACK OF ADEQUATE QA PROCEDURES
  - LACK OF TECHNICAL PROCEDURES
  - LACK OF TRAINING/TRAINING PROGRAM
- 3/14/86 BWI REQUEST TO THE CONTRACTOR TO EVALUATE WORK ACTIVITIES AGAINST MANAGEMENT CONTROL PREREQUISITES
- 4/11/86 CONTRACTOR RESPONSE
  - REVIEWED 450 WORK ACTIVITIES - RECOMMENDED 41 ACTIVITIES BE STOPPED
  - FAILED TO IDENTIFY BASIS FOR SWO RECOMMENDATION
  - LATER SUBMITTAL OF WORK EVALUATION SHEETS DID NOT SUPPORT 4/11/86 RECOMMENDATION
- 5/1/86 DOE/RL STOP WORK LETTER TO CONTRACTOR
  - IDENTIFIED SIX CATEGORIES FOR EXCEPTIONS
- 5/14/86 CONTRACTOR RESPONSE
  - APPROXIMATELY 850 WORK ACTIVITIES REVIEWED
  - APPROXIMATELY 350 WORK ACTIVITIES RECOMMENDED FOR SWO
- FOLLOW-ON ACTIVITIES
  - ADDITIONAL ITEMS WERE STOPPED BASED ON FOLLOW-ON REVIEWS
  - ULTIMATELY 1,300 ACTIVITIES WERE REVIEWED AND APPROXIMATELY HALF WERE STOPPED. THE REMAINDER FELL INTO ONE OF THE SIX EXCEPTION CATEGORIES

SWO PURPOSE

- TO REFOCUS PROJECT ATTENTION AND PRIORITIES TO INSURE APPROPRIATE MANAGEMENT AND TECHNICAL PREREQUISITES ARE PUT IN PLACE TO SUPPORT LICENSING
- PERMIT THE FOLLOWING ACTIVITIES TO CONTINUE
  - DATA GATHERING - FOR WHICH INTERRUPTION COULD RESULT IN LOSS OF SIGNIFICANT DATA
  - MANAGEMENT, OPERATING, AND QA SYSTEMS UPGRADES
  - SAFETY/MAINTENANCE ACTIVITIES
  - ADMINISTRATIVE ACTIVITIES
  - SITE CHARACTERIZATION PLAN (SCP) PREPARATION ACTIVITIES
  - ESSENTIAL ACTIVITIES/IMPRUDENT TO STOP

BWIP STOP WORK STATUS

- STOP WORK ORDER ISSUED MAY 1, 1986
- QUALITY AFFECTING ACTIVITIES STOPPED
- SOME ACTIVITIES CONTINUING - IMPRUDENT TO STOP
- BWI READINESS REVIEW BOARD ESTABLISHED
- PROJECT PARTICIPANTS REVISING PROCEDURES TO MEET BOARD AND SYSTEMS ENGINEERING REQUIREMENTS
- SURVEILLANCES BEING CONDUCTED ON CONTINUING ACTIVITIES
  - TRAINING
  - PROCEDURE WRITING
  - RECORDS
- RHO APPRAISALS OF DIRECT FUNDED CONTRACTORS - WHC, PNL, RKE, M-K
- RHO INTERNAL APPRAISALS STARTED IN LATE OCTOBER 1986
- DOE/RL AND DOE/HQ AUDITS/ASSESSMENTS TO FOLLOW

Lenihan / Boyle / Lilley

DOCUMENTS APPENDIX

SENSITIVITY TO SCORES

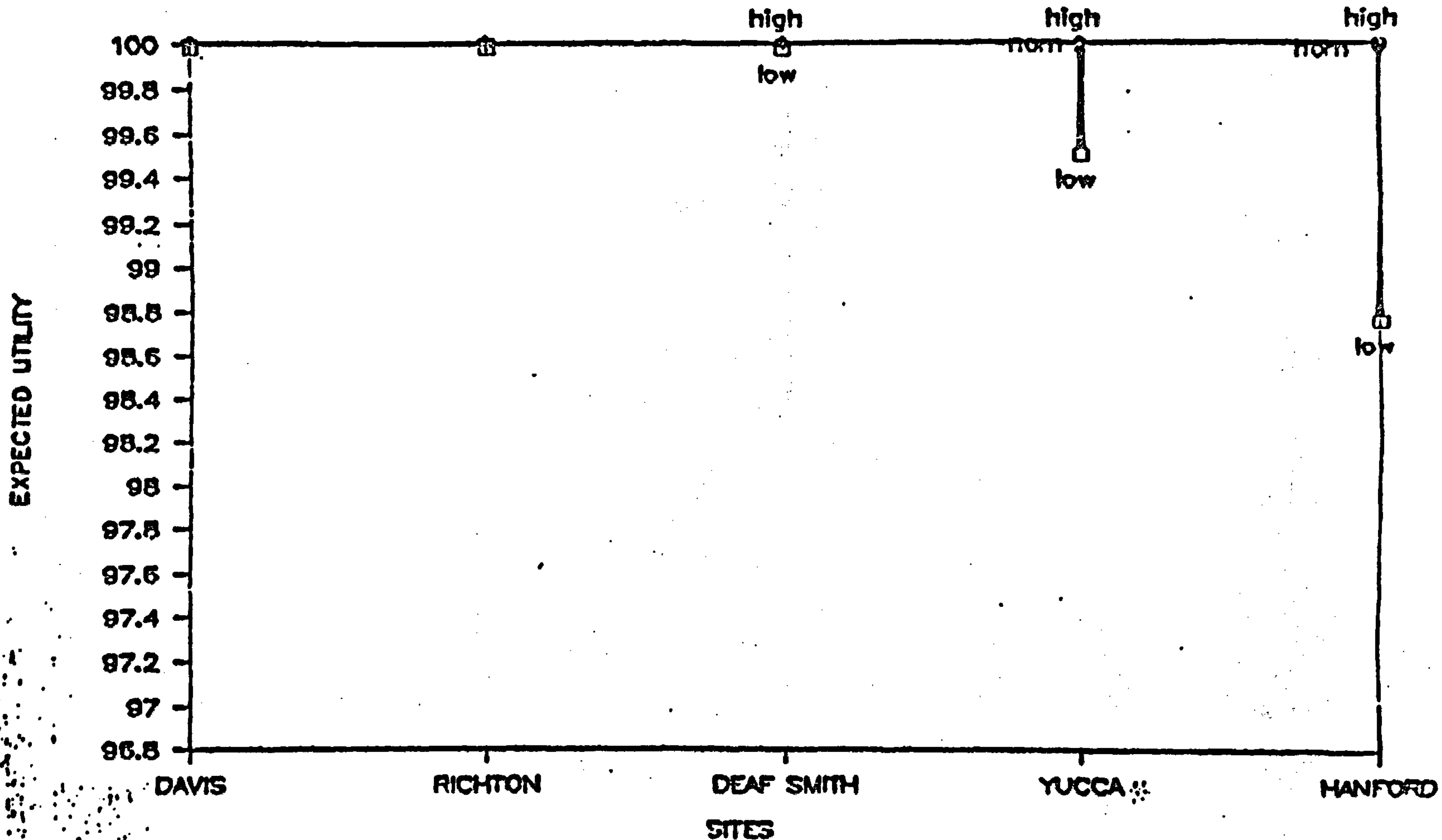


Figure S-1.

Note: "High" refers to all scores set at high values; "low" refers to all scores set at low values.

DOCUMENT A

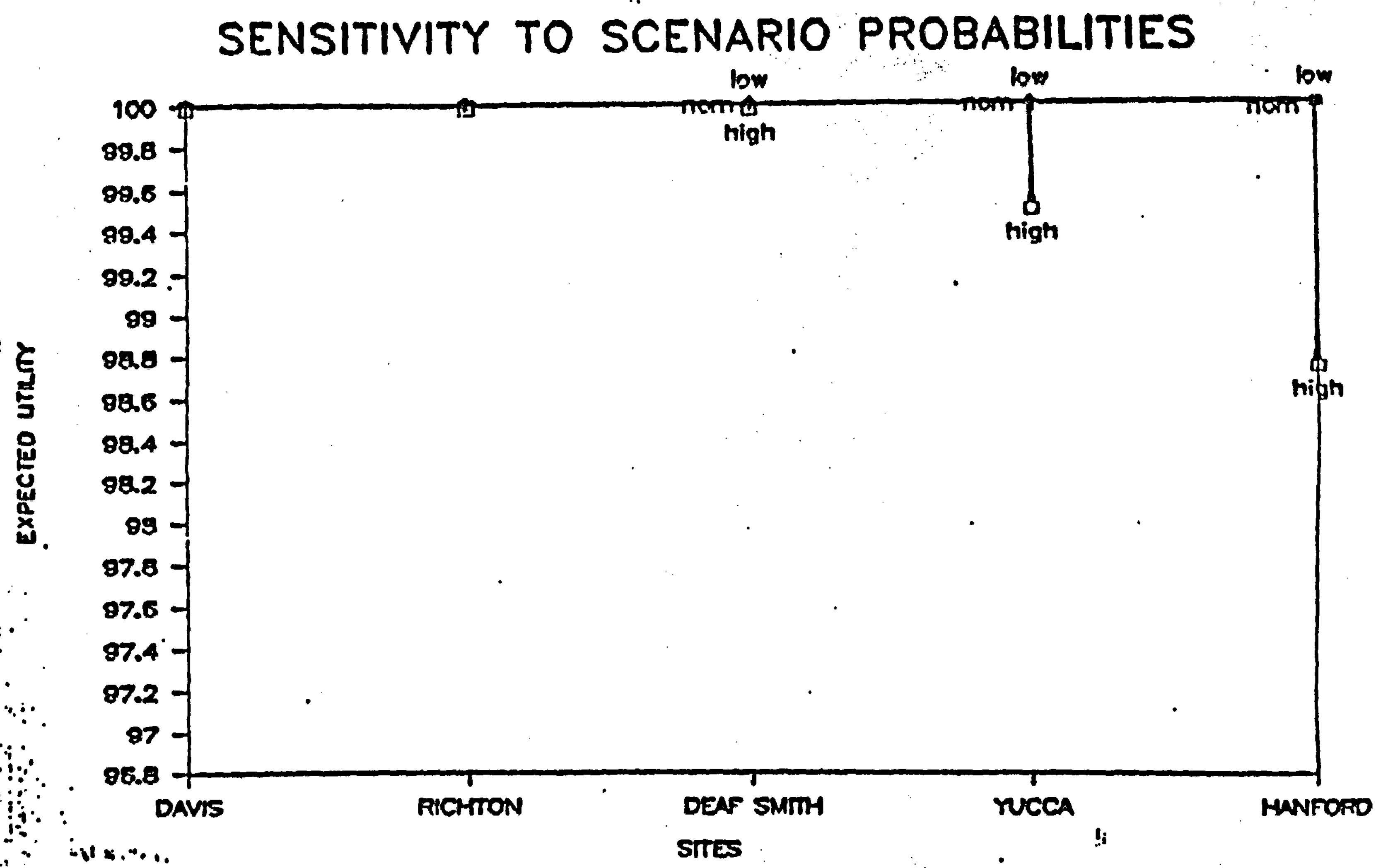


Figure S-2.

Note: "High" refers to all scenario probabilities set to high values; "low" refers to all scenario probabilities set to low values.

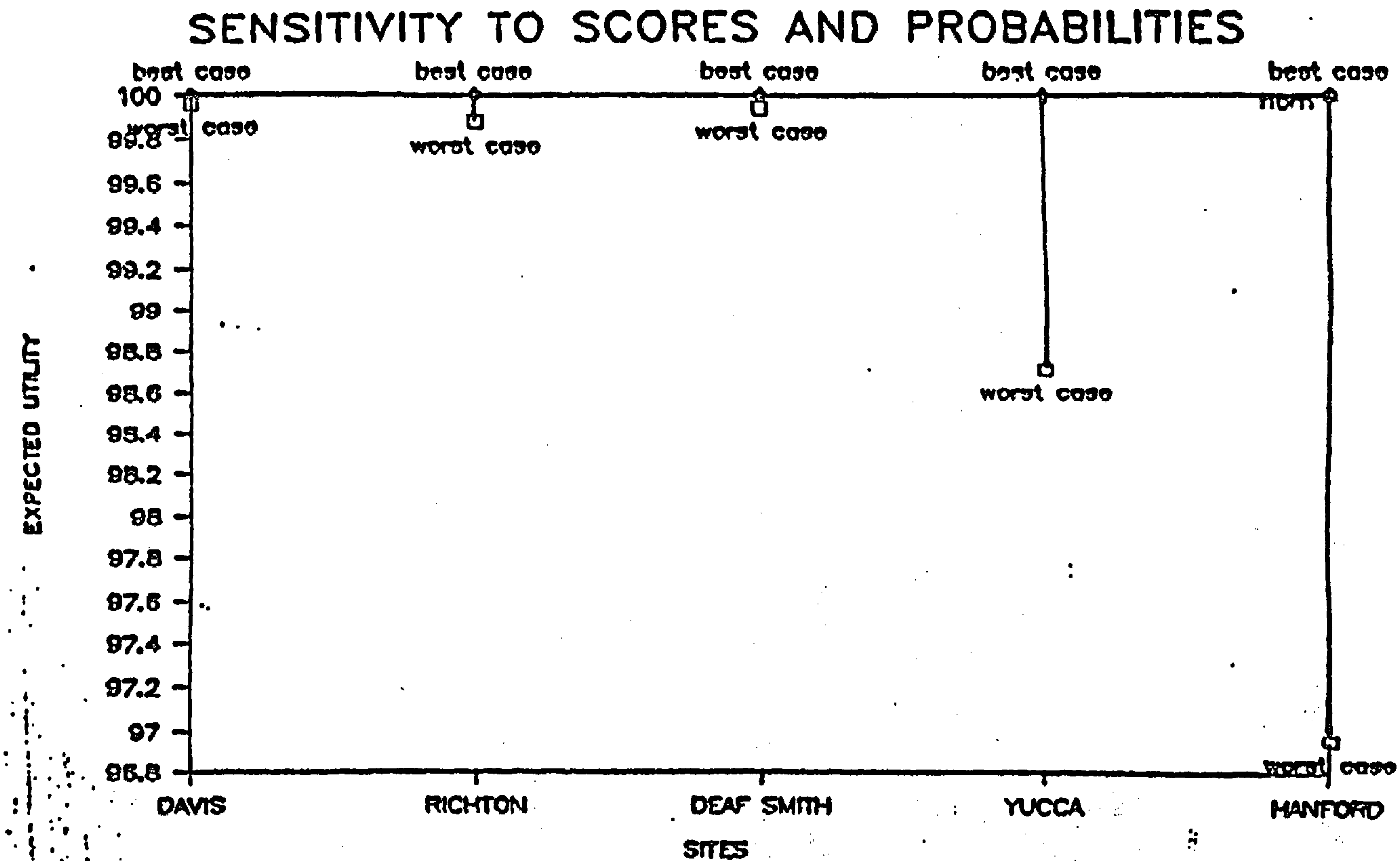


Figure S-3.

Note: "Best case" refers to all scores set high and probabilities low; "worst case" refers to scores low and probabilities high.

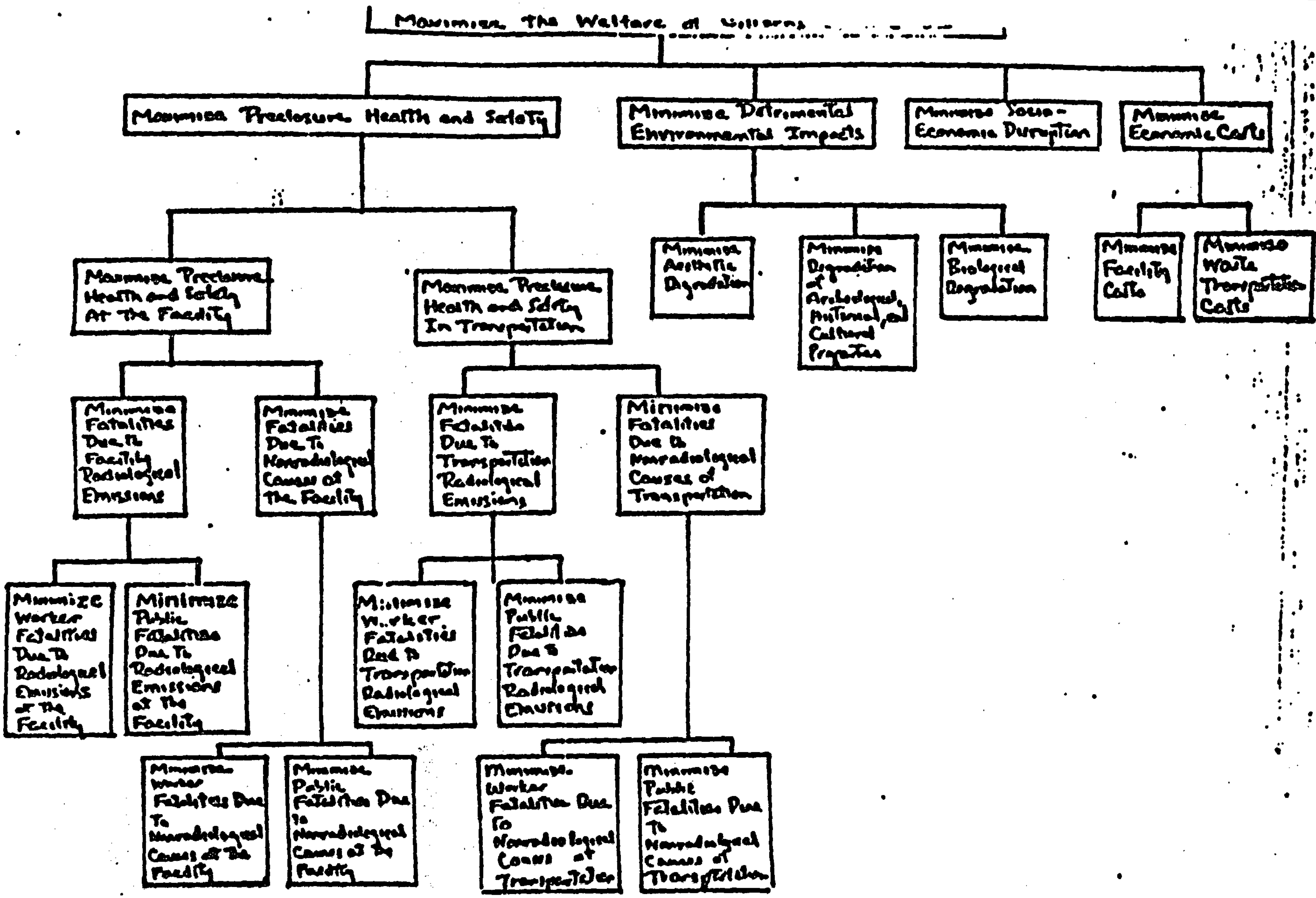


Fig. 5.1. Preclosure Objectives Hierarchy

PRECLOSURE

TABLE 5.8.A BASE CASE IMPACTS OF CANDIDATE SITES

	PERFORMANCE MEASURE	RICHTON	DEAF SMITH	DAVIS	YUCCA	HANFOR
		CANDIDATE SITES				
health & safety	X1	1	1	1	4.5	
	X2	0.7	0.5	0.1	0.1	
	X3	28.6	23.4	28.6	23.4	
	X4	0	0	0	0	
	X5	0.37	0.46	0.52	0.58	(
	X6	1.7	2.1	2.5	2.9	
	X7	1.3	1.6	2.1	2.5	
	X8	5.3	6.7	8.4	10.2	
environment	X9[a]	0.09	0.398	1	0.33	(
	X10[a]	0	0	0.12	0.12	
	X11[a]	0.1604	0.11	0.28	0.08	0.
socioecon	X12[a]	0.2	0.1604	0.2	0.0576	0.
economic	X13	8500	6500	8500	6500	1
	X14	970	1120	1240	1400	

a The impacts for the environmental and socioeconomic performan measures are the component cost equivalent ratings calculated from the base case estimate in Table 5.6 substituted into the c_i, $i=9,\ldots,$ respectively from Table 5.7.

Notes

1. This information comes from different Technical analyses
2. form of aggregation function (i.e. a multiattribi utility function that is additive) justifies summarizing impacts over each performance measure separately

Reduced Description of Impacts*

	Preclosure Health & Safety		Environmental & Socioeconomic	Economic Cost
	public fatalities	worker fatalities	percent of maximum socioeconomic impact	millions of dollars
Richton	8 (1)	31 (2)	23 (3)	9470 (1)
Deaf Smith	9 (2)	26 (1)	25 (4)	9620 (2)
Davis	11 (3)	32 (4)	42 (5)	9740 (3)
Yucca	13 (4)	31 (2)	13 (2)	9900 (4)
Hanford	15 (5)	54 (5)	4 (1)	13750 (5)

* ranking in ( )

Implications

- ✓ without tremendous weight on environmental/socioeconomic impacts relative to health & safety and cost, Hanford is last
- ✓ Yucca impacts competitive with three salt sites
- ✓ Among salt sites, Richton and Deaf Smith are both better than Davis on all four categories above

Comments on Analysis & Sensitivity of Results

- ✓ Complete multiattribute analysis definitely consistent with these implications

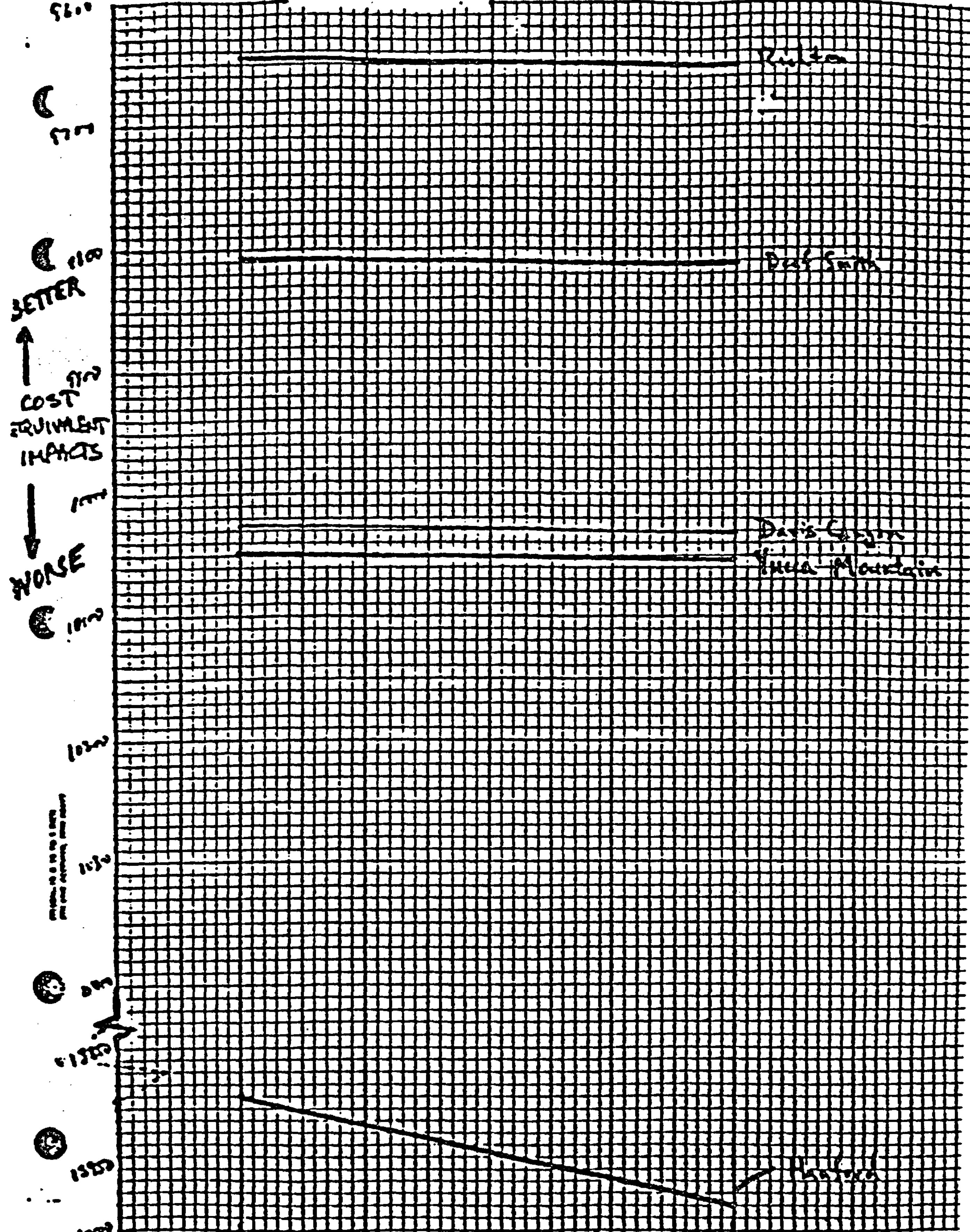
- ✓ Explicit inclusion of 'error bands' does not have Hanford overlapping any other sites under any reasonable assumptions

- ~~✓ Postclosure implications evaluate Richton, Deaf Smith, Davis and Yucca essentially the same and all preferred to Hanford~~

- ✓ With improved cost estimates for salt sites, the implications could change among these

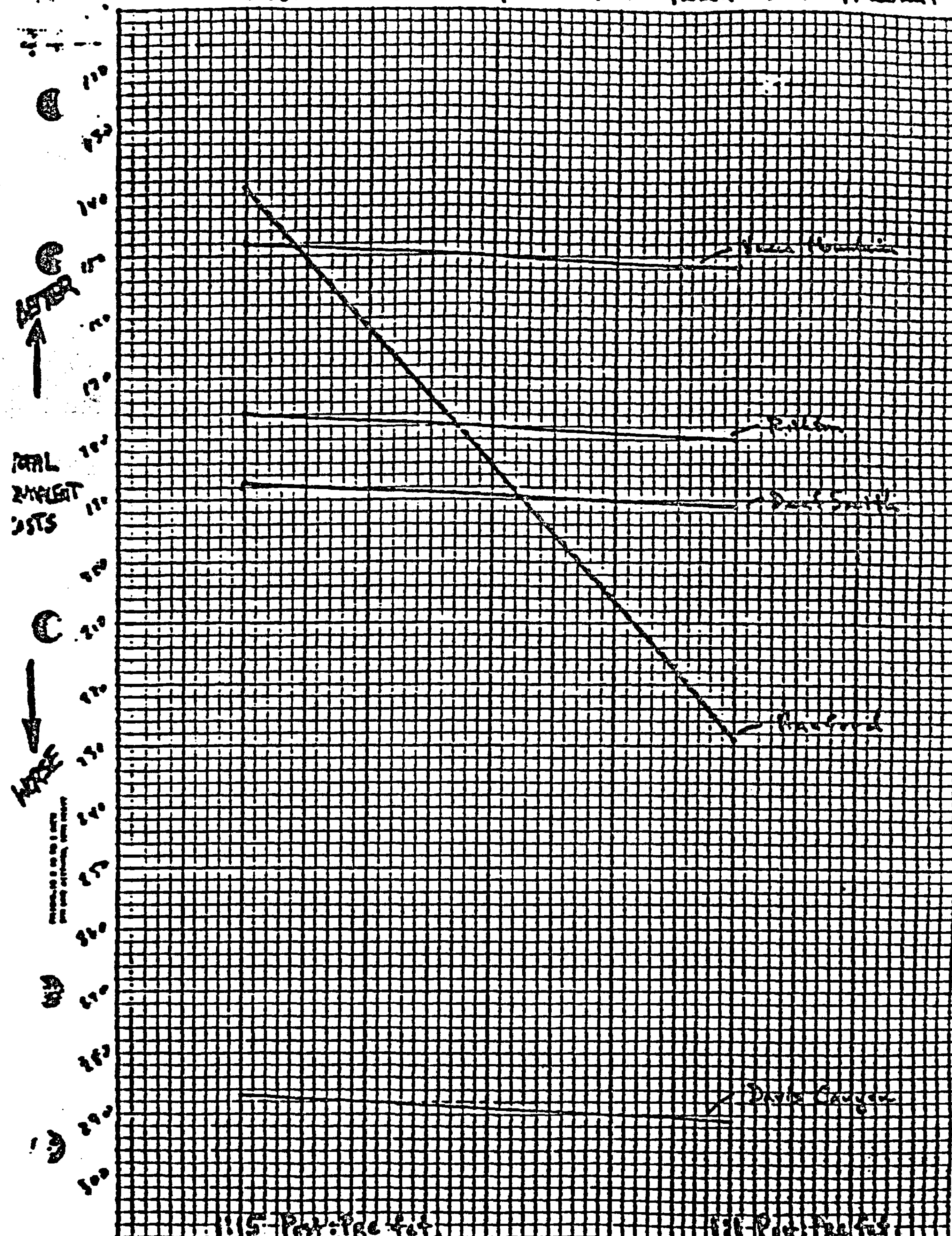
- ✓ Numerous sensitivity analyses consistent with these implications were performed:
  - ✓ low transportation scenario
  - ✓ greater weight on socioeconomic impacts
  - ✓ complete range of health/cost value tradeo
  - ✓ changes in fundamental attitudes toward both health & safety and economic risks
  - ✓ changes in aggregation structure

Overall Results - Expected Postclosure + Expected Preclosure



Increasing Weight to Postclosure

Overall Results w/o Costs Taken Into Account



Conclusions (Talking Points)

- Current results consistent with those presented back in August 1985 ("feasibility study").

- Simple draft EA methods probably produced erroneous results, as suggested by several commenters on draft EA methods.

- Nothing less than a several billion dollar error in facility cost can make Hanford "show".

- Richton and Deaf Smith appear to be clear choices of salt sites.

- Yucca Mountain currently replaces Davis Canyon and Deaf Smith in top three in sensitivity analyses. More recent cost estimates (this year's fee report) will place it in top three, for sure.

- Even without new cost estimates, Yucca Mountain clear choice between 2 Federal sites.

Why has formal methodology made such a difference?

- Formal methodology aggregates technical assessments consistent with logic of systems analysis, while draft EA analysis did not. As a result, rankings in 3 of 4 guideline groups change significantly.

- Methodology accounts for true interactions among and influences of siting guidelines. This avoids over- or under-counting, e.g., transportation.

- Draft EA used "means" to describe differences in postclosure performance. This led to large differences. Refined analysis show much smaller differences among sites in postclosure period compared to draft EA.

- Weights derived consistent with logic and procedures suggested in professional literature, not from some ill-defined generic importance of a guideline category. As a result,draft EA analysis over-counted small radiological safety differences and under-counted huge costs differences.

- Methodology accounted for things not directly addressed by simple draft EA methods, e.g., worker radiological safety.

The methodology described herein can be used as a heuristic device for involving the larger Chapter 7 working group. We are developing a detailed plan for involving this group and will be transmitting this to you soon for review.

If you have any questions please let me know.

Tom

Tom Longo

Attachment

DOCUMENT C

* MX siting strategy

BRIEFING

5A·104

FOR B. RUSCHE

ON RANKING METHODOLOGY

* Lunch w/ Parker & Rusche to discuss expecta

Sept. 9-10

* NAS not validate judgments, just logi

* pick a bogus case!

* illustrations for U(x) instead of validate

* ~ Sept. 13 briefing for env. people & lawyers

August 26, 1985

* copy of letter to Gardner, States, Commission

• brief transmittal memo

* record keeping on meeting today?

NO hand-out materials. Invite NAS for review?

* strategy for using methodology in Chap. 7?

* involvement more than observation

* copies of methodology to States

* treating states special w/r. to methodology

NOT involvement, but information

* mtg. w/ States

BACKGROUND

- Draft EA presented three simple ways of aggregating performance against individual technical guidelines.

- NAS panel and state-consulting groups severely criticized methods. Two ordinal-based methods dismissed outright, while one method (utility-estimation method) acknowledged to hold promise if done according to procedures suggested by professional literature.

- To address concerns small group set about to assess feasibility of applying formal utility-estimation method using draft EA information.

great comment for NAS

emphasis on testing of methodology, and not results. Did not have all the right expertise to develop best technic inputs

- Part I of feasibility study included in package

- In parallel w/ conduct of feasibility study, decision was made to have methodology followed by same NAS panel that [illegible] us before

PROCESS FOR APPLYING FORMAL UTILITY ESTIMATION METHOD

1. Identify siting objectives with reference to intent of Guidelines.

   - Can be above, equal to, or below guideline level.

2. Establish performance measures, X, for each siting objective (scale of 0 to 10). e.g., dollars, env. impacts, deaths

   - Verify independence among objectives.

3. Define utility curves for performance measures [$U = f(X)$].

   - Utility curve relates a given performance score to the value of achieving that score for each objective. 1→2 v. 9→10 di[illegible] [illegible]

4. Establish weights, k, for utility functions.

   - Involves value trade-offs of one performance measure against another.

   - Verify consistency with guideline constraints.

5. Perform numerical calculations.

   - Score sites against performance measures.

   - Compute utility values for each performance measure for each site.

   - Apply weights to utility values and sum results to obtain overall score for each site.

   - * Calculate sensitivity of overall scores to alternative value trade-offs.

KEY DIFFERENCES BETWEEN FORMAL METHOD
AND DRAFT EA METHODS

- Redefined objectives to avoid interdependencies and under- and over-counting.
- Used utility curves to account for nonlinear value of scores.
- Formal techniques used to derive weights (value trade-offs) consistent with guideline requirements.
- Many more steps and judgments involved, all of which are made explicit. Did not have all right people

RESULTS OF VERY PRELIMINARY ANALYSIS

- Technical inputs developed very quickly, without benefit of expert review.

- Results for postclosure analysis show sites about equal and meet objectives exceptionally well.

- Results for preclosure analysis show Hanford scores significantly below other sites. Deviation from DEA results seems traceable primarily to undercounting of transportation factors and facility costs.

- Because of requirements of primary significance of postclosure guidelines, sensitivity and uncertainty analyses are likely to show sites are virtually indistinguishable, considering on balance all of siting guidelines. Distinct suite of top three sites may not be apparent.

- Other considerations, such as diversity of rock type, risk of failure, licensability, etc., need to be evaluated. These aspects could be evaluated through formal methodology or qualitatively.

concerns

NEXT STEPS

- influence of nat. trans network needs examinatio
- 2nd repository impacts, incl local costs
- value tradeoffs need revie
- explore uncertainties to s if discrim. real or swam

Not authorized, so don't consider

PRO'S AND CON'S OF FORMAL DECISION METHOD

- As with any methodology, should be used only as an aid to decision making; it should not make the decision.

PRO'S

- Responsive to severe criticisms.
- State-of-the-art.

Informal discussions w/ N panel member most familiar methodologies

- Logical interactions among guidelines accounted for in comprehensive fashion.
- Logic and results traceable and explicit.
- Appears consistent with approach of 2nd repository program.

CON'S

- Less understandable to general public.
- Some technical inputs more difficult because of assignment of scores above guideline level; however, some inputs easier.
- Presents some new concepts and greater detail.
- Consistency with siting guidelines may not be readily apparent and may be contested.

NEXT STEPS

- Review report describing preliminary application of formal methodology. Report to NAS panel
- Present methodology to NAS panel.
- With help from larger pool of expertise, 1) check and refine methodology, and 2) develop technical input.

DOCUMENT D

Bill/Tom

I have attached an outline of the overview and a first draft of Sections I and II for your review. I have limited the level of detail in order to produce a 15 to 20 page overview.

Although the draft needs work, I'd like to know whether the approach, tone, and level of detail are what you had in mind.

I plan on coming downtown Thursday morning and can discuss the material with you then. I will continue with a first draft of Sections III and IV. I think postclosure is nearly as much; and, I think this first draft of the preclosure writeup shows quite a lot of flexibility with respect to both the number of non-salt sites and the order of the salt sites.

David

I. INTRODUCTION

A. SITE RECOMMENDATION PROCESS

1. Initial order of preference using decision-aiding methodology

2. Final order of preference using diversity guidelines (geohydrologic settings and rock types)

B. SITE RECOMMENDATION OBJECTIVE

1. Best set of 3 sites (not best 3 sites) - portfolio decision

2. Must include at least 1 non-salt site

3. Primacy of geologic considerations

II. DECISION-AIDING METHODOLOGY

A. DESCRIPTION

1. Multi-attribute, allowing disaggregation of problem into its component parts for evaluation, then re-aggregation

2. Utility-estimation, allowing explicit technical and value judgments or tradeoffs

B. POSTCLOSURE EVALUATION

1. All sites several orders of magnitude better than EPA limit for base case best-estimate, little distinction between sites

2. Importance of scenarios, uncertainty, sensitivity

C. PRECLOSURE EVALUATION

1. Individual groupings corresponding to guidelines

2. Cost driver

3. Use of differences in characterization costs for recommendation

III. DIVERSITY

A. GEOHYDROLOGIC SETTINGS

1. Differences in ground water flow systems: differences in accessible environment

   a. water quantity

   b. water quality

   c. water use

      (1) type

      (2) amount

      (3) alternative sources

   d. land use

B. ROCK TYPES

1. Avoid common failure
2. Different waste package
3. Different repository designs
4. Differences in retrievability
5. Licensing issues
6. Portfolio decision

IV. FINAL RANKING

OVERVIEW

INTRODUCTION

Section 112(b) of the Nuclear Waste Policy Act (the Act) requires that subsequent to the nomination of at least five sites as suitable for site characterization, the Secretary shall recommend to the President three of the nominated sites for characterization as candidate sites. The process used by the Department of Energy (DOE) to recommend sites for characterization is described in Section 960.3-2-3 of the DOE's siting guidelines (10 CFR Part 960). In summary, this process involves the following sequence of two distinct steps:

1. Determination of an initial order of preference of sites for characterization, based on (a) the available geophysical, geologic, geochemical, and hydrologic data; (b) other information; and (c) the associated evaluations and findings in the environmental assessments for the nominated sites.

2. Determination of a final order of preference of sites for characterization, based on a re-evaluation of the initial order of preference in light of the siting guidelines on the diversity of geohydrologic settings and the diversity of rock types.

The objective of this process is to ensure that "the sites recommended as candidate sites for characterization shall offer, on balance, the most advantageous combination of characteristics and conditions for successful development of repositories at such sites." The DOE, therefore, is faced with a portfolio decision, i.e., to recommend for characterization the best set of three sites. This is substantially different than a decision to recommend the three "best" sites. As part of this portfolio decision, the NRC has indicated in the statement of considerations accompanying 10 CFR Part 60 that the DOE should characterize three sites, at least one of which is a non-salt site.

Inherent to the recommendation decision, the DOE is required to ensure that geologic considerations are the primary factor in evaluating sites for geologic repositories. For example, the Act states that the siting guidelines "shall specify detailed geologic considerations that shall be primary criteria for the selection of sites in various geologic media." The siting guidelines, in turn, specify that site evaluations "shall place primary significance on the postclosure guidelines and secondary significance on the preclosure guidelines, with each set of guidelines considered collectively for such purposes." Further, the Nuclear Regulatory Commission (NRC) has mandated in 10 CFR Part 60 that, although they require a multiple-barrier approach to waste isolation (with no one barrier relied upon totally to provide the necessary isolation), they will require that the site (natural barriers) be the primary means of waste isolation.

DECISION-AIDING METHODOLOGY

The DOE has developed and applied a formal decision-aiding methodology as an aid in deciding which sites are preferred for recommendation for characterization. The methodology, which is based on the multi-attribute utility theory, allows disaggregation of a complex siting problem into its component parts for evaluation, and re-aggregation in a logical and appropriate manner to determine an order of preference for the sites. As such, the decision-aiding methodology was well suited to the first step of the decision process wherein the separate guidelines, and their associated favorable and potentially adverse conditions, are considered separately and then collectively. In addition, the methodology is explicit in identifying the pros and cons of each site and the factors (e.g., technical data, professional judgments, value judgments, policy decisions, and models) that are most crucial to the relative desirability of the sites. The methodology also is readily amenable to sensitivity analyses to incorporate other viewpoints and to quantify uncertainty, and, the implications of these different viewpoints can be easily identified and examined. From these, the DOE can draw insights into the basis for the site-recommendation decision.

Like all formal methods, however, the multi-attribute decision-aiding methodology is capable of providing only a partial and approximate accounting of the many factors important to the first step of the site-recommendation decision. Also, the decision-aiding methodology does not encompass the second step of the decision process, i.e., the application of the diversity guidelines to determine a final order of preference. In addition, the decision-aiding methodology is not constructed to make the portfolio decision with which the DOE is faced. Accordingly, the application of the methodology can provide DOE with insights into the basis for the site-recommendation decision but cannot make that decision.

The six basic steps of the decision-aiding methodology, as applied to the evaluation of sites, are the following:

1. Establish the objectives of repository siting and develop preclosure and postclosure performance measures for quantifying levels of performance with respect to these objectives.

2. For the postclosure analysis, specify a set of scenarios that, should they occur, might affect the performance of the repository system as represented by the postclosure-performance measures.

3. For each scenario, estimate postclosure performance with respect to each postclosure-performance measure. Estimate preclosure performance and impacts with respect to each preclosure-performance measure.

4. Assess relative values for different impact levels for each objective (i.e., assess a utility function over each performance measure) and assess value tradeoffs to integrate the achievement of different objectives into an overall utility function.

5. Using the overall utility function, aggregate impacts to obtain a composite score indicating the relative desirability of each site.

6. Perform sensitivity analyses to determine which models, data, technical judgments, and value judgments seem most significant for drawing insights from the analysis.

POSTCLOSURE EVALUATION

The DOE identified two postclosure objectives related to the extent to which the geologic repository would isolate the waste and prevent adverse impacts on the health and safety of the public after repository closure. These objectives are:

1. Minimize the adverse health effects attributable to the repository during the first 10,000 years after repository closure.

2. Minimize the adverse health effects attributable to the repository during the period 10,000 to 100,000 years after repository closure.

For both objectives, the limits on cumulative releases of radionuclides to the accessible environment (as defined by the Environmental Protection Agency (EPA) in 40 CFR Part 191) were used as a surrogate performance measure for adverse health effects. In addition, DOE developed sets of site characteristics for which various multiples of the cumulative releases were judged to be reasonable. In this manner, the DOE was able to use the results of both the preliminary performance assessments contained in the environmental assessments, to the extent practicable, and the technical evaluations of site characteristics contained in the environmental assessments in assessing the performance of a site against constructed performance measure scales for each postclosure objective. Scenarios affecting postclosure performance were identified and high, median, and low estimates of their respective probabilities were made. High, best-estimate, and low scores were then assigned for each scenario against the appropriate performance measure scale in order to quantify repository performance.

As indicated in the assessed utility of cumulative releases during the first 10,000 years following repository closure (Figure 3.5), the DOE has made a policy judgment that a site with releases that are 10,000 times lower than the EPA limit (score of 10 for the performance measure in Figure 3.3 and utility of 99.99 in Table 3-5) has little practical advantage over a site with releases that are 100 times higher (score of 6 for the performance measure in Figure 3.3 and utility of 99.00 in Table 3-5). Likewise, for the assessed utility of cumulative releases during the period of 10,000 to 100,000 years following repository closure (Figure 3.6), the DOE has made a similar policy judgment. In both cases, the policy judgment is reasonable because the releases would be so small as to be insignificant in comparison with background radiation and, as indicated in Table 3-5, further increases in score above 6 correspond to very small reductions in the magnitude of releases. Indeed, a score of 4 has an associated utility of approximately 90 percent for both the first 10,000 years and the period of 10,000 to 100,000 years.

For both time periods, the best-estimate scores assigned for all sites for all scenarios were 6 or greater (Table 3-4). Combining the best-estimate score for the base case with the median probability for that scenario results in a computed base-case expected postclosure utility ranging between 99.76 and 99.99 (Table 3-6) - clearly indicating there is little practical advantage of one site over another site with respect to postclosure releases. This does not mean that the sites are equal; to the contrary, there is an order of magnitude difference in equivalent releases between the sites. However, this difference in equivalent releases is not considered to be significant since the site with the highest equivalent releases, the Hanford site, is nearly three orders of magnitude lower than the EPA release limits. In addition, the improvement between the sites with the highest and lowest equivalent releases corresponds to a very small change, i.e., from two one-thousandths of the EPA release limit to one ten-thousandth of the EPA release limit.

When looking at both the base case and the other postclosure scenarios, the range of utility for each site was broadened, especially for the non-salt sites (Figures 3.10, 3.11, and 3.12). The results of sensitivity analyses strongly suggest that sites with lower expected postclosure utilities also tend to have greater uncertainties in postclosure performance. This range of uncertainty indicates little opportunity for the sites to improve, based on the results of site characterization studies, beyond the best-estimate values. However, there is considerable opportunity, especially for the non-salt sites, to retrogress, based on the results of site characterization studies, below the best-estimate values.

Prior to site characterization, the DOE believes the best-estimate values are the appropriate measure of postclosure performance. Accordingly, although the DOE has identified a clear distinction between the sites and a wide range of uncertainty for certain sites, the differences are not considered to be significant with respect to the best estimate of postclosure performance.

PRECLOSURE EVALUATION

The DOE identified four preclosure objectives, minimizing adverse impacts on health and safety before closure, minimize adverse environmental impacts, minimize adverse socioeconomic impacts, and minimize economic costs. The DOE further developed eight performance measures related to health and safety of the public and workers, three performance measures related to environmental impacts, one performance measure related to socioeconomic impacts, and two performance measures related to economic costs.

Base-case or best estimate scores were assigned for each site against each performance measure. In addition, a range of scores was established by estimating high and low scores. Through the use of multi-attribute utility functions for each performance measure, the separate preclosure utilities were aggregated to determine base-case impacts and to perform sensitivity analyses across the range of estimated impacts. In this manner, the aggregate impacts for each of the four preclosure objectives can be determined, and, the aggregate impacts for the total preclosure analysis can be identified.

As indicated in Table 4-11, the base-case consequence-equivalent impacts for the eight performance measures related to health and safety, both radiological and non-radiological, of the public and workers can be aggregated to show that the Richton Dome site results in the least impacts, followed by the Deaf Smith County site, the Davis Canyon site, the Yucca Mountain site, and the Hanford site. Likewise, the base-case consequence-equivalent impacts for the four environmental and socioeconomic performance measures can be aggregated to show that the Hanford site results in the least impacts, followed by the Yucca Mountain site, the Deaf Smith County site, the Richton Dome site, and the Davis Canyon site. Also, the base-case consequence-equivalent impacts for the two performance measures related to repository and transportation costs can be aggregated to show that the Yucca Mountain site results in the least impacts, followed by the Richton Dome site, the Deaf Smith County site, the Davis Canyon site, and the Hanford site.

Each of these three groupings can then be aggregated to determine the combined base-case consequences-equivalent impacts for all fourteen of the preclosure performance measures. The Yucca Mountain site results in the least impacts, followed by the Richton Dome site, the Deaf Smith County site, the Davis Canyon site, and the Hanford site.

However, looking at other combinations of preclosure performance measures can produce substantially different orders of site preference. For example, if the base-case consequence-equivalent impacts of all preclosure performance measures, except repository and transportation costs, are aggregated, the Hanford site results in the least impacts, followed by the Yucca Mountain site, the Deaf Smith County site, the Richton Dome site, and the Davis Canyon site. Indeed, the combined base-case consequence-equivalent impacts for all fourteen of the preclosure performance measures are strongly driven by the estimated total repository costs - a factor that was given the least importance of all guideline subgroups in the siting guidelines.

DOCUMENT H

Principal Shortcoming

New write-up blantantly manipulates the methodology and its application to force it to spit out the "proper" sites. It throws out certain factors, arbitrarily reduces or increases the value of others, picks certain trade offs as better than others and portrays the methodology as decision-maker.

Initial write-up tells it like it is. It describes the methodology as decision-aiding, evaluates both results and insights from the application of the methodology, and describes the rationale for the site selection. It recognizes the importance of guideline requirements and other considerations a policy-maker must legitimately consider in reaching a final decision.

Serious Shortcomings

- Provides no technical justification for the decision
- Arbitarily throws out cost as a consideration in violation of Act and Guidelines
- Winds up saying socioeconomics is the basis for the decision
- States that post-closure should not be weighed too heavily in direct violation of Act, Guidelines, NAS recommendation and common sense
- Arbitarily decides a post-closure weighting between .50 and .57 is correct. Reduces Richton v. Hanford to this one factor
- Incorrectly implies little difference in health and safety impacts among sites
- Portrays the methodology as decision-maker - a very dangerous approach
- Portrays rock diversity as requiring 3 types. If that were the case, no need for this methodology - simply pick one salt site

Leaves Out

- Understanding of proper role of the methodology as decision-aiding and its place in overall departmental process of selection

- Understanding of implications of making a portfolio decision
- Proper understanding of role of geologic considerations
- Description of value and content of the methodology
- Consideration of accessible environment differences, strongly recommended by NAS
- A most important conclusion that all sites are expected to perform exceedingly well in post-closure, allowing us the flexibility to pick sites that score "lower" for other reasons
- Any discussion of insights gained from sensitivity analyses
- The array of results the methology produces from looking at the various combinations of factors that provide justification for our decision
- Discussion that this is a preliminary decision of which sites to characterize-so cost commitments are not for total program, only for characterization
- Discussion of value of and need for considerations of rock diversity

optimistic, or pessimistic assumptions are adopted unless a very high weight is assigned to postclosure, in which case the salt sites have composite utilities that are nearly equal. Yucca Mountain is the site that is affected most significantly by the choice of pessimistic, base-case, or optimistic assumptions. Under pessimistic assumptions for postclosure performance, Yucca Mountain receives a lower postclosure expected utility due to the possibility of relatively poor performance of the site under a disruptive scenario involving a magmatic event. If pessimistic assumptions are adopted for postclosure, then Yucca Mountain is ranked first only if the scaling factor k_{post} is less than about 0.2; it is ranked in the top three only if k_{post} is less than about 0.35. Under base-case or optimistic assumptions for postclosure, Yucca Mountain is ranked first across nearly the entire ranges of k_{pre} and k_{post}.

Because of the sensitivity of the ranking of Yucca Mountain among the sites to the relative weights of k_{pre} and k_{post}, it is of interest to consider the reasonableness of different weights. As in the case with the scaling factors used in Chapters 3 and 4, the scaling factors k_{pre} and k_{post} must be based on a value judgment; specifically in this case on a value tradeoff between performance in postclosure and performance in preclosure. To judge whether particular weights for k_{pre} and k_{post} are reasonable it is necessary to review that value tradeoff. Because the ultimate concern of postclosure radiological safety is to minimize public cancer fatalities to future generations, this is probably easiest to interpret when preclosure public radiological safety is traded off against postclosure public radiational safety. However, this cannot be done as directly as it may appear.

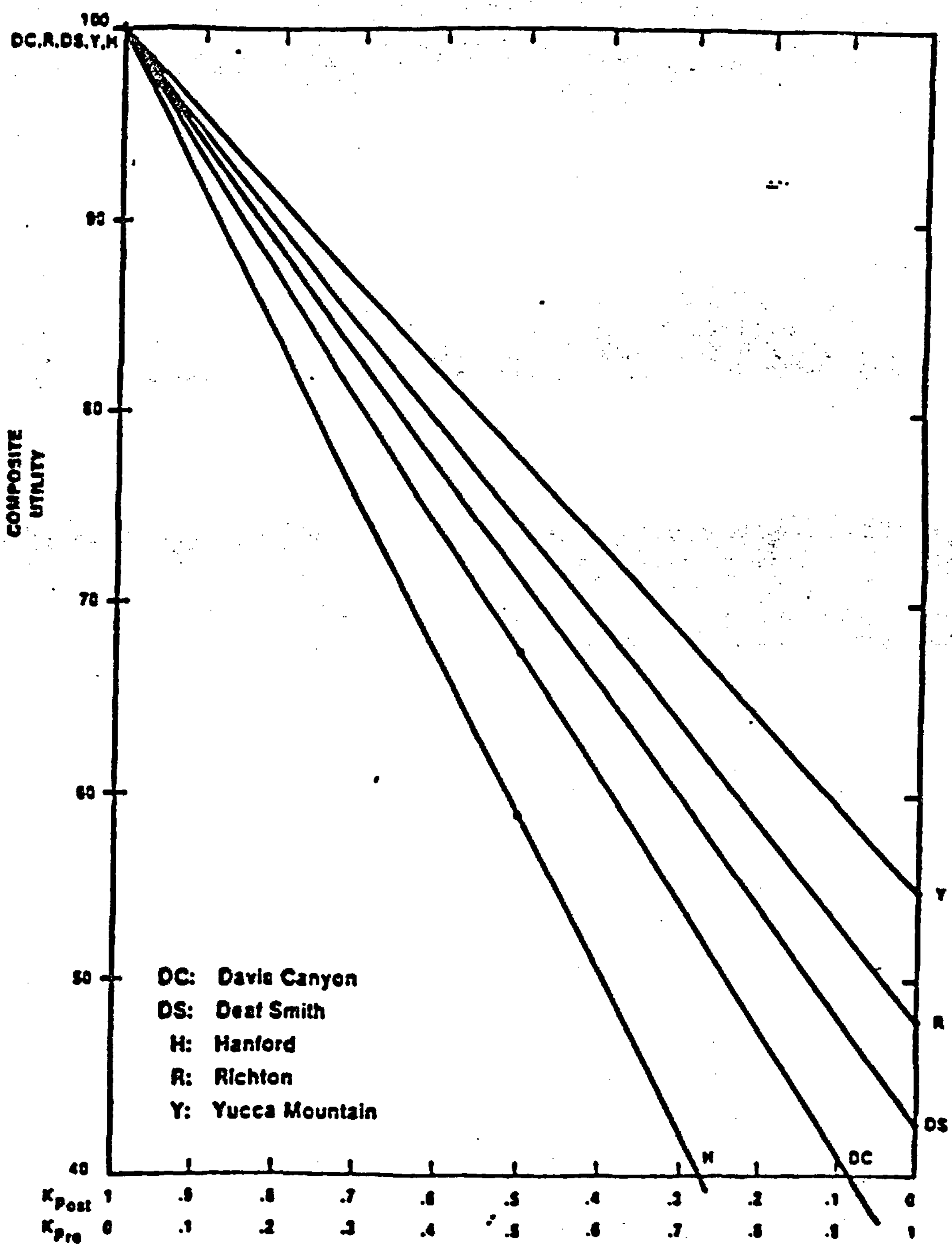


Figure 5.6. Site composite utilities calculated using optimistic assumptions for postclosure and pessimistic assumptions for preclosure.

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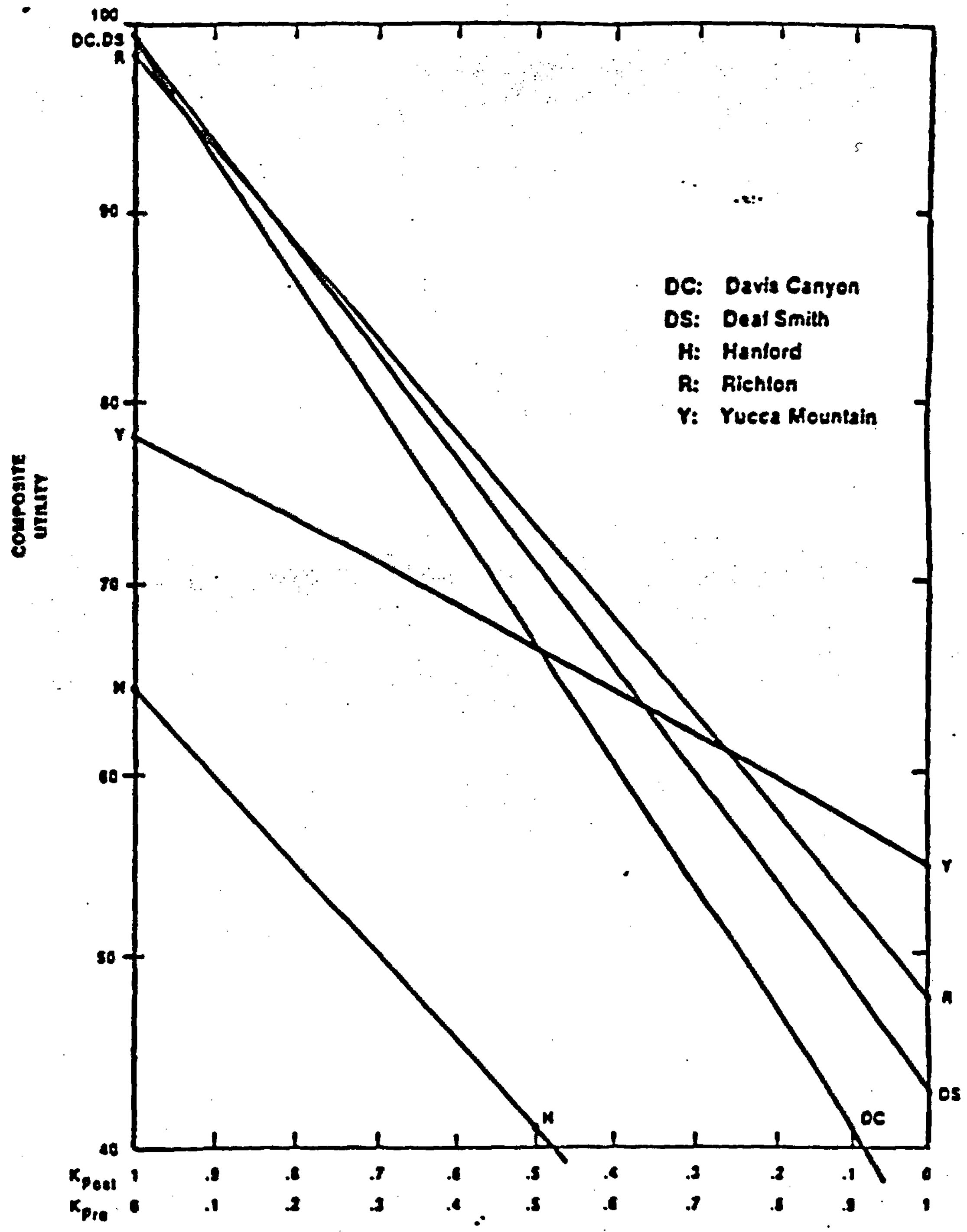

Figure 5.4. Site composite utilities calculated using pessimistic assumptions for postclosure and preclosure.

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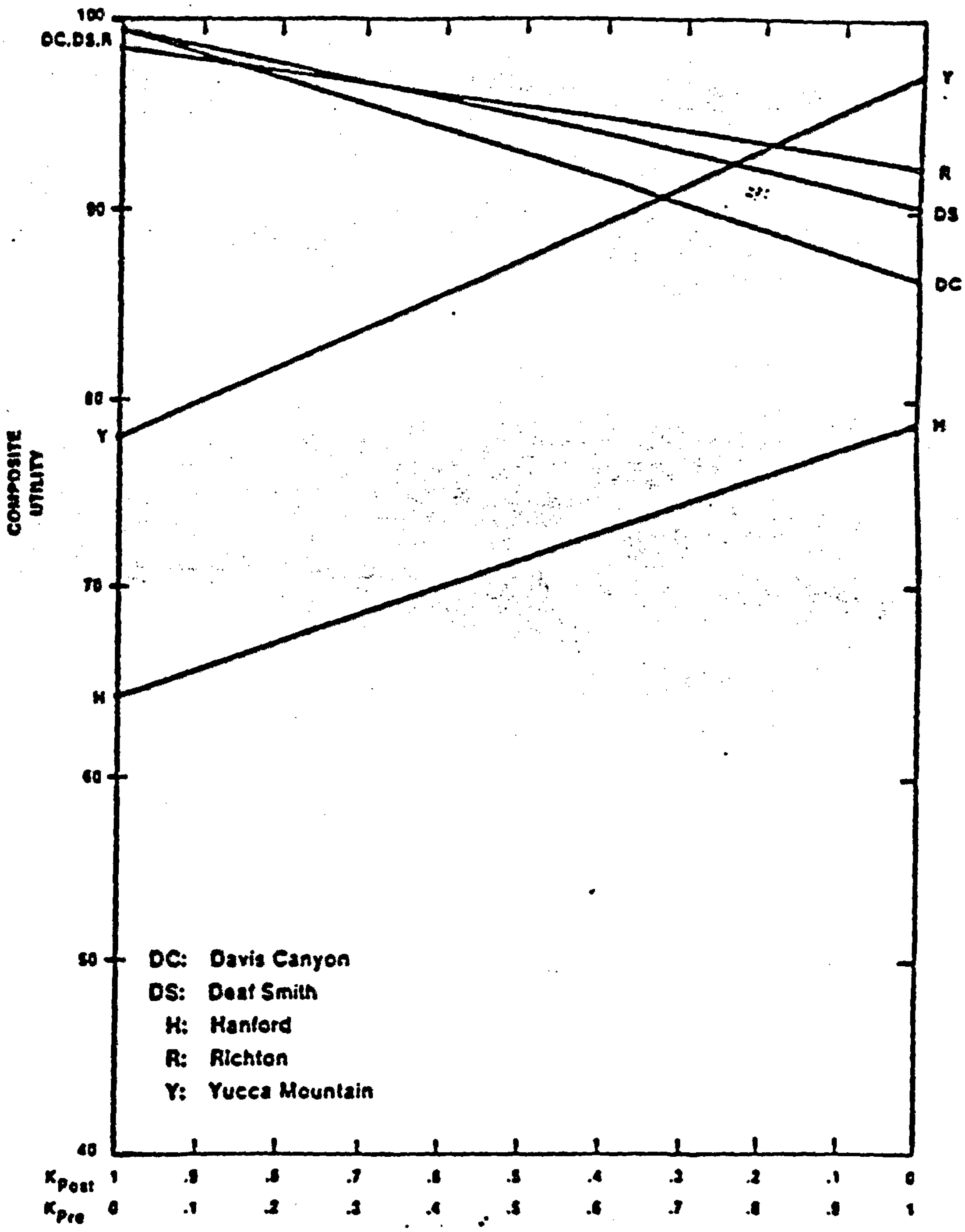

Figure 5.5. Site composite utilities calculated using pessimistic assumptions for postclosure and optimistic assumptions for preclosure.

6213-6035SC 3/31/86

Preclosure public radiological safety is measured in terms of cancer fatalities and postclosure public radiological safety is measured in terms of cumulative releases of radionuclides. Hence, the value tradeoff must specify a given number of preclosure cancer fatalities that is equally undesirable as a given postclosure release y. Table 5.1 shows the relationships of the weights k_{pre} and k_{post} and several different value tradeoffs for the case where preclosure cancer fatalities are set at 20. These were calculated using the following steps:

1. The change in preclosure utility due to an additional 20 public radiological fatalities is calculated using Equation 4-1 (1/200)(4)(20) = 0.4.

2. The change in postclosure utility due to an additional release of y is calculated using Equation 3-3 to be (0.526)(100)(y) = 52.6y.

3. The change in composite utility due to both the preclosure and postclosure changes above must be equal if and only if the increase of 20 public radiological fatalities is indifferent to the increase of y releases. Equating these changes in composite utility using Equation 5-1 yields

$$k_{pre}(0.4) = k_{post}(52.6y)$$

which implies

$$y = 0.0076 \frac{k_{pre}}{k_{post}} . \qquad (5\text{-}2)$$

Table 5-1. Relationship Between Preclosure and Postclosure Value Tradeoffs and Various k_{pre} and k_{post}

k_{pre}	k_{post} (= $1-k_{pre}$)	Postclosure releases y as undesirable as 20 preclosure public cancer fatalities (fraction of standard)	Postclosure cancer fatalities resulting from y releases*	Implied value tradeoff between postclosure and preclosure cancer fatalities
1.0	0.0	-	-	-
0.99	0.01	0.75	527	1:26
0.9	0.1	0.07	50	1:2.4
0.8	0.2	0.03	21	1:1.1
0.79	0.21	0.03	20	1:1
0.7	0.3	0.02	12	1.6:1
0.6	0.4	0.01	8.0	2.5:1
0.5	0.5	0.008	5.3	3.8:1
0.4	0.6	0.005	3.6	5.6:1
0.3	0.7	0.003	2.3	8.8:1
0.26	0.74	0.0027	2.0	10:1
0.2	0.8	0.002	1.3	15:1
0.1	0.9	0.0009	0.6	34:1
0.01	0.99	0.00008	0.05	372:1
0.0	1.0	-	-	-

*Assuming that for each 1,000 MTHM, releases at the level allowed by the standard would result in 10 health effects

The third column in Table 5-1 shows the amount of y which is indifferent to 2 preclosure public fatalities for various weights of k_{pre} and k_{post}.

The reasonableness of the various value tradeoffs may be interpreted more easily if a relationship is assumed between postclosure releases to the accessible environment and postclosure health effects. As noted in Chapter 3, 40 CFR 190 adopted the assumption that for each 1,000 metric tons of heavy metal (MTHM), cumulative releases at the level allowed by the EPA standard would result in 10 premature cancer deaths. Because a repository at any of the nominated sites is assumed to be designed to hold 70,000 MTHM, releases at the level allowed by the standard would produce approximately 700 cancer fatalities. The fourth column in Table 5-1 shows the numbers of postclosure cancer fatalities, based on the EPA assumption, that would be produced by the various postclosure releases. Because these are equivalently undesirable as 20 preclosure public radiological cancer fatalities, it is now easy to compute the implied value tradeoffs between preclosure and postclosure public cancer fatalities shown in the fifth column of Table 5-1. Because the relationship above used to provide an estimate of postclosure radiological fatalities likely overestimates these fatalities, the implied value tradeoff likely is a lower-bound on the actual relative significance given to postclosure fatalities.

It seems unreasonable to be willing to save 1 postclosure cancer fatality at the expense of more than ten preclosure cancer fatalities. Thus, the weight on k_{post} from Table 5-1 must be less than 0.74. For all $k_{post} \leq$ 0.74, the composite utilities imply an overall site ranking of Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford for all cases where postclosure impacts are assumed to be base-case or optimistic regardless of the preclosure assumptions about estimates. If pessimistic assumptions are used for postclosure performance, Yucca Mountain falls out as the preferred overall site when the implied value tradeoff between postclosure and preclosure radiological fatalities is approximately one-to-one (i.e., $k_{post} = 0.21$). It drops from among the top three sites when this implied value tradeoff is approximately 2 preclosure fatalities is equivalent to 1 postclosure fatality (i.e., $k_{post} = 0.35$).

5.2 INITIAL ORDER OF PREFERENCE FOR SITES FOR RECOMMENDATION FOR CHARACTERIZATION

The overall rankings presented in the previous sections suggest that the initial order of preference for sites for recommendation for characterization is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford. This ranking is stable for all but the most extreme assumptions on postclosure performance and the most extreme weightings of postclosure considerations versus preclosure considerations, as explained below.

For all assumptions and weightings, the Hanford site remains ranked last. For all assumptions about postclosure conditions and wide range assumed to be realistic for weights (i.e. $k_{post} \leq 0.8$), the relative ranking of the salt sites is stable; namely Richton Dome is preferred to Deaf Smith which is preferred to Davis Canyon. For pessimistic postclosure assumptions, Yucca Mountain drops from first ranked to fourth ranked as the postclosure weight increases from approximately 0.2 to 0.35 depending on the preclosure assumptions.

The clear implication from the composite analysis is that ~~the~~ Yucca Mountain, Richton Dome, and Deaf Smith ~~set~~ of sites ~~is~~ are the preferred set for characterization. There are no realistic assumptions about either preclosure or postclosure expected performance or about the values used to evaluate performance that can result in Hanford being anything but the last ranked site. And the significance of the performance differences between Hanford an all the other sites is substantial. Similarly, the Davis Canyon site is less preferred than Richton Dome and Deaf Smith for essentially all realistic assumptions. The differences in performance of Davis Canyon and these two other sites is also substantial, even though Davis Canyon is much preferred t Hanford in the analysis. Only for some extreme cases (i.e. pessimistic postclosure assumptions) could one argue directly from the analysis that the three sites to be characterized should be Richton Dome, Deaf Smith, and Davis Canyon. However, the Nuclear Regulatory Commission requires that at least ~~ere~~ one of the sites characterized not have salt ~~or~~ as the host rock. Thus, it can be definitively stated that the results of the ~~canyon site~~ composite analysis strongly suggest characterization of the Yucca Mountain, Richton Dome, and Deaf Smith sites.

The combination of the Yucca Mountain, Richton Dome, and Deaf Smith sites offers maximum diversity in geohydrologic settings. The Yucca Mountain site is unique among these sites because a repository would be constructed in the unsaturated zone. The advantages of disposing waste in thick unsaturated zones have been noted in the literature for over a decade. A major advantage is the very slow flux of water that probably exists at Yucca Mountain. Another is that the underground facility can be designed so as to allow only minimal contact of the water that does enter openings with the wastes package. Still another is that underlying tuffs contain sorptive zeolites an clays that could act as additional barriers to the downward transport of radionuclides from a repository to the water table.

The geohydrologic settings associated with the Richton Dome and Deaf Smith sites are also clearly distinguishable from another, but not as obviously as from Yucca Mountain. Richton Dome is similar in many respects to Deaf Smith because both have salt as a host rock, but Richton is a piercement structure of fairly uniform properties surrounded by sedimentary materials. The dome is surrounded by aquifers at different depths. The bedded-salt setting at Deaf Smith is underlain by relatively horizontal bedded sedimentary rocks capped by the Ogallala Formation. The geohydrologic system is dominated by the High Plains aquifer. Minor aquifers of poor water quality occur in deeper strata, nearer to the salt units.

The advantages of salt as a host rock for disposal have been documented elsewhere many times, and so are not repeated here. Chapter 1 (Section 1.2.2.) lists some of its expected advantages.

The Yucca Mountain, Richton Dome, and Deaf Smith sites do not offer maximum diversity in rock type. They do, however, meet the requirement for diversity of the Nuclear Regulatory Commission. As was explained in Section 2.1, the site-recommendation decision is analogous to a portfolio problem since the DOE must choose, not a single site for repository development, but three from five well-qualified sites for site characterization and related nongeologic data gathering. Combinations of three sites ~~process~~ possess properties that cannot be attributable to single sites (~~i.e.~~ e.g. diversity of geohydrologic settings and rock types). Thus, the set of three sites indicated as most preferable by the multiattribute utility analysis may not be the preferred set when these portfolio effects are taken into account together with the implications of this analysis. These considerations are examined in the site-recommendation letter report accompanying this report.

~~However~~.
For the sites recommended for characterization to change from those suggested in the composite analysis, the relative advantages of the portfolio effects for the changed set would have to ~~possess~~ be judged as greater than the relative advantages of the expected superior performances ~~of the set of sites~~ of the Yucca Mountain, Richton Dome, and Deaf Smith sites over Davis Canyon and Hanford. These differences in performance range from ~~[illegible] from~~ the equivalent of 1 to 5 billion do[illegible] ~~plus~~ in addition to postclosure impacts.

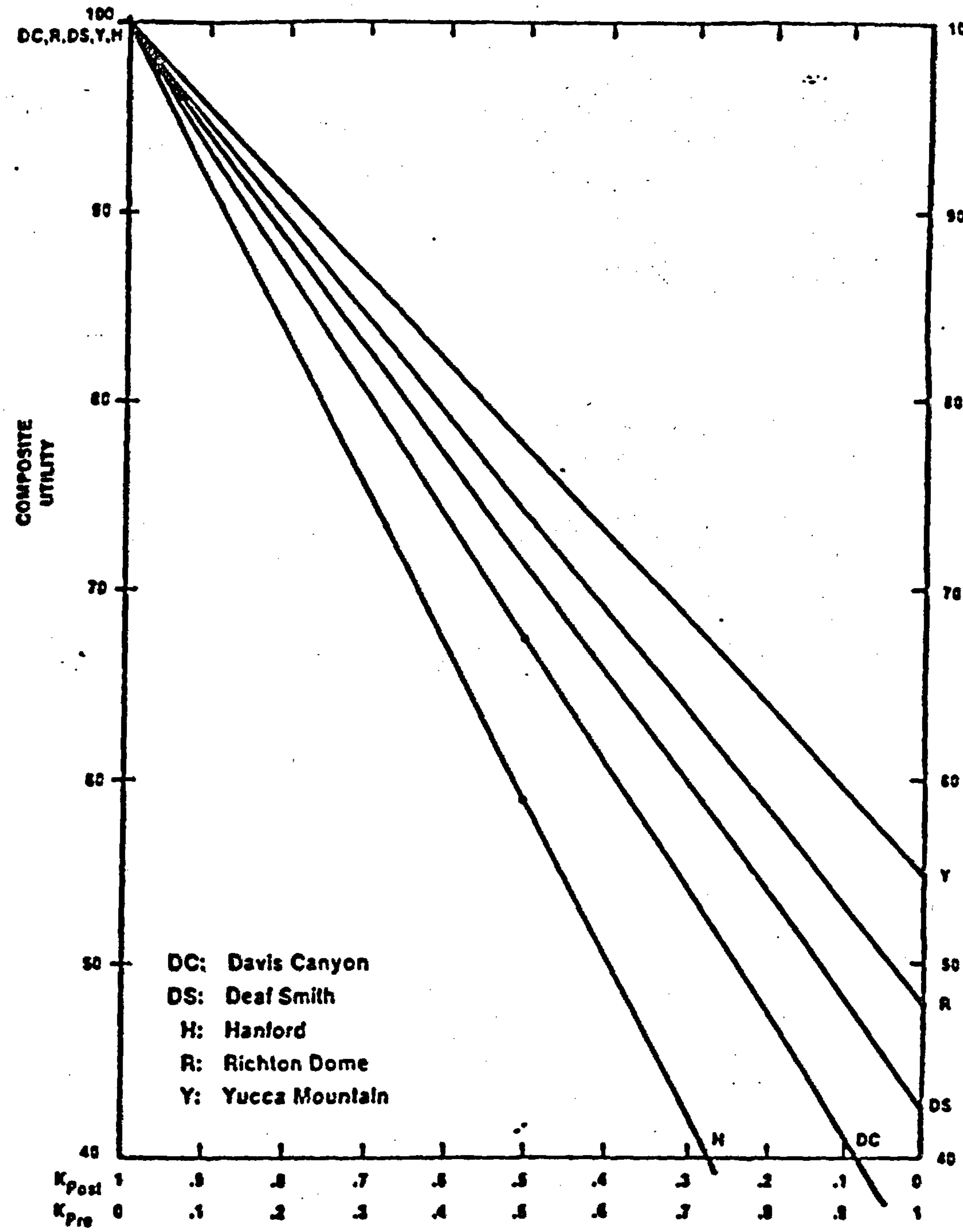

Figure 5.6. Site composite utilities calculated using optimistic assumptions for postclosure and pessimistic assumptions for preclosure.

0213-00395C 3/31/88

May 18, 1986

Tom, Bill, Henry, Bob:

My overall reactions after spending several hours with the two rev were:

1) The GC piece was too narrow in focus but had an appeal to brevity and sharpness, i.e., needed to be enhanced.

2) Our 24 pager was too "chatty" - just seemed much too conversational but it made many essential points and added substative basis.

I tried to tighten up our piece and then showed on the GC copy how would attempt to merge or reshape the pair. I'm sure the resultir product would need much smoothing - e.g. transitions, etc. I have a feeling the resulting product could still be tightened up more and should be, if practical. I think our arguments on final preference are more persuasive, i.e. - The .57 postclosure argument s contrived. Please take these thoughts as a suggestion only, add t to your own - no more - no less. Out of this will come an even be basis for this most important decision. I know you can do it!!!

Ben

Recommendation Thought Process

1. Utility Method - Decision Aiding find all 5 s.t. to exceed post-closure Criteria. Not much basis for selection ~~[illegible]~~.

2. Initial order of preference is determined by pre-closure measures and more specifically by cost of repository at times when all elements are aggregated. Guidelines say post-closure performance should be most important. Among pre-closure factors cost should be of lowest importance. Therefore initial order of preference from all aggregation is not adequate. Must look at weights i.e. disaggregated factors, e.g. geology diversity (geologically diversity assured when all are different) and "other" factors

3. ~~Initial~~ order could be inverted by aggregating all but cost factors - or discounted cost
   - consistent with guidelines
   - ~~For~~ Recognize NAS observation

   But this approach alone has appearance of arbitrariness
   Need to look further for weighting and results..

4. Starting with three "rock diversity" further (types) supports selection of Y and H

5. Look to disaggregated[illegible] for ~~confirmation~~ [illegible] ~~[illegible]~~

- Yucca ~~always~~ in top three except
- Deaf Smith always in top three
- Richton and H vary from 1 to 5
- O minus top three in ~~[illegible]~~ some case

6. Therefore choice of the set is Y, DS, H as the final order of preference

the above ~~overall~~ ranking

As noted above, ~~the~~ this overall ranking of sites is largely a reflection of differences in costs. This dependence on costs was recognized by the Board on Radioactive Waste Management of the National Academy of Sciences in its comments on the application of the methodology (see attachment to Appendix E, letter dated April 10, 1986, p. 4): "On the basis of the Board's review of the application to a single site, it appears that the expected total repository and transportation costs will have a major, if not controlling, effect on the rankings under pre-closure factors." In view of the requirements of the siting guidelines that costs be among the factors given the least importance among preclosure considerations, ~~this result~~ must be carefully considered. As shown in Figure 5-7, when repository and transportation costs are not discriminating and the postclosure weight ~~is less than~~ about .57, the three top-ranked sites are Yucca Mountain, Deaf Smith, and Hanford. ~~Again with reference to Figure 5-7, if a weight higher than [illegible] is assigned to~~ When higher weight is given to postclosure performance, the three top-ranked sites are Yucca Mountain, Deaf Smith, and Richton. The need to consider carefully the results obtained with the methodology was also recognized by the Board in the above-cited letter: "This recognition of the heavy dependence on cost reinforces the Board's judgment that the principal usefulness of the multi-attribute utility method is to illuminate the factors involved in a decision, rather than to make the decision itself."

Furthermore, as explained in Section 2.1, the site-recommendation decision is analogous to a portfolio-selection problem because the DOE is not choosing a single site for repository development; rather, the DOE must choose, from a suite of five well-qualified sites, three sites for characterization. Combinations of three sites possess properties that cannot be attributed to individual sites, such as diversity of geohydrologic settings and rock types.

* weight on costs turning GC interpretation

* NAS. will not stand behind interpr

DOCUMENT L 5

RECOMMENDATION BY THE SECRETARY OF ENERGY

OF CANDIDATE SITES FOR SITE CHARACTERIZATION

FOR THE FIRST RADIOACTIVE-WASTE REPOSITORY

SUMMARY

Pursuant to the requirements of the Nuclear Waste Policy Act of 1982 (the Act) and the Department of Energy's (DOE) siting guidelines, the five sites nominated as suitable for site characterization in the environmental assessments have been evaluated in order to recommend three candidate sites for characterization which offer, on balance, the most advantageous combination of characteristics and conditions for the successful development of repositories at such sites. The DOE has developed and applied ~~a formal~~ This decision-aiding methodology to aid in determining an initial order of preference for the nominated sites and to provide insight, from the application of the methodology, on which factors have the most influence on the initial order of preference. In addition, the DOE has considered the provisions in the siting guidelines for diversity of geohydrologic setting and diversity of rock type and other relevant information which bears on the site-recommendation decision in arriving at a final order of preference.

A

Based on these considerations, the Secretary has determined that the best set of three sites for recommendation as candidate sites for characterization consists of sites at Yucca Mountain, Nevada; Deaf Smith County, Texas; and Hanford, Washington. In addition, pursuant to the requirements of Section 114(f) of the Act, the Secretary has made a preliminary determination that all three sites are suitable for development as geologic repositories consistent with the siting guidelines.

A

~~I. [illegible]~~ METHODOLOGY AND APPROACH

Section 112(b) of the Act requires that, following issuance of the siting guidelines and consultation with the Governors of the affected States, the Secretary shall nominate at least five sites that he determines are suitable for site characterization for selection of the first repository site. Further, the Act requires in Section 112(b)(1)(E) that each nomination of a site shall be accompanied by an environmental assessment. Accordingly, the Secretary has nominated the Davis Canyon site, the Deaf Smith County site, the Hanford site, the Richton Dome site, and the Yucca Mountain site as suitable for site characterization and has caused to be published final environmental assessments, consistent with the requirements of the Act, for each nominated site.

Subsequent to the nomination, the Act requires that the Secretary shall recommend in writing to the President three of the nominated sites for characterization as candidate sites. The process used by the DOE to recommend sites for characterization is set forth in Section 960.3-2-3 of the DOE's siting guidelines (10 CFR Part 960). That section states that the recommendation decision shall be based on the available geophysical, geologic, geochemical, and hydrologic data; other information; and associated evaluations and findings reported in the environmental assessments accompanying the site nominations. On the basis of this evidence, the sites nominated as suitable for characterization shall be considered as to their order of preference as candidate sites for characterization. Subsequently, siting provisions specifying diversity of geohydrologic settings and diversity of rock types shall be considered in determining a final order of preference for the characterization of such sites.

The objective of this process is to ensure that "the sites recommended as candidate sites for characterization shall offer, on balance, the most advantageous combination of characteristics and conditions for successful development of repositories at such sites." The DOE, therefore, is charged with making a portfolio decision, i.e., a decision to recommend for characterization the set of three sites which best meets this objective. As part of this portfolio decision, the Nuclear Regulatory Commission (NRC) has previously indicated in the statement of considerations for 10 CFR Part 60 that the DOE should characterize three sites, at least one of which is a non-salt site.

In the recommendation decision, the DOE is required to utilize geologic considerations as the primary factor in evaluating sites for geologic repositories. The Act states that the siting guidelines "shall specify detailed geologic considerations that shall be primary criteria for the selection of sites in various geologic media." The siting guidelines, in turn, specify that site evaluations "shall place primary significance on the postclosure guidelines and secondary significance on the preclosure guidelines, with each set of guidelines considered collectively for such purposes." The siting guidelines also state that "comparative site evaluations shall place primary importance on the natural barriers of the site." Further, the NRC has mandated in 10 CFR Part 60 that, although a multiple-barrier approach is to be applied to waste isolation (with no one barrier relied upon totally to provide the necessary isolation), the natural barriers are to be the primary means of waste isolation.

PURPOSE

The purposes of this report are to identify the three sites the Secretary recommends to the President as candidate sites for characterization for the nation's first geologic repository, to document the basis for that decision, and to record the preliminary determination, pursuant to Section 114(f) of the Act, on the suitability of the recommended sites for development as geologic repositories. The report briefly describes the decision-aiding methodology used by the DOE in determining an initial order of preference for the five nominated sites, the results of the application of the decision-aiding methodology (including insights germane to the site-recommendation decision from application of the methodology), the diversity provisions prescribed in the Act, and the results of the application of the diversity provisions and other considerations to determine a final order of preference for the sites recommended for characterization.

DECISION-AIDING METHODOLOGY

The DOE has developed and applied a formal, multiattribute, utility-estimation, decision-aiding methodology to aid in determining preferred sites for recommendation for characterization (DOE/RW-0074, Multiattribute Utility Analysis of Sites Nominated for Characterization for the First Radioactive-Waste Repository--A Decision-Aiding Methodology). The methodology allows disaggregation of a complex siting problem into its component parts for evaluation, and then re-aggregation in a logical and appropriate manner to determine an initial order of preference for the sites. As such, the decision-aiding methodology is well-suited to the first step of the decision process wherein the separate postclosure and preclosure objectives are considered individually and then collectively. The methodology is constructed to elucidate the uncertainties inherent at this stage of the siting process, and the methodology is explicit in identifying the pros and cons of each site and the factors (e.g., technical data, professional judgments, value judgments, policy decisions, and models) that critically affect the relative desirability of the sites. The methodology is well-suited to sensitivity analyses which allow for a range of viewpoints and evaluate alternative combinations of the factors that describe discrete aspects of site performance. The implications of these sensitivity analyses can be easily identified, examined, and factored into the basis for the site-recommendation decision.

Like most formal methods, however, the decision-aiding methodology is capable of providing only a partial and approximate accounting of the many factors important to the site-recommendation decision. Furthermore, the decision-aiding methodology does not apply the diversity guidelines required to determine a final order of preference among the sites and is not structured for the portfolio decision. The application of the methodology does, however, provide valuable insights contributing to the site-recommendation decision.

The six basic steps of the decision-aiding methodology, as applied to the evaluation of sites, are the following:

1. Establish the objectives of repository siting and develop preclosure and postclosure performance measures for quantifying levels of performance with respect to these objectives.

2. For the postclosure analysis, specify a set of scenarios that, should they occur, might affect the performance of the repository system as represented by the postclosure performance measures.

3. Estimate postclosure performance for each scenario with respect to each postclosure performance measure. Estimate preclosure performance and impacts with respect to each preclosure performance measure.

4. Assess relative values for different impact levels for each objective (i.e., assess a utility function over each performance measure) and assess value tradeoffs to integrate the achievement of different objectives into an overall utility function.

5. Using the overall utility function, aggregate impacts to obtain a composite score indicating the relative desirability of each site.

6. Perform sensitivity analyses to determine which models, data, technical judgments, value judgments, and alternative combinations of factors seem most significant for drawing insights from the analysis.

POSTCLOSURE EVALUATION

The DOE identified two postclosure objectives related to the isolation of spent fuel and high-level waste from the accessible environment and prevention of adverse impacts to the health and safety of the public after repository closure. These objectives are:

1. Minimize the adverse health effects attributable to the repository during the first 10,000 years after repository closure.

2. Minimize the adverse health effects attributable to the repository during the period 10,000 to 100,000 years after repository closure.

For both objectives, the limits on cumulative releases of radionuclides to the accessible environment (as defined by the Environmental Protection Agency (EPA) in 40 CFR Part 191) were used as a surrogate performance measure for adverse health and safety impacts. Performance measure scales, based on various multiples of the EPA limits, were constructed. In addition, the DOE developed sets of site characteristics for which the various multiples of the

EPA limits on the performance measure scales were judged to be reasonable. Consistent with the EPA standard and NRC regulation, the DOE applied the EPA release limits at the edge of the accessible environment. The National Academy of Sciences Board on Radioactive Waste Management recommended that DOE evaluate the differences among the sites with respect to pathways from the accessible environment to the biosphere. The DOE reviewed the estimates of cumulative releases to the accessible environment and ground-water travel times in the environmental assessments and observed that radionuclides transported through the ground-water systems should not discharge to the ground surface or surface-water bodies during the next 10,000 to 100,000 years. Instead, likely pathways to the biosphere would consist of wells or borings drilled for water or mineral exploration. For both of these pathways, releases within the controlled area have been evaluated in the environmental assessments and, as appropriate, in the decision-aiding methodology.

Scenarios affecting postclosure performance were identified and high, base-case, and low estimates of their respective probabilities were made for each site. High, base-case, and low scores were assigned for each site for each scenario for both performance measure scales using the site characteristics, technical evaluations, and preliminary performance assessments contained in the environmental assessments. Combining the base-case probability and base-case score for any one scenario yields the best estimate of expected releases for that scenario. Combining the base-case probabilities and base-case scores for all scenarics yields the best estimate or expected value of releases for a site.

The two postclosure performance measure scales were constructed on logarithmic scales. On these scales, the differences between integer values for the scores become increasingly smaller as the integer values for the scores become higher, e.g., for the 0 to 10,000 year performance measure scale the difference in estimated releases between scores of 4 and 6 is from 0.1 to 0.01 of the EPA limit, whereas the difference in estimated releases between scores of 8 and 10 is from 0.001 to 0.0001 of the EPA limit.

In the application of the methodology, the DOE assessed the utility of cumulative releases during the first 10,000 years following repository closure and made a judgment that a site with releases that are 10,000 times lower than the EPA limit (score of 10 on the performance measure scale and utility of 99.99) has little practical advantage over a site with releases that are 100 times higher (score of 6 on the performance measure scale and utility of 99.00). The DOE made a similar judgment for the utility of cumulative releases during the period of 10,000 to 100,000 years following repository closure. In both cases, the judgment is reasonable because the releases would be so small as to be insignificant in comparison with both the EPA standard and natural background radiation and because further increases in score above 6 correspond to very small reductions in the magnitude of releases, as shown above.

For both time periods, the base-case scores assigned for all sites for all scenarios were 6 or greater. The very low cumulative releases (and high scores) are consistent with numerous studies, expert opinion, and peer review reported in the literature over the past decade. Combining the base-case scores with the base-case probabilities for all scenarios results in expected postclosure utilities for the sites ranging between 99.76 and 99.99 - clearly indicating that all five sites are expected to perform exceedingly well and that there is little practical advantage of one site over another site with respect to postclosure performance. This does not mean that the sites are equal; to the contrary, the scores indicate there may be as much as an order of magnitude difference between the sites in releases to the accessible environment over 10,000 years. However, this difference in releases is not considered to be significant since the site with the highest releases, the Hanford site, is estimated to be nearly three orders of magnitude lower than the EPA limits. In addition, the improvement between the sites with the highest and lowest releases corresponds to a very small change, i.e., from two one-thousandths (0.002) of the EPA limit to one ten-thousandth (0.0001) of the EPA limit. The results of the preliminary performance assessments in the environmental assessments tend to confirm both the low estimated releases and the slight differences in estimated releases among the sites.

The results of sensitivity analyses combining the high and low scores and the high and low probabilities for each postclosure scenario define the range of utility and uncertainty for each site. The sensitivity analyses indicate that the non-salt sites have both slightly lower expected postclosure utilities and greater uncertainties in postclosure performance. The sensitivity analyses show both the uncertainty in scores due to the limited data available prior to site characterization and the uncertainty in probabilities of the various scenarios that may affect repository performance. The sensitivity analyses also show that, because the best-estimate utilities are so high, there is little chance the sites will achieve utilities above the best-estimate values after site characterization. However, the range of utilities indicates that, especially for the non-salt sites, there is some chance the sites will achieve utilities below the best-estimate values after site characterization.

PRECLOSURE EVALUATION

The DOE identified four preclosure objectives: minimizing adverse impacts on health and safety before closure, minimizing adverse environmental impacts, minimizing adverse socioeconomic impacts, and minimizing economic costs. For these objectives, the DOE developed eight performance measures related to health and safety of the public and workers, three performance measures related to environmental impacts, one performance measure related to socioeconomic impacts, and two performance measures related to economic costs.

Base-case scores were assigned for each site for each performance measure. In addition, a range of scores was established by estimating high and low scores. Through the use of multiattribute utility functions for each performance measure, the individual preclosure utilities were aggregated to determine a best estimate of impacts and to perform sensitivity analyses across the range of estimated impacts. In this manner, the impacts for each of the four preclosure objectives were determined, and, the aggregate impacts for the total preclosure analysis were derived. As in the case of the postclosure evaluation, the application of the methodology has provided DOE with valuable insights related to the site-recommendation decision.

For the eight performance measures related to radiological and non-radiological health and safety of the public and workers, the aggregation of impacts shows that, as a best estimate, the Richton Dome site causes the least impacts, followed by the Deaf Smith County site, the Davis Canyon site, the Yucca Mountain site, and the Hanford site. For the three environmental and one socioeconomic performance measures, the aggregation of impacts shows that, as a best estimate, the Hanford site causes the least impacts, followed by the Yucca Mountain site, the Deaf Smith County site, the Richton Dome site, and the Davis Canyon site. For the two performance measures related to repository and transportation costs, the aggregation of impacts shows that, as a best estimate, the Yucca Mountain site causes the least impacts, followed by the Richton Dome site, the Deaf Smith County site, the Davis Canyon site, and the Hanford site. If these three groupings are then aggregated to determine the best estimate of combined, base-case impacts for all fourteen of the preclosure performance measures, the Yucca Mountain site causes the least impacts, followed by the Richton Dome site, the Deaf Smith County site, the Davis Canyon site, and the Hanford site.

Various ~~Looking at other combinations of~~ preclosure performance measures provide~~s~~ significant insight into the factors that most influence the relative desirability (i.e., order of preference) of the sites as determined using the decision-aiding methodology. Alternative combinations of preclosure performance measures yield different orders of preference not only between the non-salt and salt sites but also among the salt sites. For example, if the two preclosure performance measures on repository and transportation costs are not considered and the base-case impacts of the other twelve preclosure performance measures are aggregated, the Hanford site causes the least impacts, followed by the Yucca Mountain site, the Deaf Smith County site, the Richton Dome site, and the Davis Canyon site. This alternative combination demonstrates that the combined base-case impacts for all fourteen of the preclosure performance measures are most strongly influenced by the estimated repository and transportation costs — factors that are the least important of all guideline subgroups in the siting guidelines.

The combined base-case impacts for only those preclosure performance measures that estimate impacts on the public near the repository site show that, as a best estimate, the Hanford site causes the least impacts, followed by the Yucca Mountain site, the Deaf Smith County site, the Richton Dome site, and the Davis Canyon site. Introducing the impacts to the public associated with transportation of the wastes to the repository sites, however, results in an increase in impacts as the distance from the reactors increases and the order of site preference changes to the Richton Dome site, the Deaf Smith County site, the Davis Canyon site, the Yucca Mountain site, and the Hanford site. This alternative combination demonstrates the influence of the estimated health and safety impacts (primarily non-radiological) to the public and workers during transportation of the wastes to the repository sites. This influence, however, is of little significance in the aggregation of all fourteen preclosure performance measures because of the strong influence of repository and transportation costs.

~~Indeed,~~ The sensitivity analyses in the preclosure evaluation indicate that the estimated repository and transportation costs dominate site preferences determined by aggregating the fourteen preclosure performance measures over the range of high, base-case, and low scores. Although it is clear from the Act and the siting guidelines that costs are an important factor in site selection, it is equally clear that the postclosure performance of the sites and other technical factors should take precedence over costs. This is especially appropriate given the preliminary nature of the repository cost estimates available at this time. In a venture as important as the disposal of spent fuel and high-level wastes, a choice of the low-cost option ought to occur only after the geologic suitability of the sites has been more fully demonstrated following site characterization. The National Academy of Sciences Board on Radioactive Waste Management appears to confirm this viewpoint in their independent review of the decision-aiding methodology wherein they states: "This recognition of the heavy dependence on cost reinforces the Board's judgment that the principal usefulness of the multiattribute utility method is to illuminate the factors involved in a decision, rather than to make the decision itself."

COMPOSITE ANALYSIS AND INITIAL ORDER OF PREFERENCE

The results of the postclosure and preclosure analyses were aggregated to determine composite utilities for the sites. ~~As part of developing and applying the decision-aiding methodology, the DOE decided that the composite utilities would~~ to define the initial order of preference for the sites. ~~Therefore, using the base-case estimates for the postclosure and preclosure performance measures, t~~The initial order of preference, from most-preferred to least-preferred, is the Yucca Mountain site, the Richton Dome site, the Deaf

Smith County site, the Davis Canyon site, and the Hanford site. Sensitivity analyses show that this initial order of preference is unchanged for a wide range of weights or scaling factors relating postclosure and preclosure impacts.

The sensitivity analyses do show, however, that the differences among the sites in composite utility change as the relative weights assigned to postclosure and preclosure impacts change, with very small differences in composite utility when nearly all of the relative weight is assigned to postclosure impacts and larger differences in composite utility as the relative weight assigned to preclosure impacts increases.

These results clearly indicate that because the differences among the sites in postclosure utility are so small as to be insignificant, the differences among the sites in preclosure utility largely determine the initial order of preference. ~~As discussed previously,~~ these preclosure differences are dominated by the large influence of repository and transportation costs. ~~These~~ costs, given the least importance of all guideline subgroups in the siting guidelines, are very preliminary at this time, would ~~likely~~ not be realized until after site characterization and would be realized at only the one site selected from among the three characterized sites for development as the nation's first geologic repository. Indeed, the site-recommendation decision for characterization does not commit the DOE to spend these dollars for repository and transportation costs at any of the three sites. Rather, the site-recommendation decision for characterization only commits dollars for site characterization activities and other studies performed in parallel at the three sites. When considering only costs during the site characterization period, the differences between the sites are small and the costs can be considered reasonably comparable for any three sites.

The repository costs estimates are highest for the Hanford site. These estimated costs are sharply reduced for all sites, especially the Hanford site, if the cost estimates are based on the time value of money, rather than constant 1985 dollars, for activities that will occur decades later, e.g., backfilling, decommissioning and closure. Likewise, the cost differences between the Hanford site and the salt sites would be offset by the estimated differences in the cost of retrieval, in the unlikely event that retrieval would be necessary. Accordingly, the higher costs at the Hanford site are not so firm as to be the dominant factor in the site-recommendation decision. In addition, the selection of a site with higher costs for development as the first geologic repository would be entertained only if the postclosure performance of the sites and other technical factors evaluated during site characterization show the higher costs to be warranted.

DIVERSITY PROVISIONS

The siting guidelines specify that diversity of geohydrologic settings and diversity of rock types shall be considered in determining a final order of preference for the characterization of candidate sites. The five sites nominated by the Secretary as suitable for site characterization provide the maximum diversity in geohydrologic settings because each site is in a distinct geohydrologic setting. Any combination of three recommended sites will, therefore, provide the maximum diversity in geohydrologic settings. ~~However, the five nominated sites include only three types of host rock (basalt, salt, and tuff).~~

The DOE interprets the provision on diversity of rock types to provide both insurance against ~~any~~ common-mode deficiencies or failure related ~~indigenous~~ to a particular rock type and an opportunity to evaluate the siting, design, licensing, construction, and operation of a geologic repository for diverse rock types. The provision on diversity of rock types offers an opportunity for the DOE to consider, during the site selection process, the advantages of alternatives in such areas as repository design, waste package design, and options for retrievability. as well as ~~In addition, DOE can consider the advantages of~~ alternative performance allocations and performance assessment capabilities for sites in different rock types. ~~Further, the DOE can consider the relative advantages diverse rock types provide for assuring the highest likelihood of a licensable site emerging from site characterization and ultimately being developed as a licensed geologic repository.~~

~~The provision favoring diversity of rock types strongly influences the portfolio decision to recommend the best set of three sites.~~ The Act specifies that the siting guidelines shall require the Secretary to "consider the various geologic media in which sites for repositories may be located and, to the extent practicable, to recommend sites in different geologic media." The siting guidelines state that "to the extent practicable...sites recommended as candidate sites for characterization shall have different types of host rock." ~~These requirements~~, taken together with the guideline to cons~~ider diversity of rock~~ types in determining a ~~final order of preference~~ for ~~characterization~~ of sites, make the intent of the Act and the siting guidelines clear. ~~That is to say, t~~The diversity of rock type is sufficiently important to alter the initial order of preference, determined using the information presented in the environmental assessments and the application of the decision-aiding methodology, if the differences between sites are small and the sites recommended are within an acceptable range. Indeed, these requirements are ~~can be~~ interpreted to favor the recommendation of sites in three different rock types unless there are compelling reasons to do otherwise.

~~For example, the Secretary would not apply the provision~~ favoring ~~diversity of rock types if the recommended sites were not found to be suitable~~ for site characterization, ~~i.e., if the findings stipulated in Appendix III~~ of the siting guidelines have ~~not been reached~~. The analyses and findings in the environmental assessments demonstrate that the recommended sites have been found suitable for site characterization; and, the results of the preliminary performance assessments in the environmental assessments and the postclosure evaluation in the decision-aiding methodology indicate both very small cumulative releases to the accessible environment and a high degree of confidence that all of the sites will meet the EPA standard. Indeed, these findings ~~indications~~ warrant the preliminary determination by the Secretary that each of the three recommended sites is suitable for development as a geologic repository.

FINAL ORDER OF PREFERENCE

As mandated by the siting guidelines, the DOE has evaluated the available geophysical, geologic, geochemical and hydrologic data; other information; and associated evaluations and findings reported in the environmental assessments. In addition, the DOE has developed and applied a formal decision-aiding methodology to determine an initial order of site preference and provide insights contributing to the site-recommendation decision. Subsequently, the DOE has considered the siting provisions specifying diversity of geohydrologic settings and diversity of rock types to determine a final order of preference of three candidate sites for characterization from among the five nominated sites in the environmental assessments.

In reaching the site-recommendation decision, the Secretary has placed emphasis, commensurate with the provisions of the Act and the siting guidelines, on the diversity of rock types. The Secretary believes that it is important at this time to maintain the insurance provided by the diversity of rock types against common modes of failure in a particular rock type. In addition, the Secretary believes that it is important to preserve, through the period of site characterization, the opportunity to evaluate different types of host rock for the advantages of alternative waste package designs and development programs, repository designs, performance assessment capabilities, performance allocations among the various repository subsystems (e.g., the site, the engineered barrier system, and the waste package), and options for retrievability. This flexibility can also enhance the probability of having at least one licensable site following site characterization.

The Secretary also has placed emphasis on the requirements in the Act, the siting guidelines, and the NRC regulation (10 CFR Part 60) that the long-term performance of the natural barriers (i.e., the site) should have primary importance. The Secretary finds that all sites are expected to have releases orders of magnitude lower than the EPA standard and that there is little difference among the sites on this most significant aspect of the site evaluations. The Secretary recognizes that the discrimination among the sites indicated by the preclosure evaluation, therefore, becomes all the more determinative in establishing the initial order of preference — a situation which is not consistent with the intent of the Act, the siting guidelines, and 10 CFR Part 60.

In coming to a final order of preference, the decision-aiding methodology has provided significant insights which contribute to the site-recommendation decision. These insights include both the relative desirability (order of preference) of the sites and identification of the factors that most influence the order of preference. In the postclosure evaluation, it is significant that all sites are expected to perform exceptionally well in isolating the high-level wastes and spent fuel from the accessible environment. Although there are measurable differences between the sites, these differences are small and not significant with respect to the ability to meet the EPA standard. Thus, the postclosure evaluation is most important, not as a discriminator, but as evidence that all sites are quite attractive with regard to postclosure performance.

There is also much insight to be derived from an analysis of the preclosure results. Once again, all sites are expected to perform well. However, in the preclosure evaluation there are more performance objectives, which provide a greater variety of performance measures and a greater complexity in aggregating them into a composite score. Accordingly, it is appropriate to look at various combinations of performance measures to develop insight into those factors that cause discrimination among the sites. Several insights are readily apparent. In the composite aggregation of all the preclosure performance measures, repository and transportation costs dominate the results, even though the siting guidelines place costs among the least important category of consideration, behind health and safety, environment, socioeconomics, and transportation. Aggregating all preclosure performance measures other than repository and transportation costs markedly alters the rank ordering of the sites. Other alternative combinations of preclosure performance measures (e.g., aggregating only health and safety impacts at the repository site instead of health and safety impacts both in transporting the wastes and at the repository site) can also markedly alter the order of site preference.

Taking this information into account, the Yucca Mountain site scores well and is attractive as a candidate site. It is expected to perform very well in postclosure and scores best in preclosure when all performance measures are aggregated. In almost every alternative combination of preclosure performance measures considered, the Yucca Mountain site scores at or near the top. It is also the only tuff site and therefore preserves the option to characterize the maximum number of rock types.

The Hanford site also scores well in postclosure. Though it is highest in expected releases to the environment, the estimated releases over 10,000 years represent only two-tenths of one percent (0.002) of the EPA standard. Its relative standing among the sites in preclosure depends markedly on the alternative combinations of performance measures considered. While it is ranked last when all of the preclosure objectives are aggregated, it is clear that this ranking is driven by the significantly higher expected costs. In fact, if all preclosure objectives except repository and transportation costs are aggregated, Hanford becomes the most desirable site, a telling factor given the low relative importance assigned by the siting guidelines to costs. The Hanford site also scores first in minimizing impacts on the environment, minimizing impacts on socioeconomic conditions, and minimizing impacts on the health and safety of workers and the public at or near the site. While expected repository and transportation costs are significantly higher than for the other four sites, and the transportation impacts, primarily non-radiological, away from the site are higher than for the other four sites, the decision being made now is to choose a slate of three sites to characterize. The costs of characterization of all the sites, including Hanford, are quite comparable. Since Hanford is the only basalt site, it too preserves the option to maximize the number of rock types characterized.

This leaves consideration of the three salt sites. First, it is clear that all three sites are expected to perform exceptionally well in postclosure. In fact, the analyses show them performing exceedingly well, even in the event that highly unlikely disruptive events occur. However, the preclosure evaluation shows clearly that the Davis Canyon site is the least-preferred salt site for the overall aggregation of preclosure performance measures and any of the other combinations considered.

Evaluating the relative performance of the Deaf Smith County site and the Richton Dome site is more difficult. For example, aggregating all of the preclosure performance measures shows a slight preference for the Richton Dome site over the Deaf Smith County site. Aggregating the same performance measures except for repository and transportation costs, however, shows a slight preference for the Deaf Smith County site over the Richton Dome site. Likewise, aggregating the preclosure health and safety impacts both during transportation and at the repository shows a slight preference for the Richton Dome site over the Deaf Smith County site, but, aggregating only the impacts to the public and workers at or near the repository site shows a slight preference for the Deaf Smith County site over the Richton Dome site. In addition, aggregating the performance measures related to environment and socioeconomics shows a slight preference for the Deaf Smith County site over the Richton Dome site. In fact, the various combinations of preclosure performance measures considered in this analysis show that the Deaf Smith County site always ranks second or third in order of preference, whereas the Richton Dome site ranges from first to fourth in order of preference for the same combinations of preclosure performance measures.

Given this information, ~~the Secretary has determined that the portfolio~~ decision ~~(i.e., the decision to recommend for characterization the~~ set of three sites ~~which~~ best meets the ~~siting objective to offer, on balance,~~ the most advantageous combination of characteristics and conditions for successful development of repositories[1] is best met by recommending sites at Yucca Mountain, Nevada; Deaf Smith County, Texas; and Hanford, Washington for characterization as candidate sites. ~~The recommendation of these three~~ sites for characterization provides ~~the maximum~~ diversity of rock types and is, ~~therefore~~, consistent with the provisions of the Act and the siting guidelines.

In addition, ~~pursuant to the requirements of Section~~ 114(f) of the Act, the Secretary ~~has made a preliminary~~ determination that all three sites are suitable for development ~~as geologic repositories consistent~~ with the siting guidelines.

Chapter 5

COMPOSITE ANALYSIS

This chapter combines the results of the postclosure and preclosure multiattribute utility analyses to obtain an overall ranking of the sites and explores the sensitivity of that ranking to basic assumptions. Section 5.1 formally aggregates the quantitative results using the logic of multiattribute utility analysis. Section 5.2 presents the initial order of preference for sites for recommendation for characterization. The ~~initial order of preference~~ place ~~This~~ relies on qualitative logic to reinforce the insights obtained from the formal aggregation.

5.1 FORMAL AGGREGATION OF POSTCLOSURE AND PRECLOSURE RESULTS

The results of the postclosure and preclosure analyses may be formally aggregated using the logic of multiattribute utility analysis. Based on independence assumptions discussed in Appendix G, the composite utility, which quantifies the estimated overall desirability of a site, may be expressed as

$$U_{comp} = k_{pre}U_{pre} + k_{post}[E(U_{post})], \tag{5-1}$$

where U_{pre} is the preclosure utility of the site computed from Equation (4-1), $E(U_{post})$ is the expected postclosure utility of the site (sum of the postclosure utilities estimated assuming various postclosure scenarios weighted by the estimated probabilities of the scenarios) calculated from Equation (3-4), and k_{pre} and k_{post} are scaling factors that sum to 1.

To ~~The use Equation 5-1, U_{pre} and $E[U_{post}]$ for the sites is taken directly from results in Chapters 4 and 3 respectively~~. are Not The mix of To select specific scaling factors requires value tradeoffs to be made between preclosure and postclosure impacts. Before discussing this in detail, it is informative to conduct a sensitivity analysis over the entire ~~possible~~ ranges of ~~both~~ k_{pre} and k_{post} ~~is informative~~.

Figure 5-1 presents the composite utility for each site using base-case estimates for both preclosure and postclosure. Figure 5-2 expands that part of the ranges of k_{pre} and k_{post} in which a change of the ranking of sites according to composite utility occurs. The base-case utility for preclosure is taken from Table 4-11 and the base-case expected utility for postclosure is taken from Table 3-6. The full range of possible relative weighting is considered, since k_{pre} and k_{post} range from $k_{pre} = 0$ and $k_{post} = 1$ (all weight given to postclosure considerations) to $k_{pre} = 1$ and $k_{post} = 0$ (all weight given to preclosure considerations).

It is clear from the figures that the ranking of the sites remains the same for a wide range of weightings. Over most of the range ~~In~~ order of overall desirability~~, the site ranking~~ is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford. When an extremely high weight is assigned to postclosure impacts (i.e., $k_{post} \geq 0.998$), the ranking becomes Davis Canyon and Richton Dome (approximately tied for first), Yucca Mountain and Deaf Smith (approximately tied for third), and Hanford last.

No 9 ~~As indicated in Chapter 3, all the sites have extremely high expected postclosure utilities.~~ Because the differences among the expected postclosure utilities are very small, the differences among the composite utilities for the various sites are very small if essentially all of the weight is given to postclosure.

Figures 5-3 through 5-6 show composite utilities for the five sites when assumptions other than base-case~~, nominal~~ assumptions are used. Figure 5-3 shows the results when optimistic assumptions (high scores and low probabilities for disruptive and unexpected features scenarios) are used for postclosure and optimistic assumptions (low impact levels) are used for preclosure. Figure 5-4 shows the results when pessimistic assumptions are used (low scores and high probabilities for disruptive and unexpected features scenarios) are used for postclosure and pessimistic assumptions (high impact levels) are used for preclosure. Figures 5-5 and 5-6 show the mixed cases in which optimistic or pessimistic assumptions are adopted for the postclosure analysis and the reverse assumption is adopted for preclosure.

Although the weights of k_{pre} and k_{post} at which the ranking of the sites change~~s~~ depending on whether base-case, pessimistic, or optimistic assumptions are adopted, certain patterns are clear and stable under a wide range of assumptions. Most significantly, the Hanford site is in all cases ranked last (i.e., has the lowest composite utility), regardless of the relative weight assigned to preclosure and postclosure. This is so because it is ranked last for all sets of assumptions in both preclosure and postclosure ~~[illegible]~~. The relative ranking among the salt sites (Richton Dome, Deaf Smith, Davis Canyon) remains the same regardless of whether base-case, optimistic, or pessimistic assumptions are adopted unless a very high weight is assigned to postclosure, in which case the salt sites have composite utilities that are nearly equal. Yucca Mountain is the site that is affected most significantly by the choice of pessimistic, base-case, or optimistic assumptions. Under pessimistic assumptions for postclosure performance, Yucca Mountain receives a lower expected postclosure utility due to the possibility of relatively large releases from a repository at ~~relatively poor performance of~~ the site under a disruptive scenario involving a magmatic event. If pessimistic assumptions are adopted for postclosure, then Yucca Mountain is ranked first only if the scaling factor k_{post} is less than about 0.2; it is ranked in the top three only if k_{post} is less than about 0.35. Under base-case or optimistic assumptions for postclosure, Yucca Mountain is ranked first across nearly the entire range of k_{pre} and k_{post} possibilities.

Because of the sensitivity of the ranking of Yucca Mountain ~~among the sites~~ to the relative weights of k_{pre} and k_{post}, it is of interest to consider the reasonableness of different weights. As in the case of the scaling factors used in Chapters 3 and 4, the scaling factors k_{pre} and k_{post} must be based on a value judgment; ~~specifically~~ in this case ~~of~~ a value tradeoff between performance in postclosure and performance in preclosure. ~~To judge whether particular numerical values for k_{pre} and k_{post} are reasonable it is necessary to review that value tradeoff. Because the ultimate concern of postclosure radiological safety is to minimize public cancer fatalities to future generations, this is probably easiest to interpret when preclosure public radiological safety is traded off against postclosure public radiational safety. However, this is not as direct to do as it may appear.~~

Value Tradeoffs Radiological Health Effects

Table 5-1. ~~Relationship~~ Between Preclosure and Postclosure ~~Value~~ Releases ~~Tradeoffs and~~ Various k_{pre} and k_{post} Implied By

k_{pre}	k_{post} (= 1-k_{pre})	Postclosure releases y ~~as~~ valued as undesirable as ~~20~~ 10 preclosure public cancer fatalities (fraction of EPA standard)	C Postclosure cancer fatalities resulting from y releases*	C Implied Value tradeoff between postclosure and preclosure cancer fatalities
1.0	0.0	-	-	-
0.99	0.01	0.75 0.38	527	1:26
0.9	0.1	~~0.07~~ 0.02	50	1:2.4
0.8	0.2	~~0.03~~ [illegible]	21	1:1.1
~~0.79~~	~~0.21~~	0.03 -	20	1:1
0.7	0.3	~~0.02~~ 0.01	12	1.6:1
0.6	0.4	~~[illegible]~~ 0.006	8.0	2.5:1
0.5	0.5	~~0.008~~ 0.004	5.3	3.8:1
0.4	0.6	~~0.005~~ [illegible]	3.6	5.6:1
0.3	0.7	~~0.003~~ 0.002	2.3	8.8:1
~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	2.0	10:1
0.2	0.8	~~0.002~~ 0.001	1.3	15:1
0.1	0.9	~~0.0009~~ 0.0004	0.6	34:1
0.01	0.99	~~0.00008~~ 0.00004	0.05	372:1
0.0	1.0	-	-	-

*Assuming that for each 1,000 MTHM, releases at the level allowed by the standard would result in 10 health effects

C

~~The third column in Table 5-1 shows the amount of y which is indifferent to 20 preclosure public fatalities for various weights of k_{pre} and k_{post}.~~

The reasonableness of the various value tradeoffs presented in Table 5-1 may be interpreted more easily if a relationship is assumed between postclosure releases to the accessible environment and postclosure health effects. As noted in Chapter 3, 40 CFR 190 adopted the assumption that for each 1,000 metric tons of heavy metal (MTHM), cumulative releases at the level allowed by the EPA standard would result in 10 premature cancer deaths. Because a repository at any of the nominated sites is assumed to be designed to hold 70,000 MTHM, releases at the level allowed by the standard would produce approximately 700 cancer fatalities. ~~The fourth column in~~ Table 5-~~1~~2 shows the ~~numbers of~~ tradeoff between preclosure and postclosure cancer fatalities~~, based on the EPA assumption, that would be produced by the various postclosure releases. Because these are equivalently undesirable as 20 preclosure public radiological cancer fatalities, it is now easy to compute the implied value tradeoffs between preclosure and postclosure public cancer fatalities shown in the fifth column of Table 5-1~~ implied by the various k_{pre} and k_{post} if the releases shown Table 5-1 are converted to postclosure fatalities using the EPA assumption. Because the EPA relationship between postclosure releases and ~~above used to provide an estimate of postclosure~~ radiological fatalities likely overestimates these fatalities, the implied value tradeoff likely is a lower-bound on the actual relative significance given to postclosure fatalities. ~~It seems unreasonable to be willing to save 1 postclosure cancer fatality at the expense of more than ten preclosure cancer fatalities. Thus, the weight on k_{post} from Table 5-1 must be less than 0.74. For all k_{post} ≤ 0.74,~~ the composite utilities imply an overall site ranking of Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford for ~~all cases~~ k_{post} = 0.77 where postclosure impacts are assumed to be base-case or optimistic regardless of the preclosure ~~assumptions about~~ estimates. If pessimistic assumptions are used for postclosure performance, Yucca Mountain falls out ~~of~~ as the preferred overall site when the implied value tradeoff between postclosure and preclosure radiological fatalities is approximately one-to-one (i.e., k_{post} = 0.21). It drops from among the top three sites under pessimistic assumptions, when this implied value tradeoff is such that approximately 2 preclosure fatalities ~~is equivalent to~~ would be accepted to avoid 1 postclosure fatality (i.e., k_{post} = 0.35).

5.2 INITIAL ORDER OF PREFERENCE FOR SITES FOR RECOMMENDATION FOR CHARACTERIZATION

The overall rankings presented in the previous sections suggest that the initial order of preference for sites for recommendation for characterization is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford. This ranking is stable for all but the most extreme assumptions on postclosure performance and the most extreme weightings of postclosure considerations versus preclosure considerations.

The sites in the top-three positions offer maximum diversity in geohydrologic settings. The Yucca Mountain site is unique among these sites because a repository would be constructed in the unsaturated zone. The advantages of disposing waste in thick unsaturated zones have been noted in the literature for over a decade. A major advantage is the very slow flux of water that probably exists at Yucca Mountain. Another is that the undergroun facility can be designed so as to allow only minimal contact of the water tha does enter openings with the wastes package. Still another is that underlyin tuffs contain sorptive zeolites and clays that could act as additional barriers to the downward transport of radionuclides from a repository to the water table.

The geohydrologic settings associated with the Richton Dome and Deaf Smith sites are also clearly distinguishable from another, but not as obviously as from Yucca Mountain. Richton Dome is similar in many respects to Deaf Smith because both have salt as a host rock, but Richton is a piercement structure of fairly uniform properties surrounded by sedimentary materials. The dome is surrounded by aquifers at different depths. The bedded-salt setting at Deaf Smith is underlain by relatively horizontal bedded sedimentary rocks capped by the Ogallala Formation. The geohydrologic system is dominated by the High Plains aquifer. Minor aquifers of poor water quality occur in deeper strata, nearer to the salt units.

The advantages of salt as a host rock for disposal have been documented elsewhere many times, and so are not repeated here. Chapter 1 (Section 1.2.2.) lists some of its expected advantages.

The Yucca Mountain, Richton Dome, and Deaf Smith sites do not offer maximum diversity in rock type. (They do, however, meet the minimum requirement for diversity of the Nuclear Regulatory Commission.) As was explained in Section 2.1, the site-recommendation decision is analogous to a portfolio problem since the DOE must choose, not a single site for repository development, but three from five well-qualified sites for site characterization and related nongeologic data gathering. It is possible that other combinations of three sites would have properties not possessed by the individual sites in the top-three positions. Whether the set of three sites indicated as most preferable by the methodology is acceptable as a portfolio is examined in the site-recommendation letter report accompanying this report.

Chapter 5

COMPOSITE ANALYSIS

This chapter combines the results of the postclosure and preclosure multiattribute utility analyses to obtain an overall ranking of the sites and explores the sensitivity of that ranking to basic assumptions. Section 5.1 formally aggregates the quantitative results using the logic of multiattribute utility analysis. Section 5.2 presents the initial order of preference for sites for recommendation for characterization. This relies on qualitative logic to reinforce the insights obtained from the formal aggregation.

5.1 FORMAL AGGREGATION OF POSTCLOSURE AND PRECLOSURE RESULTS

The results of the postclosure and preclosure analyses may be formally aggregated using the logic of multiattribute utility analysis. Based on independence assumptions discussed in Appendix G, the composite utility, which quantifies the estimated overall desirability of a site, may be expressed as

$$U_{comp} = k_{pre}U_{pre} + k_{post}[E(U)_{post})], \qquad (5\text{-}1)$$

where U_{pre} is the preclosure utility of the site computed from Equation (4-1), $E(U_{post})$ is the expected postclosure utility of the site (sum of the postclosure utilities estimated assuming various postclosure scenarios weighted by the estimated probabilities of the scenarios) calculated from Equation (3-4), and k_{pre} and k_{post} are scaling factors that sum to 1.

To use Equation 5-1, $E[U_{post}]$ and U_{pre} for the sites are taken directly from results in Chapters 3 and 4 respectively. The determination specific scaling factors requires value tradeoffs to be made between preclosure and postclosure impacts. Before discussing this in detail, a sensitivity analysis over the entire possible ranges of both k_{pre} and k_{post} is informative.

Figure 5-1 presents the composite utility for each site using base-case estimates for both preclosure and postclosure. Figure 5-2 expands that part of the ranges of k_{pre} and k_{post} in which a change of the ranking of sites according to composite utility occurs. The base-case utility for preclosure is taken from Table 4-11 and the base-case expected utility for postclosure taken from Table 3-6. The full range of possible relative weighting is considered, since k_{pre} and k_{post} range from $k_{pre} = 0$ and $k_{post} = 1$ (all weight given to postclosure considerations) to $k_{pre} = 1$ and $k_{post} = 0$ (all weight given to preclosure considerations). It is clear from the figu: that the ranking of the sites remains the same for a wide range of weightings. In order of overall desirability, the site ranking is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford.

When an extremely high weight is assigned to postclosure impacts (i.e. $k_{post} \geq 0.998$), the ranking becomes Davis Canyon and Richton Dome approximately tied for first, Yucca Mountain and Deaf Smith approximately t for third, and Hanford last.

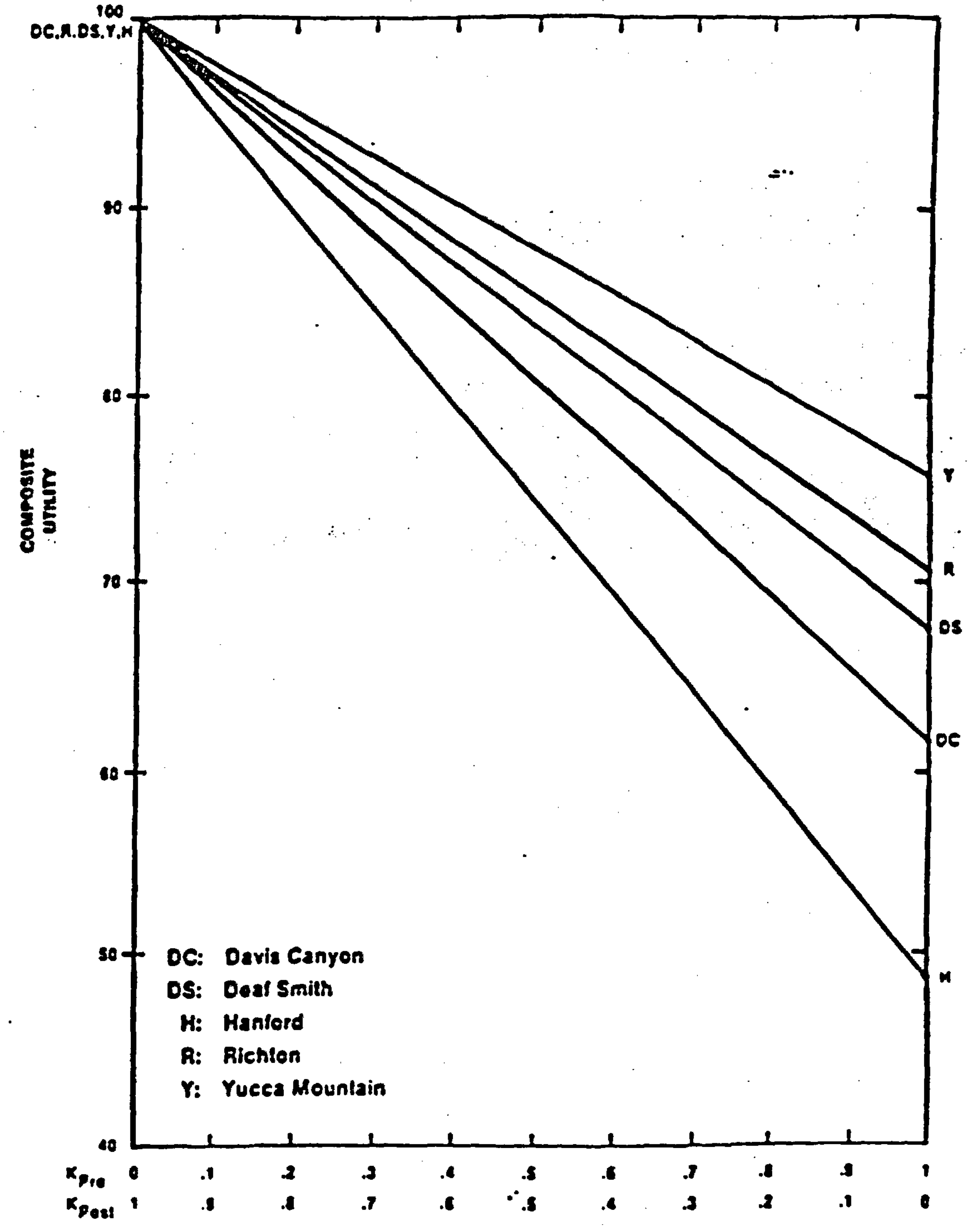

Figure 5.1. Site composite utilities for all possible preclosure-postclosure weightings calculated using base-case and nominal assumptions.

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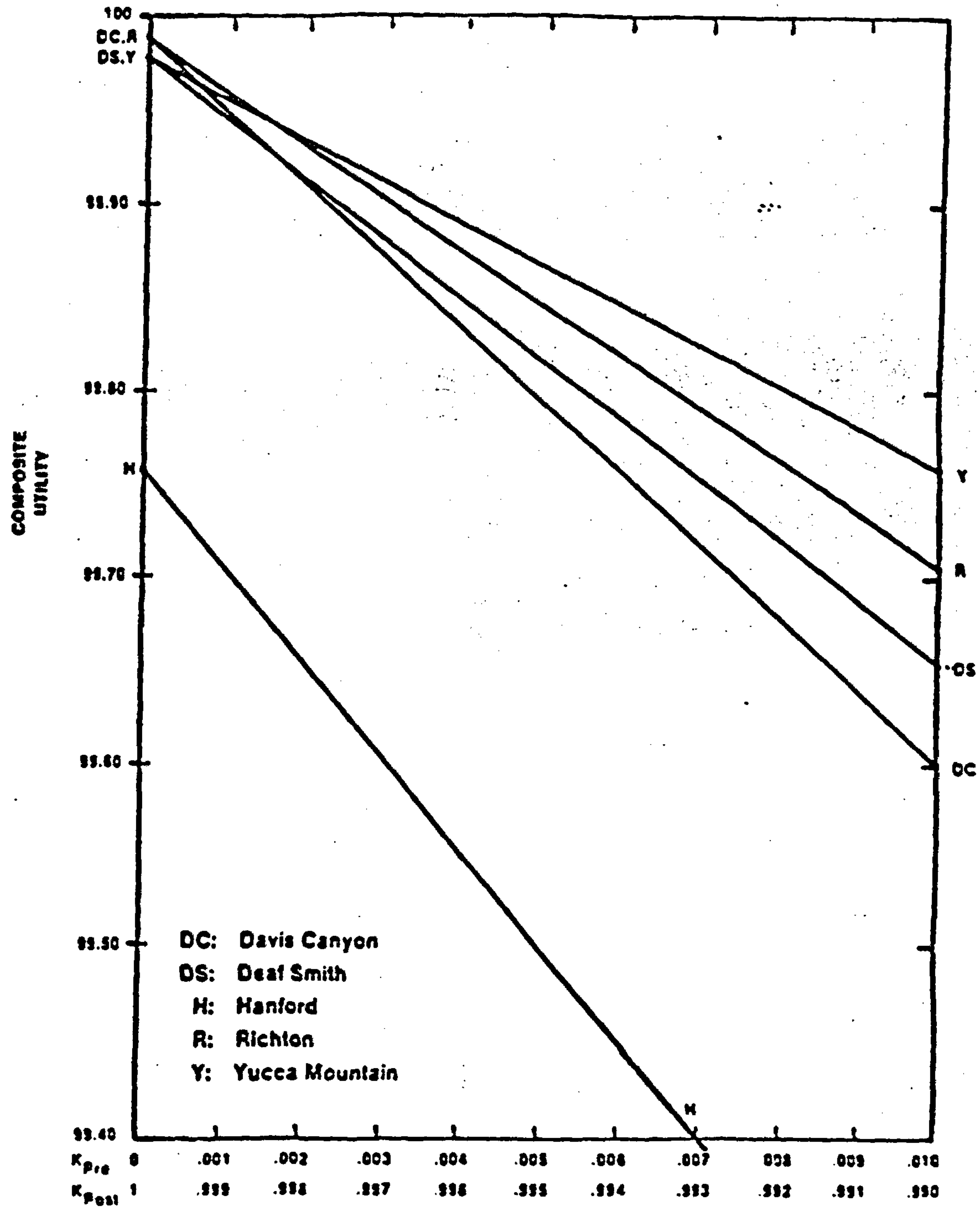

Figure 5.2. Site composite utilities for high postclosure weightings calculated using base-case and nominal assumptions

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As indicated in Chapter 3, all the sites have extremely high expected postclosure utilities. Because the differences among the expected postclos utilities are very small, the differences among the composite utilities for the various sites are very small if essentially all of the weight is given t postclosure.

Figures 5-3 through 5-6 show composite utilities for the five sites whe assumptions other than base-case, nominal assumptions are used. Figure 5-3 shows the results when optimistic assumptions (high scores and low probabilities for disruptive and unexpected features scenarios) are used for postclosure and optimistic assumptions (low impact levels) are used for preclosure. Figure 5-4 shows the results when pessimistic assumptions are used (low scores and high probabilities for disruptive and unexpected feature scenarios) are used for postclosure and pessimistic assumptions (high impact levels) are used for preclosure. Figures 5-5 and 5-6 show the mixed cases in which optimistic or pessimistic assumptions are adopted for the postclosure analysis and the reverse assumption is adopted for preclosure.

Although the weights of k_{pre} and k_{post} at which the ranking of the sites changes depending on whether base-case, pessimistic, or optimistic assumptions are adopted, certain patterns are clear and stable under a wide range of assumptions. Most significantly, the Hanford site is in all cases ranked last (i.e., it has the lowest composite utility), regardless of the relative weight assigned to preclosure and postclosure. This is so because it is ranked last for all sets of assumptions in both preclosure and postclosure. The relative ranking among the salt sites (Richton Dome, Deaf Smith, Davis Canyon) remains the same regardless of whether base-case,

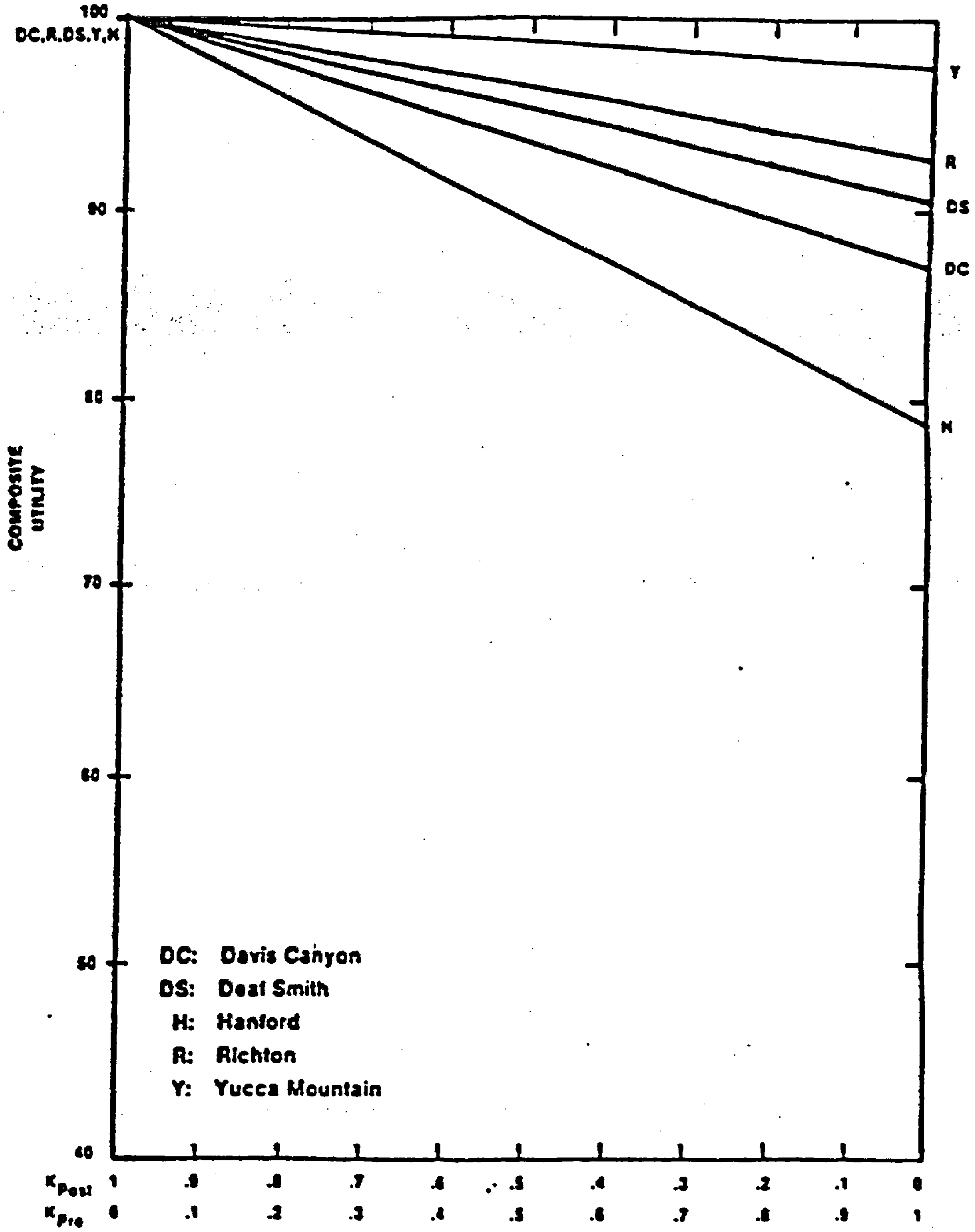

Figure 5.3. Site composite utilities calculated using optimistic assumptions for postclosure and preclosure.

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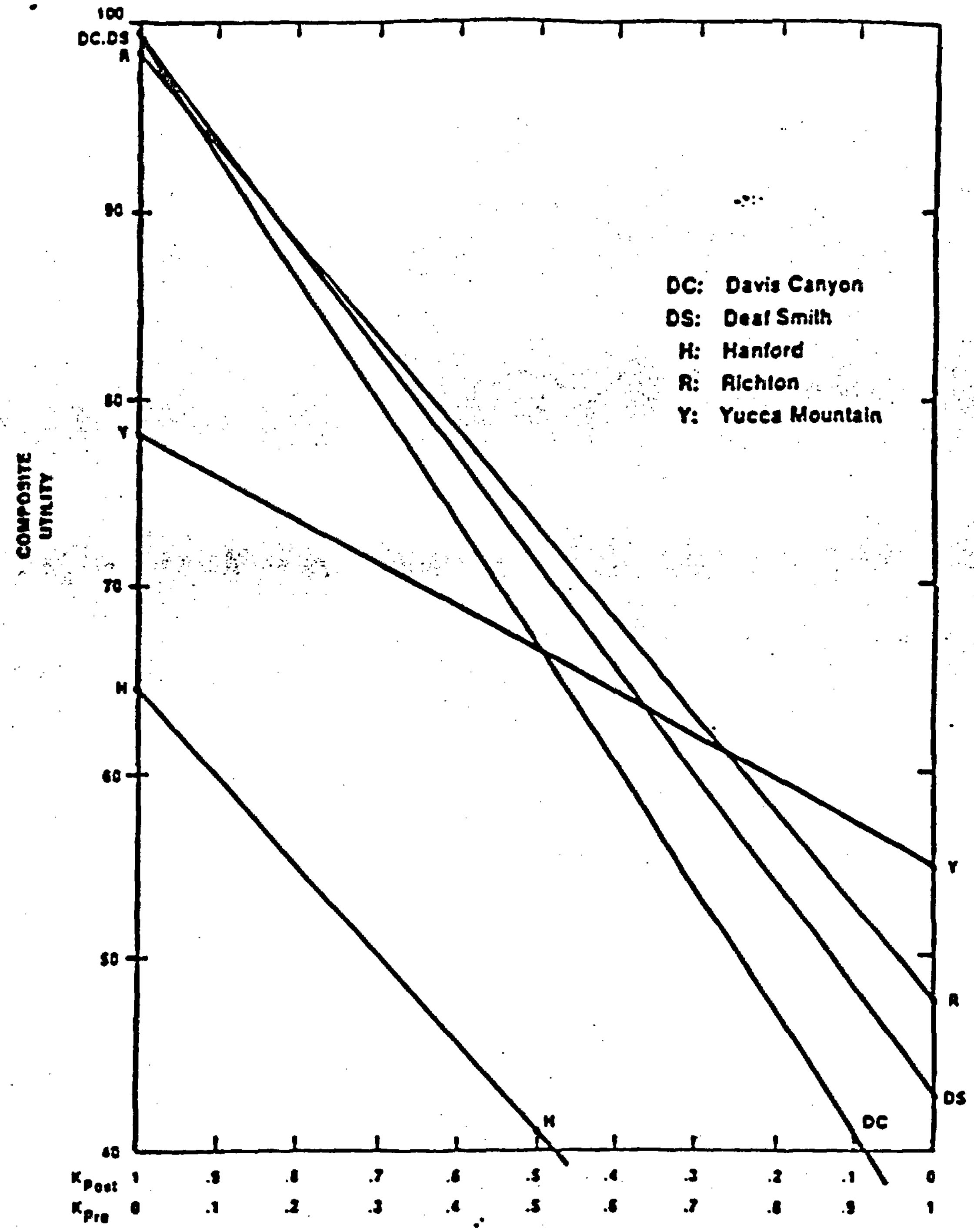

Figure 5.4. Site composite utilities calculated using pessimistic assumptions for postclosure and preclosure.

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Chapter 5

COMPOSITE ANALYSIS

This chapter combines the results of the postclosure and preclosure multiattribute utility analyses to obtain an overall ranking of the sites and explores the sensitivity of that ranking to basic assumptions. Section 5.1 formally aggregates the quantitative results using the logic of multiattribute utility analysis. Section 5.2 presents the initial order of preference for sites for recommendation for characterization. This discussion relies on qualitative logic to reinforce the insights obtained from the formal aggregation.

5.1 FORMAL AGGREGATION OF POSTCLOSURE AND PRECLOSURE RESULTS

The results of the postclosure and preclosure analyses may be formally aggregated using the logic of multiattribute utility analysis. Based on independence assumptions discussed in Appendix G, the composite utility, which quantifies the estimated overall desirability of a site, may be expressed as

$$U_{comp} = k_{pre}U_{pre} + k_{post}[E(U_{post})], \qquad (5\text{-}1$$

where U_{pre} is the preclosure utility of the site computed from Equation (4-1), $E(U_{post})$ is the expected postclosure utility of the site (sum of the postclosure utilities estimated assuming various postclosure scenarios weighted by the estimated probabilities of the scenarios) calculated from Equation (3-4), and k_{pre} and k_{post} are scaling factors that sum to 1. The selection of specific scaling factors requires value tradeoffs to be made between preclosure and postclosure impacts. Before discussing this in detail, it is informative to conduct a sensitivity analysis over the entire range of k_{pre} and k_{post}.

Figure 5-1 presents the composite utility for each site using base-case estimates for both preclosure and postclosure. Figure 5-2 expands that part of the ranges of k_{pre} and k_{post} in which a change of the ranking of sites according to composite utility occurs. The base-case utility for preclosure is taken from Table 4-11 and the base-case expected utility for postclosure is taken from Table 3-6. The full range of possible relative weighting is considered, since k_{pre} and k_{post} range from $k_{pre} = 0$ and $k_{post} = 1$ (all weight given to postclosure considerations) to $k_{pre} = 1$ and $k_{post} = 0$ (all weight given to preclosure considerations).

It is clear from the figures that the ranking of the sites remains the same for a wide range of weightings. Over most of the range of possible weightings, the order of overall desirability is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford. When an extremely high weight is assigned to postclosure impacts, i.e., $k_{post} \geq 0.998$, the site ranking becomes Davis Canyon and Richton Dome (approximately tied for first), Yucca Mountain and Deaf Smith (approximately tied for third), and Hanford last. Because the differences among the expected postclosure utilities are very small, the differences among the composite utilities for the various sites are very small if essentially all of the weight is given to postclosure.

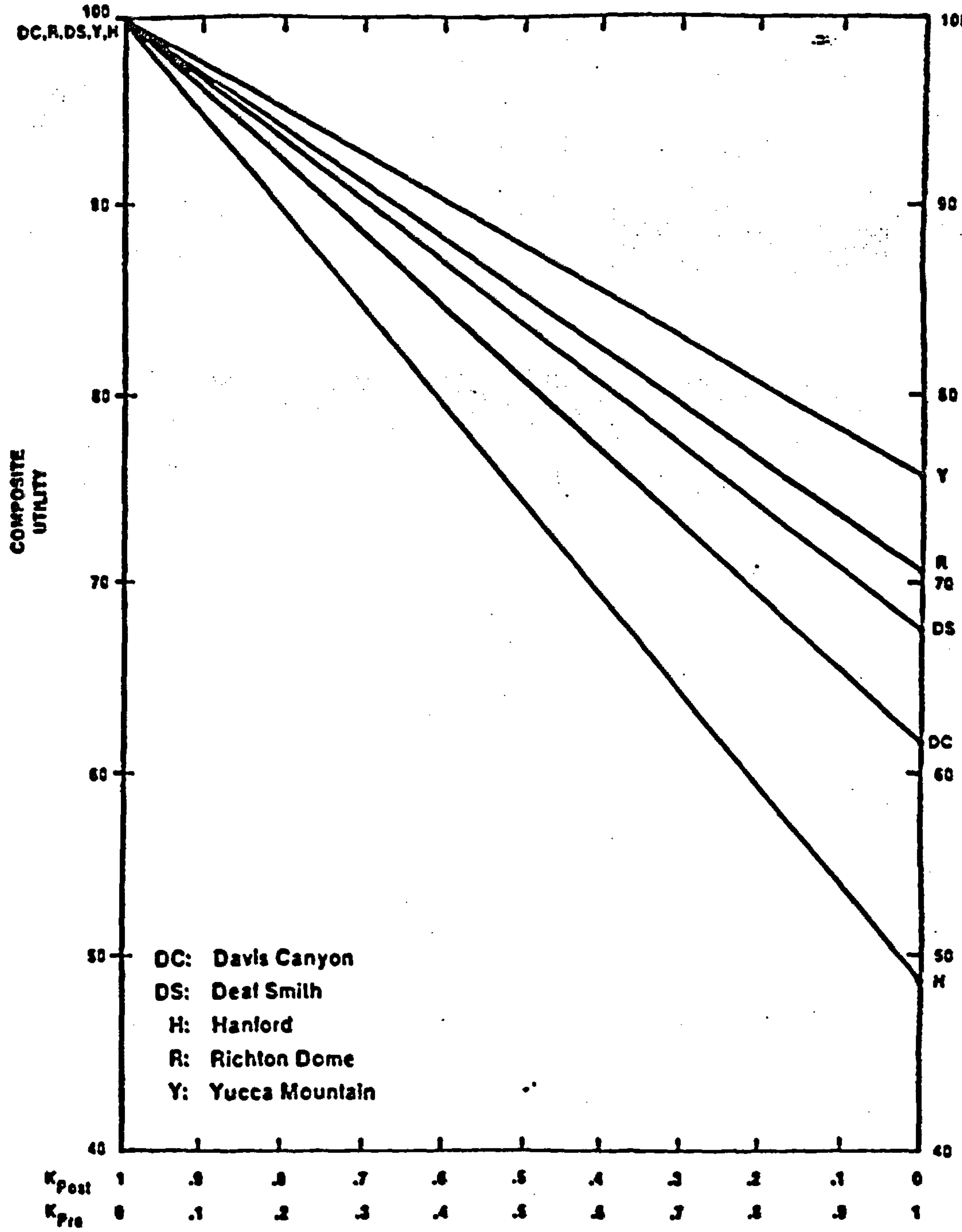

Figure 5.1. Site composite utilities for all possible preclosure-postclosure weightings calculated using base-case and nominal assumptions.

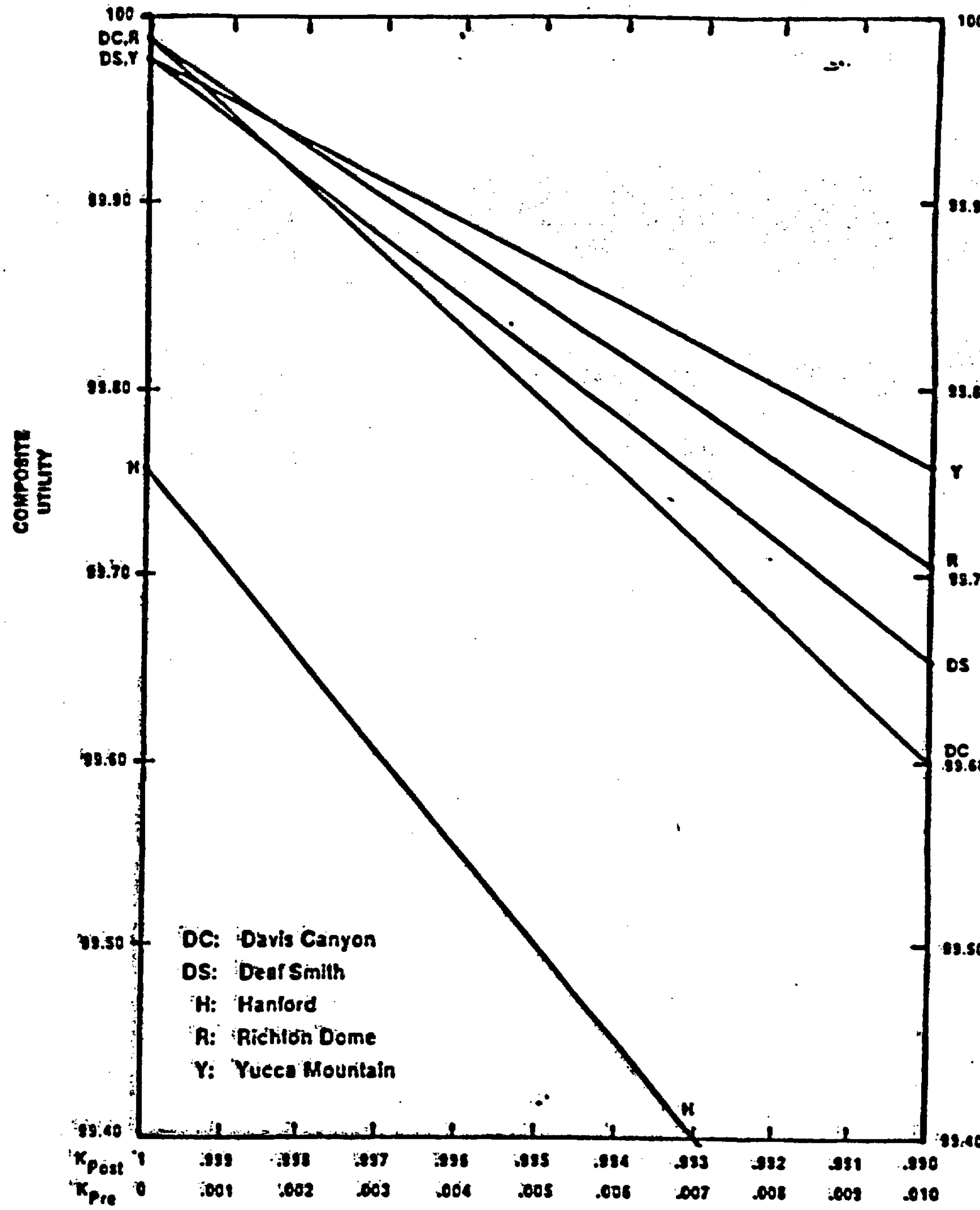

Figure 5.2. Site composite utilities for high postclosure weightings calculated using base-case and nominal assumptions.

Figures 5-3 through 5-6 show composite utilities for the five sites when assumptions other than base-case assumptions are used. Figure 5-3 shows the results when optimistic assumptions (high scores and low probabilities for disruptive and unexpected features scenarios) are used for postclosure and optimistic assumptions (low impact levels) are used for preclosure. Figure 5-4 shows the results when pessimistic assumptions (low scores and high probabilities for disruptive and unexpected features scenarios) are used for postclosure and pessimistic assumptions (high impact levels) are used for preclosure. Figures 5-5 and 5-6 show the mixed cases in which optimistic or pessimistic assumptions are adopted for the postclosure analysis and the reverse assumption is adopted for preclosure.

Although the weights of k_{pre} and k_{post} at which the overall ranking changes depends on whether base-case, pessimistic, or optimistic assumptions are adopted, certain patterns are clear and stable under a wide range of assumptions. Most significantly, the Hanford site is in all cases ranked last (i.e., it has the lowest composite utility), regardless of the relative weight assigned to preclosure and postclosure. This is so because it is ranked last for all sets of assumptions in both preclosure and postclosure. The relative ranking among the salt sites (Richton Dome, Deaf Smith, Davis Canyon) remains the same regardless of whether base-case, optimistic, or pessimistic assumptions are adopted unless a very high weight is assigned to postclosure, in which case the salt sites have composite utilities that are nearly equal. Yucca Mountain is the site that is affected most significantly by the choice of pessimistic, base-case, or optimistic assumptions. Under pessimistic assumptions for postclosure performance, Yucca Mountain receives a lower expected postclosure expected utility due to the possibility of ~~relatively large~~ releases from a repository at the site under a disruptive scenario involving a magmatic event. If pessimistic assumptions are adopted for postclosure, then Yucca Mountain is ranked first only if the scaling factor k_{post} is less than about 0.2; it is ranked in the top three only if k_{post} is less than about 0.35. Under base-case or optimistic assumptions for postclosure, Yucca Mountain is ranked first across nearly the entire ranges of k_{pre} and k_{post}.

Because of the sensitivity of the ranking of Yucca Mountain to the relative weights of k_{pre} and k_{post}, it is of interest to consider the reasonableness of different weights. As in the case with the scaling factors used in Chapters 3 and 4, the scaling factors k_{pre} and k_{post} must be based on a value judgment; in this case a value tradeoff between performance in postclosure and performance in preclosure. To judge whether particular numerical values for k_{pre} and k_{post} are reasonable it is necessary to select convenient measures for summarizing preclosure and postclosure performance and to consider whether the tradeoffs between these measures are reasonable. This tradeoff is most conveniently considered in terms of preclosure and postclosure radiological safety. Specifically, if preclosure radiological safety is expressed in terms of public cancer fatalities and postclosure radiological safety is expressed in terms of cumulative releases, the value tradeoff may be expressed as postclosure releases y (occurring in the first 10,000 years) that would be just as undesirable as the occurrence of 10 additional preclosure cancer fatalities. Table 5.1 shows the weights k_{pre} and k_{post} corresponding to several different tradeoffs. These were calculated using the following steps:

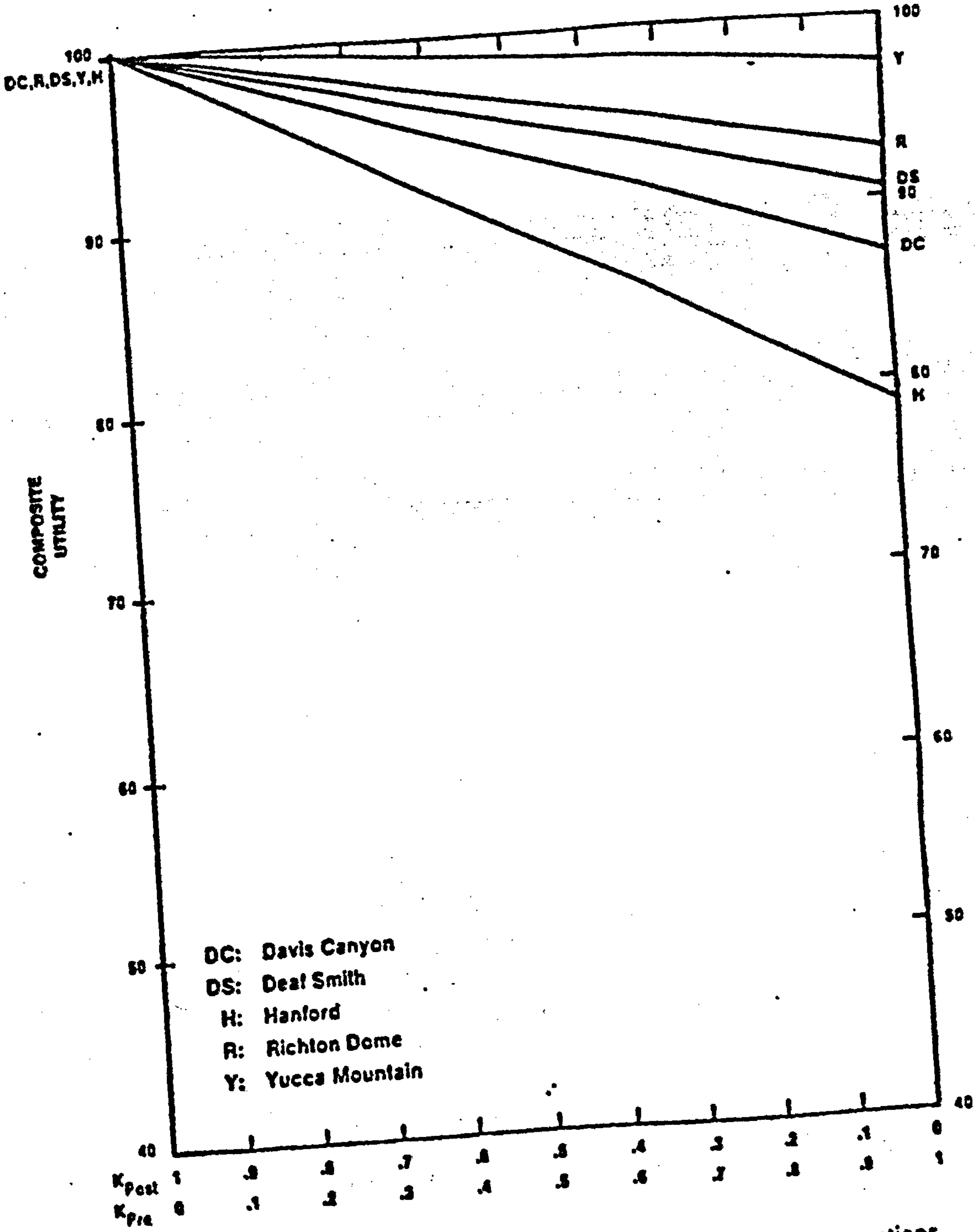

Figure 6.3. Site composite utilities calculated using optimistic assumptions for postclosure and preclosure.

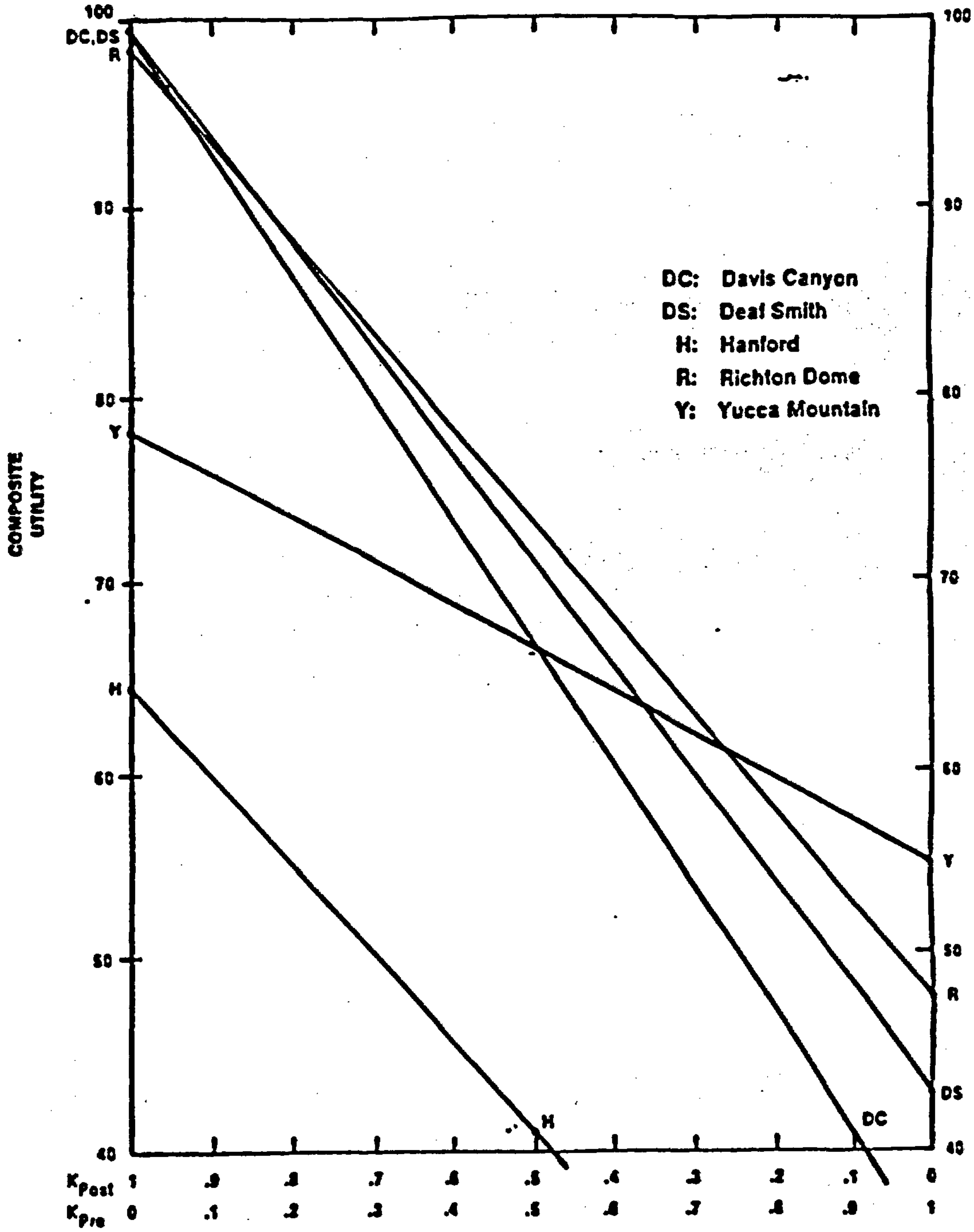

Figure 5.4. Site composite utilities calculated using pessimistic assumptions for postclosure and preclosure.

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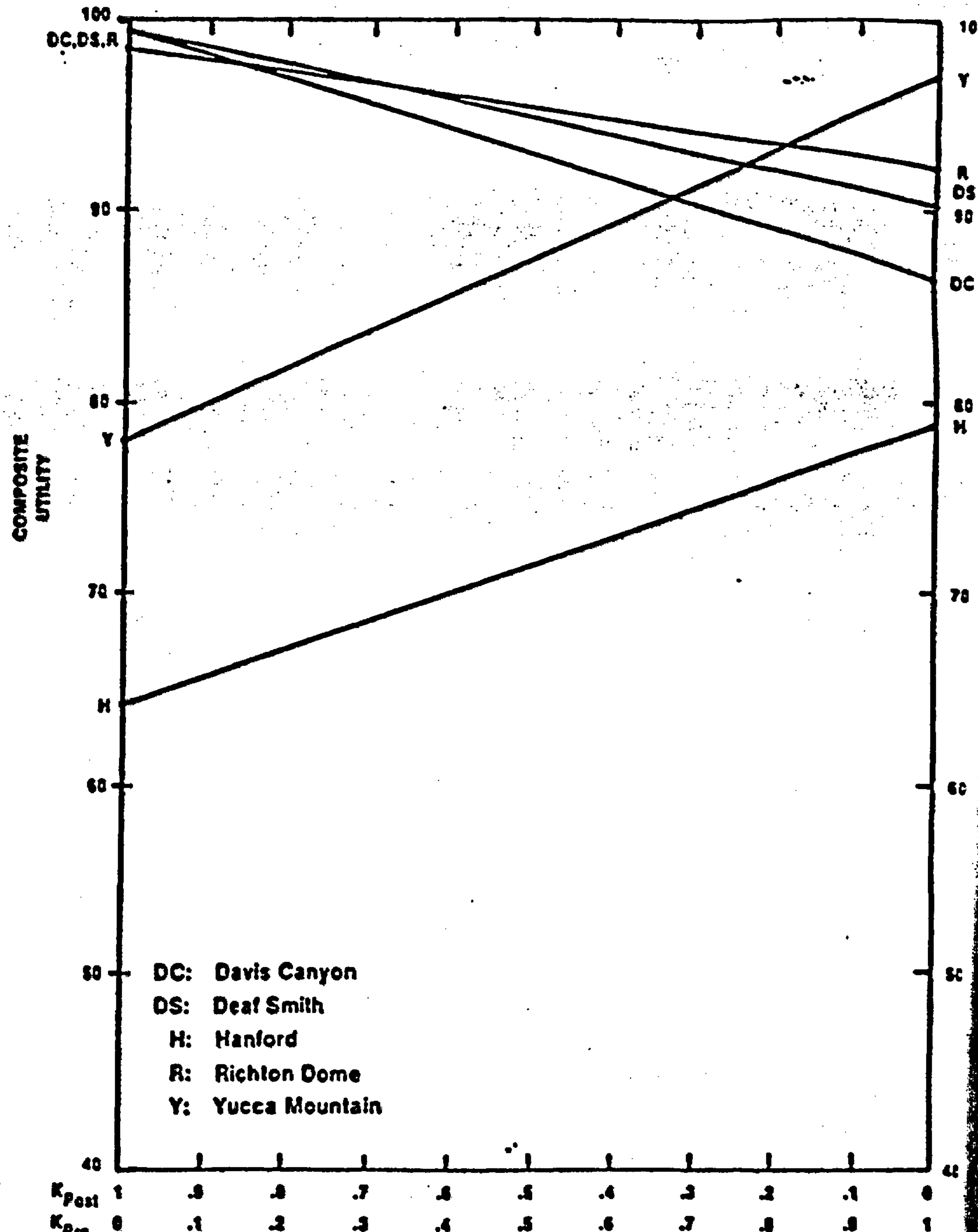

Figure 5.5. Site composite utilities calculated using pessimistic assumptions for postclosure and optimistic assumptions for preclosure.

Deaf Smith because both have salt as a host rock, but Richton Dome is a piercement structure of uniform properties surrounded by sedimentary materials. The dome is surrounded by aquifers at different depths. The bedded-salt setting at the Deaf Smith site is underlain by relatively horizontal bedded sedimentary rocks capped by the Ogallala Formation. The geohydrologic system is dominated by the High Plains aquifer. Minor aquifers of poor water quality occur in deeper strata, nearer to the salt units. The advantages of salt as a host rock for the disposal of radioactive waste have been documented elsewhere many times, including those summarized in Section 1.2.2.

The Yucca Mountain, Richton Dome, and Deaf Smith sites do not offer maximum diversity in rock type. They do, however, meet the requirement of the Nuclear Regulatory Commission for diversity. As was explained in Section 2.1, the site-recommendation decision is analogous to a portfolio problem since the DOE must choose, not a single site for repository development, but three from five well-qualified sites for site characterization and related nongeologic data gathering. Combinations of three sites possess properties that cannot be attributable to single sites (e.g., diversity of geohydrologic settings and rock types). Thus, the set of three sites indicated as most preferable by the multiattribute utility analysis may not be the preferred set when these portfolio effects are taken into account together with the implications of this analysis. For the sites recommended for characterization to change from those suggested in the composite analysis, the relative advantages of the portfolio effects for the changed set would have to be judged to be greater than the relative advantages of the expected superior performances of the Yucca Mountain, Richton Dome, and Deaf Smith sites over the Davis Canyon and Hanford sites. These differences in performance range from the equivalent of 1 to 5 billion dollars in preclosure impacts in addition to postclosure impacts. These considerations are examined in the site-recommendation letter report accompanying this report.

Table 5-1. Value Tradeoffs Between Preclosure Radiological Health Effects and Postclosure Releases Implied by Various k_{pre} and k_{post}

k_{pre}	k_{post} (= $1-k_{pre}$)	Postclosure releases y valued as undesirable as 10 preclosure public cancer fatalities (fraction of EPA standar
1.0	0.0	-
0.99	0.01	0.38
0.9	0.1	0.03
0.8	0.2	0.02
0.7	0.3	0.01
0.6	0.4	0.006
0.5	0.5	0.004
0.4	0.6	0.003
0.3	0.7	0.002
0.2	0.8	0.001
0.1	0.9	0.0004
0.01	0.99	0.00004
0.0	1.0	-

1. The decrease in preclosure utility due to an additional ten public cancer fatalities is calculated using Equation 4-1 to be $(1/200)(4)(10) = 0.2$.

2. The decrease in postclosure utility due to an additional release y during the first 10,000 years is calculated using Equation 3-3 to be $(0.526)(100)(y) = 52.6y$.

3. The tradeoff of postclosure versus preclosure implies that each of the above changes produce the same decrease in composite utility. From Equation 5-1, therefore,

$$k_{pre}(0.2) = k_{post}(52.6y)$$

which implies

$$y = 0.0038 \frac{k_{pre}}{k_{post}}$$

The entries in Table 5-1 indicate the releases y (expressed as fractions of the EPA standard) that would be regarded as equally undesirable as 10 preclosure public radiological fatalities for various weights k_{pre} and k_{post}.

The reasonableness of the various value tradeoffs presented in Table 5-1 may be interpreted more easily if a relationship is assumed between postclosure releases to the accessible environment and postclosure health effects. As noted in Chapter 3, 40 CFR 190 adopted the assumption that for each 1,000 metric tons of heavy metal (MTHM), cumulative releases at the level allowed by the EPA standard would result in 10 premature cancer deaths. Because a repository at any of the nominated sites is assumed to be designed to hold 70,000 MTHM, releases at the level allowed by the standard would produce approximately 700 cancer fatalities. Table 5-2 shows the tradeoff between preclosure and postclosure cancer fatalities implied by various k_{pre} and k_{post} if the releases shown in Table 5-1 are converted to postclosure fatalities using the EPA assumption. Because the EPA relationship between postclosure releases and radiological fatalities likely overestimates these fatalities, the implied value tradeoff likely is a lower-bound on the actual relative significance given to postclosure fatalities.

As may be seen from Figures 5-1 to 5-3 and Figure 5-6, the composite utilities imply an overall site ranking of Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford for all $k_{post} \leq 0.99$ provided that postclosure impacts are assumed to be base-case or optimistic (regardless of the preclosure assumptions). Values of k_{post} greater than 0.99 would, according to Table 5-2, imply a willingness to accept more than 350 preclosure cancer fatalities to avoid one postclosure cancer fatality. Most people would probably view such a high postclosure weight to be unreasonable. If pessimistic assumptions are used for postclosure performance, Yucca Mountain falls out as the preferred overall site when the implied value tradeoff between postclosure and preclosure radiological fatalities is approximately one-to-one (i.e., $k_{post} = 0.21$). It drops from among the top three sites, under pessimistic assumptions, when this implied value tradeoff is such that approximately 2 preclosure fatalities would be accepted to avoid 1 postclosure fatality (i.e., $k_{post} = 0.35$).

Table 5-2. Value Tradeoffs Between Preclosure and Postclosure Radiological Health Effects Implied by Various k_{pre} and k_{post}

k_{pre}	k_{post} (= $1-k_{pre}$)	Implied Value Tradeoff Between Preclosure and Postclosure Cancer Fatalities
1.0	0.0	-
0.99	0.01	1:26
0.9	0.1	1:2.4
0.8	0.2	1:1.1
0.79	0.21	1:1
0.7	0.3	1.6:1
0.6	0.4	2.5:1
0.5	0.5	3.8:1
0.4	0.6	5.6:1
0.3	0.7	8.8:1
0.26	0.74	10:1
0.2	0.8	15:1
0.1	0.9	34:1
0.01	0.99	372:1
0.0	1.0	-

5.2 INITIAL ORDER OF PREFERENCE FOR SITES FOR RECOMMENDATION FOR CHARACTERIZATION

The overall rankings presented in the previous sections suggest that the initial order of preference for sites for recommendation for characterization is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford. This ranking is stable for all but the most extreme assumptions on postclosure performance and the most extreme weightings of postclosure considerations versus preclosure considerations, as explained below.

For all assumptions and weightings, the Hanford site remains ranked last. For all assumptions about postclosure conditions and the wide range assumed to be realistic for weights (i.e., $k_{post} \leq 0.8$), the relative ranking of the salt sites is stable; specifically, Richton Dome is preferred to Deaf Smith which is preferred to Davis Canyon. For pessimistic postclosure assumptions, Yucca Mountain drops from first ranked to fourth ranked as the postclosure weight increases from approximately 0.2 to 0.35 depending on the preclosure assumptions.

The clear implication from the composite analysis is that Yucca Mountain, Richton Dome, and Deaf Smith are the preferred set of sites for characterization. There are no realistic assumptions about either preclosure or postclosure expected performance or about the values used to evaluate performance that can result in the Hanford site being anything but the last ranked site. The significance of the performance differences between the Hanford site and all the other sites is substantial. Similarly, the Davis Canyon site is less preferred than the Richton Dome and Deaf Smith sites for essentially all realistic assumptions. The differences in performance of the Davis Canyon site and the other two salt sites is also substantial, even though the Davis Canyon is much preferred to the Hanford site in the analysis. Only for some extreme cases (i.e., pessimistic postclosure assumptions) could one argue directly from the analysis that the three sites to be characterized should be Richton Dome, Deaf Smith, and Davis Canyon. However, the Nuclear Regulatory Commission requires that at least one of the sites characterized not have salt as the host rock. Thus, it can be definitively stated that the results of the composite analysis strongly suggest characterization of the Yucca Mountain, Richton Dome, and Deaf Smith sites.

The combination of the Yucca Mountain, Richton Dome, and Deaf Smith sites offers maximum diversity in geohydrologic settings. The Yucca Mountain site is unique among these sites because a repository would be constructed in the unsaturated zone. The advantages of disposing waste in thick unsaturated zones have been noted in the literature for over a decade. A major advantage is the very slow flux of ground water that probably exists at Yucca Mountain. Another is that the underground facility can be designed so as to allow only minimal contact of the water with the waste packages. Still another is that underlying tuffs contain sorptive zeolites and clays that could act as additional barriers to the downward transport of radionuclides from a repository to the water table.

The geohydrologic settings associated with the Richton Dome and Deaf Smith sites are also clearly distinguishable from another, but not as obviously as from Yucca Mountain. Richton Dome is similar in many respects to

Deaf Smith because both have salt as a host rock, but Richton Dome is a piercement structure of uniform properties surrounded by sedimentary materials. The dome is surrounded by aquifers at different depths. The bedded-salt setting at the Deaf Smith site is underlain by relatively horizontal bedded sedimentary rocks capped by the Ogallala Formation. The geohydrologic system is dominated by the High Plains aquifer. Minor aquifers of poor water quality occur in deeper strata, nearer to the salt units. The advantages of salt as a host rock for the disposal of radioactive waste have been documented elsewhere many times, including those summarized in Section 1.2.2.

The Yucca Mountain, Richton Dome, and Deaf Smith sites do not offer maximum diversity in rock type. They do, however, meet the requirement of the Nuclear Regulatory Commission for diversity. As was explained in Section 2.1, the site-recommendation decision is analogous to a portfolio problem since the DOE must choose, not a single site for repository development, but three from five well-qualified sites for site characterization and related nongeologic data gathering. Combinations of three sites possess properties that cannot be attributable to single sites (e.g., diversity of geohydrologic settings and rock types). Thus, the set of three sites indicated as most preferable by the multiattribute utility analysis may not be the preferred set when these portfolio effects are taken into account together with the implications of this analysis. For the sites recommended for characterization to change from those suggested in the composite analysis, the relative advantages of the portfolio effects for the changed set would have to be judged to be greater than the relative advantages of the expected superior performances of the Yucca Mountain, Richton Dome, and Deaf Smith sites over the Davis Canyon and Hanford sites. These differences in performance range from the equivalent of 1 to 5 billion dollars in preclosure impacts in addition to postclosure impacts. These considerations are examined in the site-recommendation letter report accompanying this report.

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5.2 INITIAL ORDER OF PREFERENCE FOR SITES FOR RECOMMENDATION FOR CHARACTERIZATION

It can be stated, therefore, that the results of the multiattribute utility analysis ~~The overall rankings presented in the previous sections~~ suggest that the initial order of preference for sites for recommendation for characterization is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford. This ranking is stable for all but the most extreme assumptions on postclosure performance and the most extreme weightings of postclosure considerations versus preclosure considerations, as explained below.

For all assumptions and weightings, the Hanford site remains ranked last. For all assumptions about postclosure conditions and the wide range assumed to be realistic for weights (i.e., $k_{post} \leq 0.8$), the relative ranking of the salt sites is stable; specifically, Richton Dome is preferred to Deaf Smith which is preferred to Davis Canyon. For pessimistic postclosure assumptions, Yucca Mountain drops from first ranked to fourth ranked as the postclosure weight increases from approximately 0.2 to 0.35 depending on the preclosure assumptions.

The clear implication from the composite analysis is that Yucca Mountain, Richton Dome, and Deaf Smith are the preferred ~~set of~~ sites for characterization. ~~There are no realistic assumptions about either preclosure or postclosure expected performance or about the values used to evaluate performance that can result in the Hanford site being anything but the last ranked site.~~ rel. The significance of the performance differences between the Hanford site and all the other sites is substantial. Similarly, the Davis Canyon site is less preferred than the Richton Dome and Deaf Smith sites for essentially all realistic assumptions. The differences in performance of the Davis Canyon site and the other two salt sites is also substantial, even though the Davis Canyon is much preferred to the Hanford site in the analysis. Only for some extreme cases (i.e., pessimistic postclosure assumptions) could one argue directly from the analysis that the three sites to be characterized should be Richton Dome, Deaf Smith, and Davis Canyon. However, the Nuclear Regulatory Commission requires that at least one of the sites characterized not have salt as the host rock. Thus, ~~it can be definitively stated that the results of the composite analysis strongly suggest characterization of the Yucca Mountain, Richton Dome, and Deaf Smith sites~~ this combination of sites is disallowed by existing regulations.

The combination of the Yucca Mountain, Richton Dome, and Deaf Smith sites offers maximum diversity in geohydrologic settings. The Yucca Mountain site is located in a region composed of alternating sequences of block-faulted mountains and alluvium-filled valleys of the Alluvial Basins geohydrologic setting. Yucca Mountain is a typical small fault-block mountain in this region and is composed entirely of volcanic rocks. The site is in the relatively dry unsaturated zone, well above the water table. This is a unique geohydrologic subsetting in comparison with the other sites, which are all situated well below the water table. The Yucca Mountain site will rely principally on a very low water flux through unsaturated rocks in a very arid environment, the natural ability of this type of system to exclude flowing or standing water from the repository, and the sorption characteristics of the minerals in the host rock to ensure waste containment and isolation.

~~The geohydrologic settings associated with the Richton Dome and Deaf Smith sites are also clearly distinguishable from one another, but not as obviously as from Yucca Mountain. Richton Dome is similar in many respects to Deaf Smith because both have salt as a host rock, but Richton Dome is a piercement structure of uniform properties surrounded by sedimentary materials. The dome is surrounded by aquifers at different depths. The Deaf Smith site is underlain by relatively horizontal bedded sedimentary rocks capped by the Ogallala Formation. The shallow geohydrologic system is dominated by the High Plains aquifer. Minor aquifers of poor water quality occur in deeper strata, nearer to the salt units. The advantages of salt as a host rock for the disposal of radioactive waste have been documented elsewhere many times, including those summarized in Section 1.2.2.~~

~~The Yucca Mountain, Richton Dome, and Deaf Smith sites~~ do not offer maximum diversity in rock type. They do, however, meet the requirement of the Nuclear Regulatory Commission for diversity. stet As was explained in Section 2.1, the site-recommendation decision is analogous to a portfolio problem since the DOE must choose, not a single site for repository development, but three from five well-qualified sites for site characterization and related nongeologic data gathering. Combinations of three sites possess properties that cannot be attributable to single sites (e.g., diversity of geohydrologic settings and rock types). Thus, the ~~combination of~~ three sites indicated as most preferable by the multiattribute utility analysis may not be the preferred combination when these portfolio effects are taken into account together with the implications of this analysis. For the sites recommended for characterization to change from those suggested in the composite analysis, the relative advantages of the portfolio effects for the changed combination would have to be judged to be greater than the relative advantages of the expected superior performances of the Yucca Mountain, Richton Dome, and Deaf Smith sites over the Davis Canyon and Hanford sites. These differences in performance range from the equivalent of 1 to 5 billion dollars in preclosure impacts in addition to postclosure impacts. The relative advantages of other combinations of three sites as portfolios are examined in the site-recommendation letter ~~report~~ accompanying this report.

A The three sites indicated as most preferable by the methodology -- Yucca Mountain, Richton Dome, and Deaf Smith -- offer maximum diversity in geohydrologic settings but

INSERT (A)

¶ As mentioned in Chapters 1 and 2, the purposes [of] the decision-aiding methodology are to provide insights [in]to the comparative advantages and disadvantages of the five sites and, in so doing, to determine an initial order of preference for sites for recommendation for characterization. [With] reference to the postclosure, preclosure, and composite an[alyses] of sites presented previously, the major insights from the mult[iattribute] utility analysis are as follows:

Postclosure Analysis

- All five sites appear capable of providing exceptionally good p[erformance] to current and future populations for at least 100,000 years [after] permanent closure
- The Richton Dome, [Davis] Canyon, Deaf Smith, and Yucca Mo[untain] sites appear to be virtually indistinguishable in terms of expected postclosure performance. The Hanford site is discern[ibly] less favorable than the other four sites (by about a f[actor] of 10), but is still far above the threshold of acceptablity established by the EPA. It is noted th[at] the primary containment requirements of the EPA -- the cri[teria] of acceptability used here -- are extremely stringent.
- The confidence in the performance of the three salt sit[es] is exceptionally high, and is higher than that for the non[salt] sites.

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Chapter 5

COMPOSITE ANALYSIS

This chapter combines the results of the postclosure and the preclosure multiattribute utility analyses to obtain an overall ranking of the sites and explores the sensitivity of that ranking to basic assumptions. Section 5.1 uses the logic of multiattribute utility analysis to formally aggregate the quantitative results. Section 5.2 summarizes the insights obtained from the multiattribute utility analysis and presents the initial order of preference for sites for recommendation for characterization.

5.1 FORMAL AGGREGATION OF POSTCLOSURE AND PRECLOSURE RESULTS

Using the logic of multiattribute utility analysis, the results of the postclosure and preclosure analyses can be formally aggregated. Given the independence assumptions discussed in Appendix G, the composite utility, which quantifies the estimated overall desirability of a site, can be expressed as

$$U_{comp} = k_{pre}U_{pre} + k_{post}[E(U_{post})], \qquad (5\text{-}1)$$

where U_{pre} is the preclosure utility of the site computed from Equation 4-1, $E(U_{post})$ is the expected postclosure utility of the site calculated from Equation 3-4, and k_{pre} and k_{post} are scaling factors that sum to 1. (The expected postclosure utility is the sum of the postclosure utilities estimated for various postclosure scenarios weighted by the estimated probabilities of the scenarios.)

As explained in Appendix G, it is not easy to interpret the scaling constants since they depend on the ranges of the performance measures. Independent of their ranges, the scaling constants most emphatically cannot be used as indicators of the importance of the respective performance measure. The selection of specific scaling factors requires value tradeoffs between preclosure and postclosure impacts. These value tradeoffs measure how much one is willing to give up on postclosure performance to gain a specific amount on preclosure performance. Before discussing this in detail, it is informative to conduct a sensitivity analysis over the entire range of k_{pre} and k_{post}.

Figure 5-1 presents the composite utilities obtained from the results of analyses for the preclosure and the postclosure periods. Figure 5-2 expands that part of the ranges of the scaling factors k_{pre} and k_{post} in which a change in the ranking of sites according to composite utility occurs. The base-case utility for preclosure performance is taken from Table 4-11, and the base-case expected utility for postclosure performance is taken from Table 3-6. The full range of possible relative weightings is considered, from the case where all the weight is given to the postclosure utility ($k_{pre} = 0$ and $k_{post} = 1$) to the case where all the weight is given to the preclosure utility ($k_{pre} = 1$ and $k_{post} = 0$).

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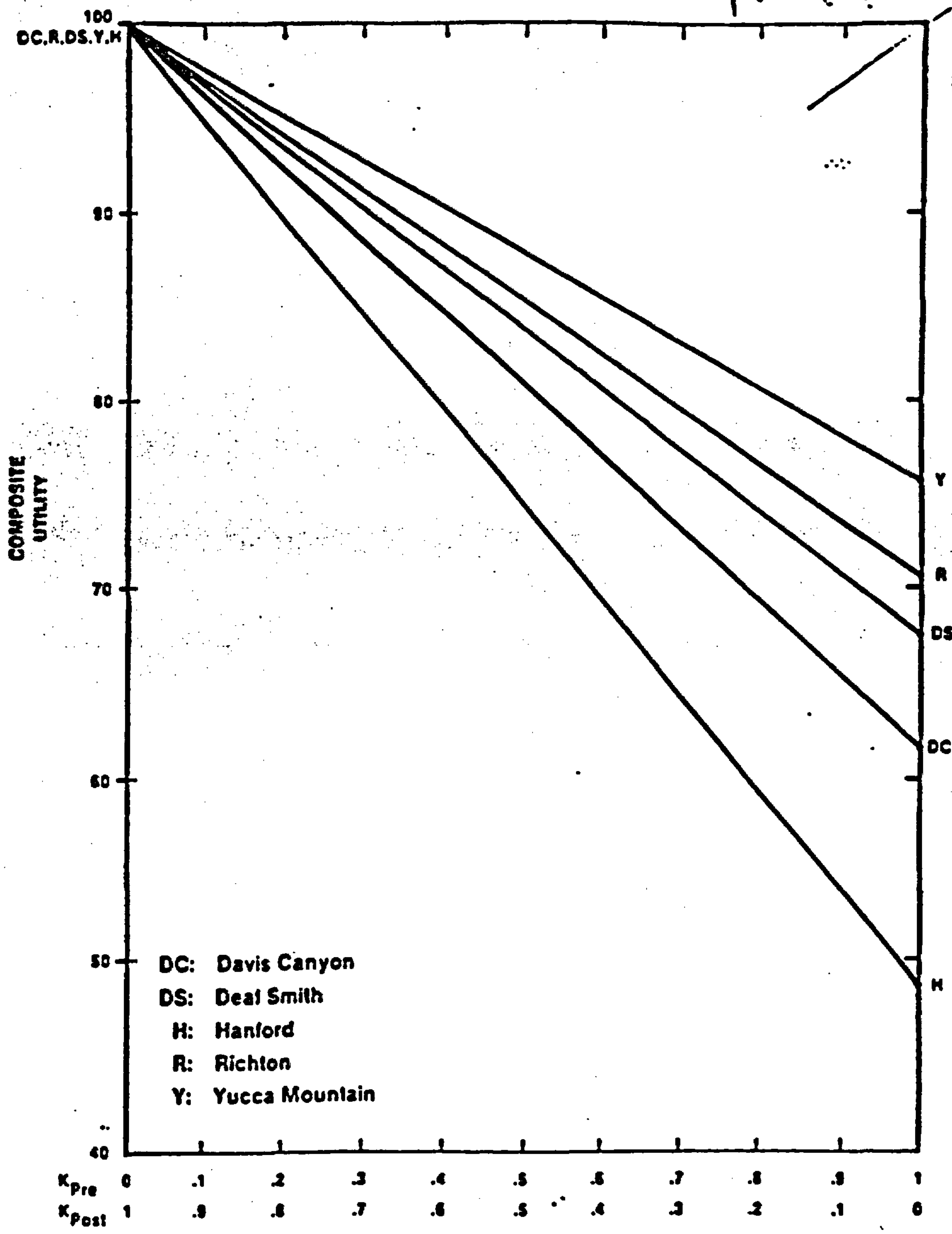

Figure 5.1. Site composite utilities for all possible preclosure-postclosure weightings calculated using base-case and nominal assumptions.

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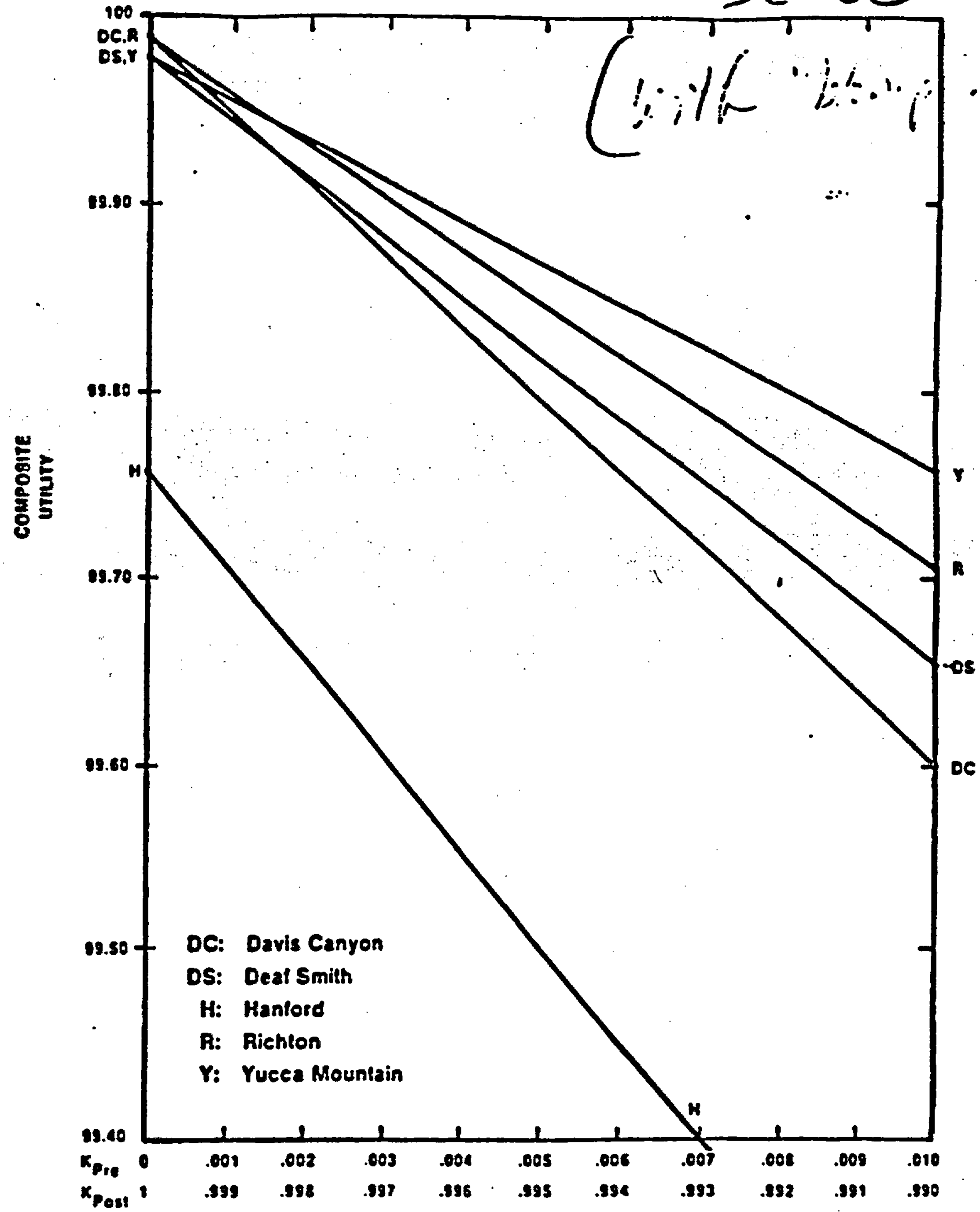

Figure 5.2. Site composite utilities for high postclosure weightings calculated using base-case and nominal assumptions.

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It is clear from Figures 5-1 and 5-2 that the ranking of the sites remains the same for a wide range of weightings. Over most of the range of possible weightings, the order of overall desirability is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford. When an extremely high weight is assigned to the expected postclosure utility (i.e., $k_{post} \geq 0.998$), the site ranking becomes Davis Canyon and Richton Dome (approximately tied for first), Yucca Mountain and Deaf Smith (approximately tied for second), and Hanford last. Because the differences among the expected postclosure utilities are very small, the differences among the composite utilities for the various sites are also very small when essentially all of the weight is given to the expected postclosure utility.

Figures 5-3 through 5-6 show composite utilities for the five sites when assumptions other than base-case assumptions are used. Figure 5-3 shows the results when optimistic assumptions (high scores and low probabilities for scenarios involving disruptive events and unexpected features) are used for the postclosure analysis and optimistic assumptions (low impact levels) are used for the preclosure analysis. Figure 5-4 shows the results when pessimistic assumptions (low scores and high probabilities for scenarios involving disruptive and unexpected features) are used for the postclosure analysis and pessimistic assumptions (high impact levels) are used for the preclosure analysis. Figures 5-5 and 5-6 show the mixed cases in which optimistic or pessimistic assumptions are adopted for the postclosure analysis and the reverse assumption is adopted for the preclosure analysis.

Although the values of the scaling factors at which the overall ranking changes depend on whether base-case, pessimistic, or optimistic assumptions are used, certain patterns are clear and stable under a wide range of assumptions. ~~Most significantly,~~ ~~the~~ Hanford site is in all cases ~~ranked last~~ (i.e., it has the lowest composite utility), regardless of the relative weight assigned to the preclosure and the postclosure utilities. This is so because it is ranked ~~last~~ for ~~all sets of assumptions in~~ both the preclosure and the postclosure analyses. The relative ranking among the salt sites (Richton Dome, Deaf Smith, Davis Canyon) remains the same regardless of whether base-case, optimistic, or pessimistic assumptions are used unless a very high weight is assigned to the postclosure utility, in which case the salt sites have composite utilities that are nearly equal. Yucca Mountain is the site whose ranking is most affected by the choice of pessimistic, base-case, or optimistic assumptions. Under pessimistic assumptions for postclosure performance, Yucca Mountain receives a lower expected postclosure utility because of the possibility of relatively large releases from a repository at the site under a disruptive scenario involving a magmatic event. If pessimistic assumptions are used for postclosure performance, then Yucca Mountain is ranked first only if the postclosure scaling factor k_{post} is less than about 0.2; it is ranked in the top three only if k_{post} is less than about 0.35. Under base-case or optimistic assumptions for postclosure performance, Yucca Mountain is ranked first across nearly the entire ranges of k_{pre} and k_{post}.

Because of the sensitivity of the ranking of Yucca Mountain to the relative values of k_{pre} and k_{post}, it is of interest to consider the reasonableness of different weights. As in the case with the scaling factors used in Chapters 3 and 4, the scaling factors k_{pre} and k_{post} must be based on a value judgment, in this case a value tradeoff between postclosure

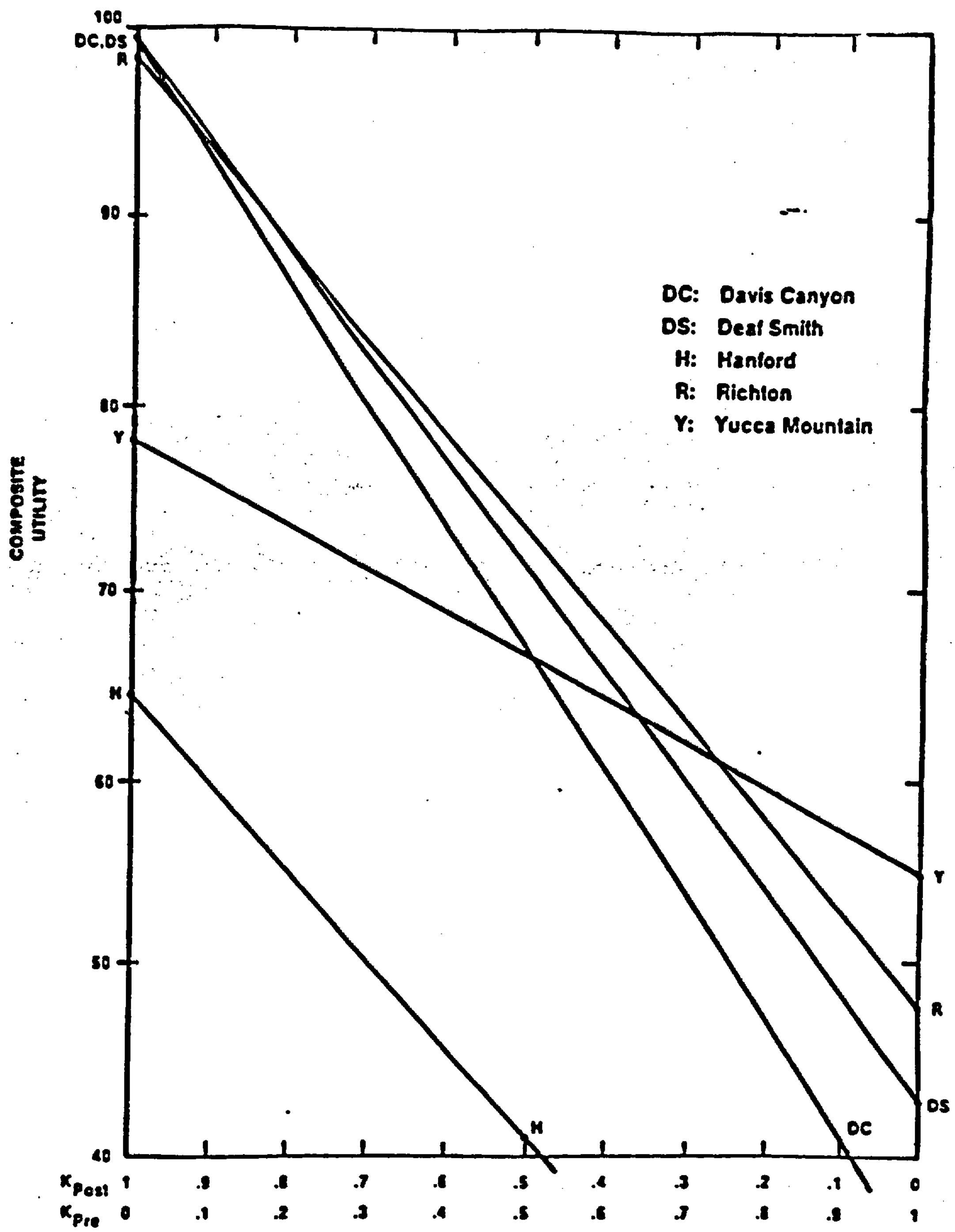

Figure 5.4. Site composite utilities calculated using pessimistic assumptions for postclosure and preclosure.

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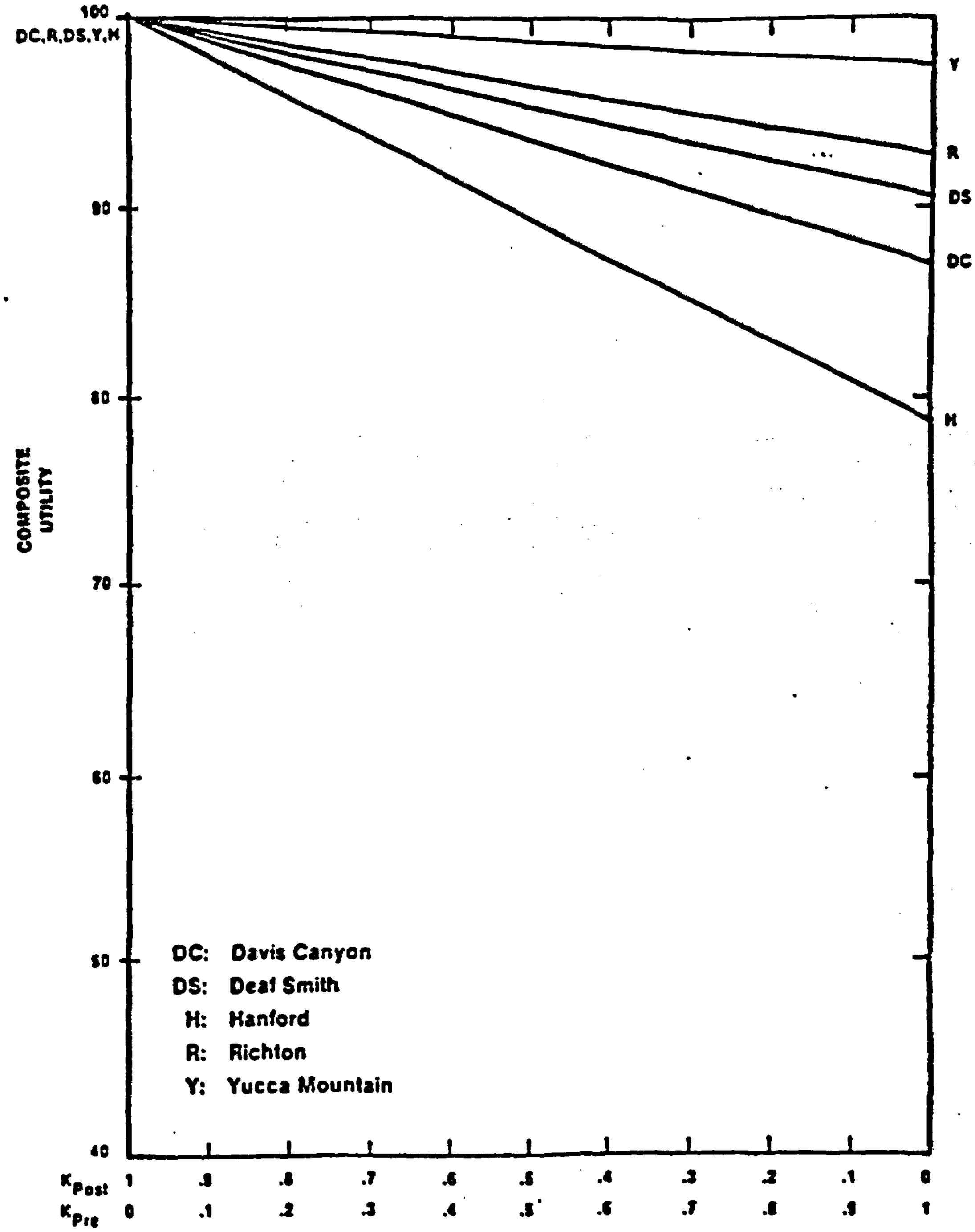

Figure 5.3. Site composite utilities calculated using optimistic assumptions for postclosure and preclosure.

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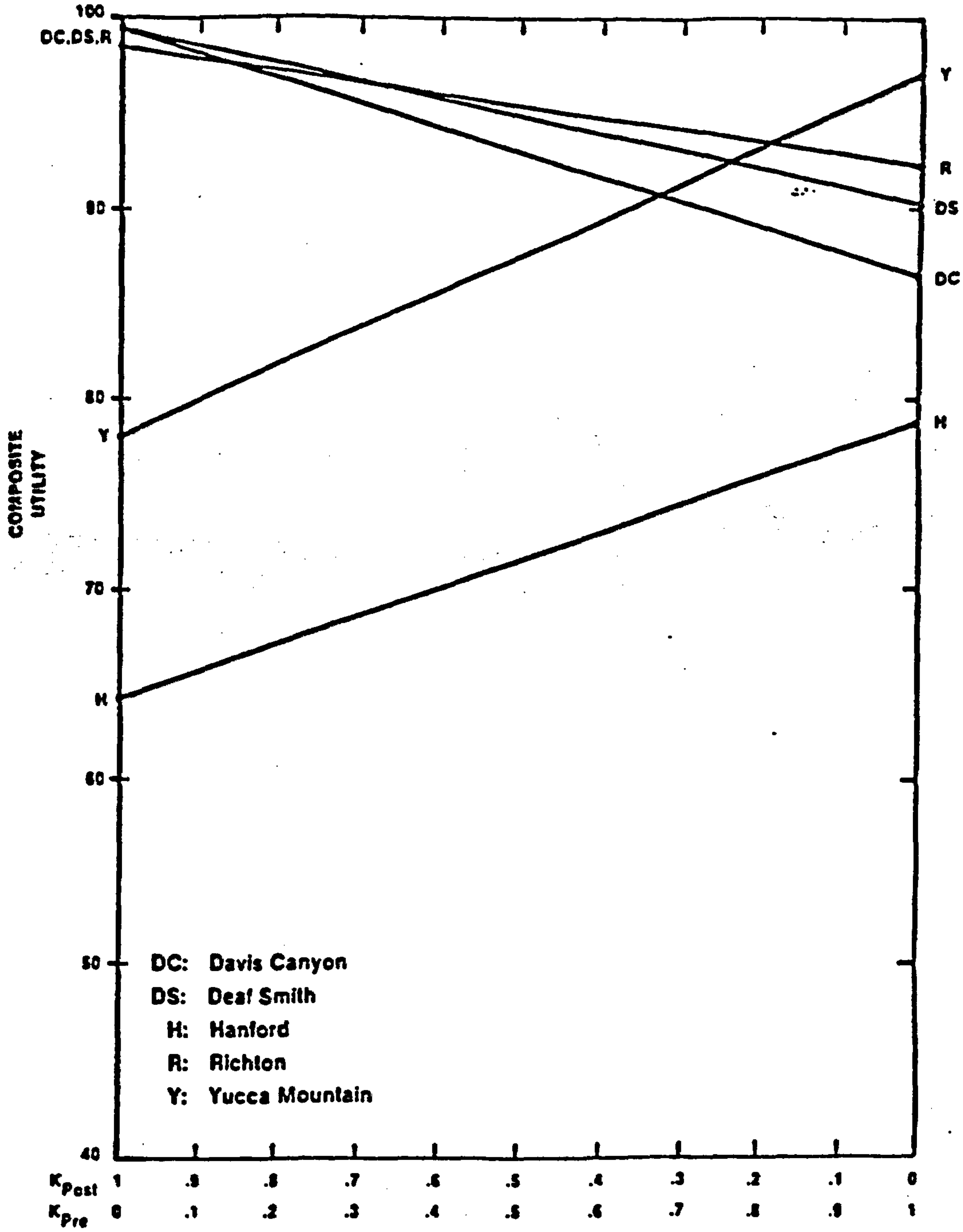

Figure 5.5. Site composite utilities calculated using pessimistic assumptions for postclosure and optimistic assumptions for preclosure.

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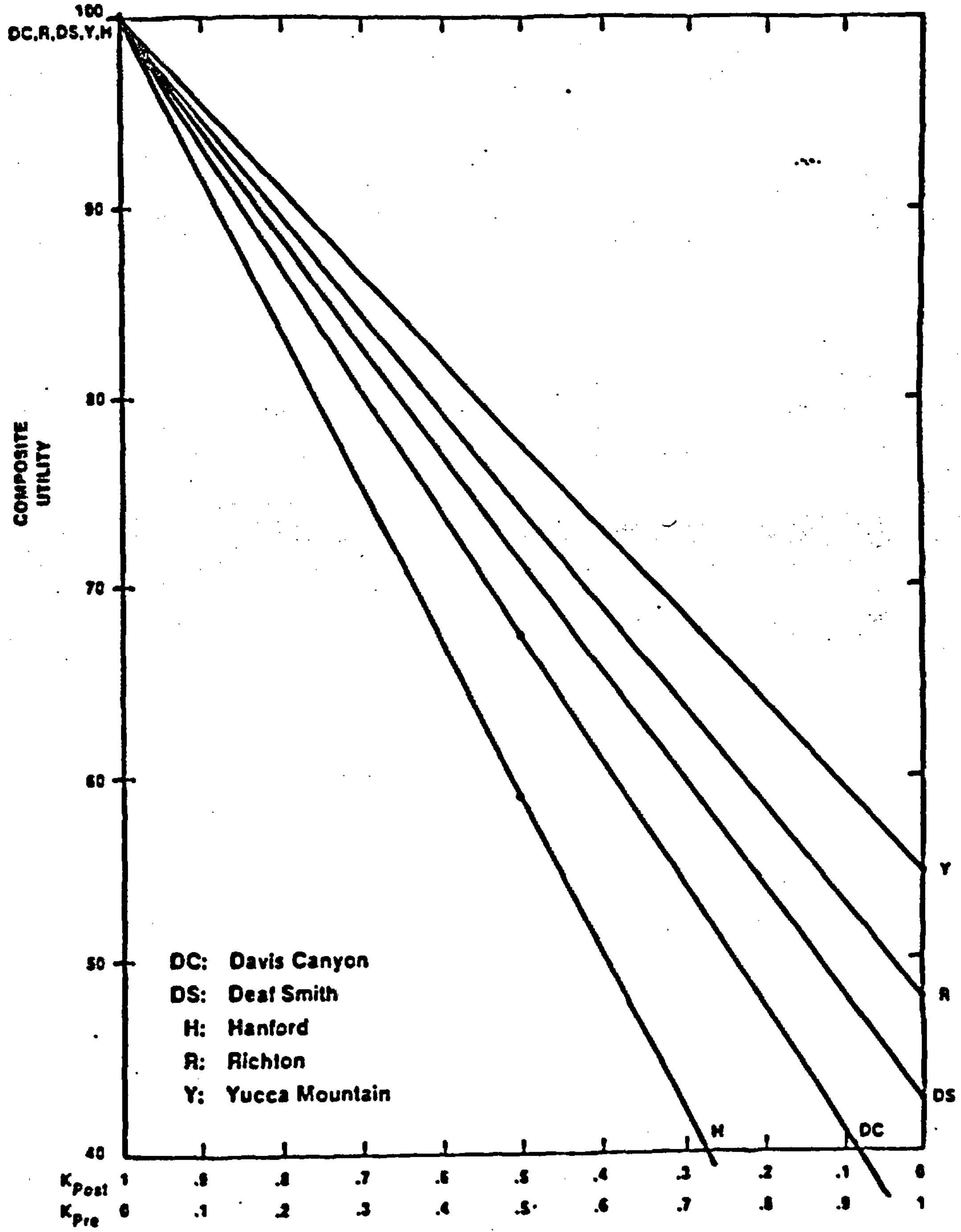

Figure 5.6. Site composite utilities calculated using optimistic assumptions for postclosure and pessimistic assumptions for preclosure.

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performance and preclosure performance. To judge whether particular numerical values for k_{pre} and k_{post} are reasonable, it is necessary to select convenient measures for summarizing preclosure and postclosure performance and to consider whether the tradeoffs between these measures are reasonable. This tradeoff is most conveniently considered in terms of preclosure and postclosure radiological safety. Specifically, if preclosure radiological safety is expressed in terms of cancer fatalities and postclosure radiological safety is expressed in terms of cumulative releases, the value tradeoff can be expressed as postclosure releases y (occurring in the first 10,000 years) that would be just as undesirable as the occurrence of 10 additional preclosure cancer fatalities. Table 5-1 shows the scaling factors k_{pre} and k_{post} corresponding to several different tradeoffs. These scaling factors were calculated as follows:

1. The preclosure-utility decrease from an additional 10 public fatalities from cancer is found from Equation 4-1 to be (1/200)(4)(10) = 0.2.

2. The postclosure-utility decrease from an additional release y during the first 10,000 years is found from Equation 3-3 to be (0.526)(100)(y) = 52.6y, where y is expressed as fractions of the EPA standard.

3. The postclosure-versus-preclosure tradeoff implies that each of the above changes produces the same decrease in composite utility. From Equation 5-1, therefore,

$$k_{pre}(0.2) = k_{post}(52.6y),$$

which implies that

$$y = 0.0038\ (k_{pre}/k_{post}).$$

Table 5-1 shows the releases y (expressed as fractions of the EPA standard) that would be regarded as undesirable as 10 preclosure public fatalities from cancer for various values of the scaling factors.

The reasonableness of the various value tradeoffs in Table 5-1 can be seen more easily if a relationship is assumed between postclosure releases to the accessible environment and postclosure health effects. As noted in Chapter 3, in 40 CFR Part 191 the U.S. Environmental Protection Agency adopted the assumption that, for each 1000 metric tons of uranium (MTU), cumulative releases at the level allowed by the EPA standard would result in 10 premature deaths from cancer. Because a repository at any of the nominated sites is assumed to accept 70,000 MTU, releases at the level allowed by the standard would produce approximately 700 cancer fatalities.

Table 5-2 shows the tradeoff between preclosure and postclosure cancer fatalities implied by various values of the scaling factors if the releases shown in Table 5-1 are converted to postclosure fatalities under the EPA assumption. Because the EPA relationship between postclosure releases and cancer fatalities probably overestimates the fatalities, the implied value tradeoff is likely to be a lower bound on the relative significance of postclosure fatalities.

Table 5-1. Value tradeoffs between preclosure radiological health effects and postclosure releases implied by various values of the scaling factors k_{pre} and k_{post}

k_{pre}	[a]k_{post}	Postclosure release y deemed as undesirable as 10 preclosure fatalities[b] (fraction of EPA standard[c])
1.0	0.0	—
0.99	0.01	0.38
0.9	0.1	0.03
0.8	0.2	0.02
0.7	0.3	0.01
0.6	0.4	0.006
0.5	0.5	0.004
0.4	0.6	0.003
0.3	0.7	0.002
0.2	0.8	0.001
0.1	0.9	0.0004
0.01	0.99	0.00004
0.0	1.0	—

[a]Since the scaling factors sum to 1, here $k_{post} = 1 - k_{pre}$.
[b]Preclosure cancer fatalities incurred by the public from the repository.
[c]Primary containment requirements of 10 CFR Part 191, Subpart B.

Table 5-2. Value tradeoffs between preclosure and postclosure radiological health effects implied by various values of the scaling factors k_{pre} and k_{post}

k_{pre}	[a] k_{post}	Implied value tradeoff between preclosure and postclosure cancer fatalities
1.0	0.0	—
0.99	0.01	1:26
0.9	0.1	1:2.4
0.8	0.2	1:1.1
0.79	0.21	1:1
0.7	0.3	1.6:1
0.6	0.4	2.5:1
0.5	0.5	3.8:1
0.4	0.6	5.6:1
0.3	0.7	8.8:1
0.26	0.74	10:1
0.2	0.8	15:1
0.1	0.9	34:1
0.01	0.99	372:1
0.0	1.0	—

[a] Since the scaling factors sum to 1, here $k_{post} = 1 - k_{pre}$.

As can be seen from Figures 5-1, 5-2, 5-3 and Figure 5-6, the composite utilities imply that the overall site ranking is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford for all postclosure weights equal to or less than 0.99, provided that postclosure impacts are assumed to be at the base-case level or optimistic (regardless of the preclosure assumptions). Values of k_{post} greater than 0.99 would, according to Table 5-2, imply a willingness to accept more than 350 preclosure cancer fatalities to avoid one postclosure cancer fatality. ~~Most people would probably consider such a high postclosure weight to be unreasonable.~~ If pessimistic assumptions are used for postclosure performance, Yucca Mountain falls out as the overall preferred site when the implied value tradeoff between postclosure and preclosure cancer fatalities is approximately 1:1 (i.e., $k_{post} = 0.21$). ~~It drops from among the top three sites when, under pessimistic assumptions, this implied value tradeoff is such that approximately two preclosure fatalities would be accepted to avoid one postclosure fatality (i.e., $k_{post} = 0.35$).~~

5.2 INITIAL ORDER OF PREFERENCE FOR SITES FOR RECOMMENDATION FOR CHARACTERIZATION

As indicated in Chapters 1 and 2, the purposes of the decision-aiding methodology are to provide insights as to the comparative advantages and disadvantages of the five sites and, in so doing, to determine an initial order of preference for sites for recommendation for characterization. With reference to the postclosure, preclosure, and composite analyses of sites presented previously, the major insights derived from the multiattribute utility analysis are summarized as follows:

Postclosure analysis

- All five sites appear capable of providing exceptionally good radiological protection of future populations for at least 100,000 years after closure.

- The Davis Canyon, Deaf Smith, Richton Dome, and Yucca Mountain sites appear to be virtually indistinguishable in terms of the expected postclosure performance. The Hanford site is just discernibly less favorable than the other four sites, but its performance is still far above the threshold of acceptability established by the EPA. It is noted that the primary containment requirements of the EPA—the criterion of acceptability used here—provide a very stringent standard for protecting public health and safety: the risk to the public is not to exceed the risks that would have existed if the uranium ore used to create the wastes had not been mined to begin with.

- The confidence in the performance of the three salt sites (Davis Canyon, Deaf Smith, and Richton Dome) is exceptionally high, and it is higher than that for the nonsalt sites (Hanford and Yucca Mountain).

- The overall postclosure ranking of Davis Canyon, Richton Dome, Deaf Smith, Yucca Mountain, and Hanford is stable over a wide range of sensitivity analyses.

Preclosure analysis

- With regard to preclosure health and safety, the site rankings are Richton Dome, Deaf Smith, Davis Canyon, Yucca Mountain, and Hanford. The differences among the sites do not appear to be large, however, especially when viewed in the context of the very small incremental risks being imposed on workers and the general public from repository siting, construction, operation (including waste-transportation operations), and closure.

- With regard to environmental and socioeconomic impacts, the site rankings are Hanford, Yucca Mountain, Deaf Smith, Richton Dome, and Davis Canyon. The difference between sites is greater than the difference on health-and-safety impacts. However, this difference is relatively small in comparison with differences in total economic costs.

- With regard to total economic costs, the site rankings are Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford. The difference between the most favorable site and the least favorable site is ~~very large,~~ equal to 4,380 million (4.38 billion) dollars.

- The overall ranking of sites considering all preclosure impacts is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford. This ranking is stable over a wide range of sensitivity analyses.

- The overall preclosure ranking is mainly attributable to the large differences among sites in total economic costs. The fact that cost is the major preclosure discriminator can be explained by the screening process that led to the nominated sites (see Chapter 1). Because criteria used in screening were concerned with health and safety and the environment, but not with economic costs, sites expected to perform poorly on objectives other than costs have already been eliminated. If cost had been a screening criterion as well, the cost variability among the nominated sites would also be smaller.

Composite analysis

- Because the differences in postclosure site performance are very small and the differences in preclosure site performance are relatively large, the overall composite results are largely a reflection of the preclosure impacts.

- The composite overall ranking of sites is basically insensitive to the relative values of the scaling factors, k_{post} and k_{pre}.

- The composite overall ranking under a wide range of assumptions is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford.

It follows, therefore, that the initial order of preference for sites for recommendation for characterization is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford. This ranking is stable except for the most extreme assumptions about postclosure performance combined with the most extreme weightings of postclosure impacts versus preclosure impacts, as explained below.

For all reasonable assumptions and weightings, the Hanford site is ranked last. For all assumptions about postclosure conditions and the wide range assumed to be realistic for the values of the scaling factors (i.e., $k_{post} \leq 0.8$), the ranking of the salt sites is stable; specifically, Richton Dome is preferred to Deaf Smith, which is preferred to Davis Canyon. For pessimistic postclosure assumptions in the composite analysis, Yucca Mountain drops from the first-ranked site to the fourth-ranked site as the postclosure weight increases from approximately 0.2 to 0.35, depending on the preclosure assumptions.

~~The three sites indicated as most preferable by the methodology--Yucca Mountain, Richton Dome, and Deaf Smith--offer maximum diversity in geohydrologic settings but not maximum diversity in rock type. They do, however, meet the requirement of the Nuclear Regulatory Commission for diversity.~~ As explained in Section 2.1, the site-recommendation decision is analogous to a portfolio-selection problem because the DOE is not choosing a single site for repository development; rather, the DOE must choose, from a suite of five well-qualified sites, three sites for site characterization. Combinations of three sites possess properties that cannot be attributed to individual sites, such as diversity of geohydrologic settings and rock types. Thus, the three sites indicated as most preferable by the multiattribute utility analysis reported here do not necessarily constitute the most preferred combination when these portfolio effects are taken into account. The relative advantages of other combinations of three sites as portfolios together with other information the Secretary of Energy believes is important to making the decision are examined in the site-recommendation report.

4.7 CONCLUSIONS FROM THE PRECLOSURE ANA

The previous sections presented results for a base-ca analysis and for numerous sensitivity analyses involving ch in the level of impacts, in the value judgments, and in the of the multiattribute utility function. The conclusions from analyses are ~~as follows~~ described in this section.

The base-case analysis indicates that the relative rank of sites considering all of the preclosure considerations is Yucca Mountain, Richton Dome, Deaf Smith, Davis Can and Hanford. ~~The difference between the first-ranked Yucca Mountain site and the second-ranked Richton Dome site is the same as that between the third-ranked Deaf Smith site and the fourth-ranked Davis Canyon site. The fifth-ranked Hanford site is a distant fifth - more than twice the difference between any of the other adjacent rankings.~~ (see Table 4-1

In terms of expected utility points, where one utile is equivalent to 200 million dollars, the (rounded) difference ~~is~~ between Yucca Mountain and Richton Dome is 5.6 between Richton Dome and Deaf Smith 3.2, between Deaf Smith and Davis Canyon 5.6, and between Davis Canyon and Hanford ~~is~~ 12.8. Thus the most significant difference between the five sites is between the fourth-ranked Davis Canyon and the fifth-ranked Hanford site. The ~~very large~~ difference ~~between the top four sites and the Hanford site~~ is largely attri to the influence of repository and transportation costs. ~~In fact~~ If rep

The relative ranking obtained for the base-case is almost completely insensitive to any changes in either the technical or value judgments, except to costs.

The stability of the base-case results were [tested] by extensive sensitivity analyses. The ~~results~~ relative ranking obtained in the base case is almost completely insensitive to any changes in the technical or value judgments, except for costs. If one could argue that the costs associated with the Hanford site would somehow decrease while the costs for all the other sites would increase, then the Hanford site could ~~would~~ be competitive.

The probability ~~likelihood~~ of this with regard to transportation costs is obviously ~~extremely~~ low since Hanford is the farthest site from the sources of waste. The probability of this scenario with regard repository costs is more uncertain, given the uncertainty in site conditions and consequently repository design prior to the sinking of exploratory shafts. However, Sev site characteristics ~~make the~~ and much mining experience with salt and some at-depth experience in existing tunnels nearby under conditions similar to those expected at Yucca Mountain make the scenario unlikely with regard to repository costs. For example, the basalt at Hanford is ~~much~~ harder than the other rock types under consideration, requiring labor-intensive, low-productivity mining techniques. The depth, stress conditions, ~~relatively~~ high temperature ~~and~~ potential for large groundwater inflows at repository depth ~~[illegible]~~ coupled with ~~[illegible]~~ little underground construction experience, all contribute to the high repository cost estimates. These conditions do not appear ~~[illegible]~~ subject to great

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4.7 CONCLUSIONS FROM THE PRECLOSURE ANALYSIS

¶ The previous sections presented results for a base-case analysis and for numerous sensitivity analyses. The conclusions from these analyses are described in this section.

¶ The base-case analysis indicates that the relative rankin of sites considering all preclosure considerations is Yucca Mountai Richton Dome, Deaf Smith, Davis Canyon, and Hanford. In terms of expected utility points, where one utile is equivalent to 200 mill dollars, the (rounded) difference between Yucca Mountain and Rich is 5.6, between Richton Dome and Deaf Smith 3.2, betwe Deaf Smith and Davis Canyon 5.6, and between Davis Can and Hanford 12.8. Thus the largest difference between the five is between the fourth-ranked Davis Canyon and the fifth-ranked Hanford site. This difference is attributable to the influence . repository and transportation costs. In fact, if costs were tota ignored, the Hanford site would be the first-ranked site on prec considerations.

¶ The stability of the base-case results was tested | sensitivity analyses involving changes in the level of impacts, in value judgments, and in the form of the multiattribute util function itself. The relative ranking of sites obtained in t base case is totally insensitive to any changes in the level impacts, except for costs. The ranking is insensitive to any c in the value judgments or in the form of the utility function

¶ If one could argue that the costs associated with the Hanfor site could, somehow, decrease significantly while the costs for other sites simultaneously ~~...~~ increase significantly, then the Hanford site w be a competitor. The probability of ~~this scenario with reg.~~ to transportation costs is obviously extremely low since costs are a strong function of Hanfo is the farthest from the sources of waste. The probability o this scenario with regard to repository costs is more uncerta given the uncertainty in site conditions, regulatory requirements, etc. and consequently reposito

design prior to the sinking of exploratory shafts and in-situ testi
However, several factors suggest that the Hanford-low and other-site cost scenario is also unlikely. First, extensive underground con experience in salt and some experience in other excavations in t at the Nevada Test Site suggest that the potential for major geologic surpr a major cause for cost escalations in underground construction -- i relatively low (in salt and tuff) compared to the Hanford site. Second, some [redacted]

of the (adverse) factors that contribute (significantly) to the high cost estimates for the Hanford site are not likely improve after site characteri e.g., labor intensive, low mining productivity ~~due to rock hardness~~ due to underground conditions

Chapter 4

PRECLOSURE ANALYSIS OF THE NOMINATED SITES

This chapter presents a preclosure analysis of the five sites nominated as suitable for characterization. Section 4.1 presents the objectives defined for the evaluation of the sites. Section 4.2 defines a performance measure for each objective to indicate the degree to which the five sites achieve the objectives. Section 4.3 describes the performance of each site in terms of a set of performance measures. Section 4.4 discusses the multiattribute utility function assessed to integrate the ratings on the different performance measures into an overall evaluation of the sites. The results of the base-case evaluation and numerous sensitivity analyses are presented in Sections 4.5 and 4.6, respectively.

4.1 THE OBJECTIVES HIERARCHY

The perspective taken in this analysis is that the sites should be evaluated in terms of minimizing adverse preclosure impacts. This requires that the set of objectives characterize in an operational manner the meaning of "adverse preclosure impacts." Specifically, the preclosure guidelines (10 CFR 960.5) specify the factors to be considered in evaluating and comparing sites on the basis of expected repository performance before closure. The preclosure guidelines specify three categories of factors: radiological safety; environment, socioeconomics, and transportation; and ease and cost of siting, construction, operation, and closure.

The preclosure guidelines were used as the basis for constructing the set of objectives represented by the objectives hierarchy in Figure 4-1. A combination of a top-down and botton-up approach was used to develop the objectives hierarchy shown. In the top-down approach, members of DOE management identified in Appendix A were asked to make explicit the most general values bearing on the ranking of the sites for the site-characterization decision. It was decided to make anticipated site performance the fundamental basis for site ranking. The most general values bearing on site performance were then identified (e.g., health, environmental quality, socioeconomic welfare, and economic costs). These general values were then made more specific by asking what was meant by each, why it was important, how it might be affected by site selection, and so forth. Criteria of completeness, nonredundancy, significance, operationality, and decomposability were then applied to refine and improve the specification of lower-level objectives. The bottom-up approach involved working with DOE technical staff to generate lists of evaluation criteria using the siting guidelines, the "Supplementary Information" and Appendix IV to the guidelines. The identified criteria were then organized in a hierarchical fashion and refined.

The Hanford site is least favorable in the categories of public health, worker health, and economic cost; it is most favorable in terms of environmental and socioeconomic impacts. However, in comparison with Yucca Mountain, a tremendous relative weight would need to be placed on equivalent socioeconomic impacts for the sites to be close to equally desirable. Specifically, for Hanford to be competitive with Yucca Mountain, it would be necessary for the value tradeoffs to indicate a willingness to increase total fatalities by over 30 and costs by over 5 billion dollars in order to decrease the equivalent socioeconomic impact by 9 percent of the maximum impact. Such value tradeoffs seem unreasonable. For Hanford to be competitive with any of the salt sites, the value tradeoffs would need to indicate a willingness to increase total fatalities by over 25 and costs by over 2.5 billion dollars to reduce socioeconomic impacts by 39 percent of the maximum impact. The necessary value tradeoffs would need to be even more extreme to compete with the best two of the three sites in salt. The implication is that, subject to the impact data on the sites, it seems unlikely that ~~any~~ many viewpoints would be consistent with the value tradeoffs necessary for Hanford to be a competitive site on preclosure considerations.

The same logic as above suggests that the most favorable of the five nominated sites on preclosure considerations is Yucca Mountain. Of the four remaining sites (i.e., all candidates except Hanford), Yucca Mountain is most favorable in terms of worker fatalities, environmental and socioeconomic impacts, and economic costs. Because of the possibility of transportation accidents involving the public, Yucca Mountain has six more statistical public fatalities than has the site with the fewest public fatalities (i.e., Richton Dome). When public and worker fatalities are combined, Yucca Mountain has the fewest (equal to the number at Richton Dome) of all sites. Hence, if the value tradeoffs indicate that six public fatalities due to transportation accidents are less important than (1) six worker fatalities, (2) over 10 percent additional equivalent socioeconomic impact relative to the maximum, and (3) over 1 billion dollars of cost, the most favorable site is Yucca Mountain. Most viewpoints would be consistent with such values.

As a consequence of the above, the salt sites would be expected to fall between the most favorable site (Yucca Mountain) and the least favorable site (Hanford). Among these, the Davis Canyon site is dominated by the Richton Dome site and essentially dominated by the Deaf Smith site. That is to say, Davis Canyon is less favorable than Richton Dome in terms of public fatalities, worker fatalities, environmental and socioeconomic impacts, and economic costs. Davis Canyon is less favorable than Deaf Smith in terms of public fatalities, environmental and socioeconomic impacts, and economic costs, and only very slightly better in terms of worker fatalities. Regardless of the value tradeoffs among these categories, Davis Canyon must be less preferred on preclosure considerations than the other salt sites for almost any set of values.

Comparing Richton Dome and Deaf Smith, it is clear that Richton Dome is preferred to Deaf Smith with respect to both public and worker fatalities and economic costs, whereas Deaf Smith is preferred on environmental and socioeconomic impacts. If the 4 percent of equivalent socioeconomic impacts by which Richton Dome exceeds Deaf Smith is less important than (1) two additional public fatalities, (2) two additional worker fatalities, and (3)

650 million dollars, then the Richton Dome site is preferred to Deaf Smith. Value judgments representing most viewpoints would be consistent with this conclusion.

In summary, with the aggregation of impacts shown in Table 4-8, which are based on relatively noncontroversial value tradeoffs, a preclosure ranking of sites that would be consistent with a wide variety of viewpoints is Yucca Mountain first, followed by Richton Dome, Deaf Smith, Davis Canyon, and Hanford.

4.5.2 BASE-CASE ANALYSIS

The aggregate analysis may, for many individuals, produce sufficient insight to develop a reasonable ranking of the nominated sites. It is nevertheless worthwhile to present the complete base-case analysis for three reasons:

- o To verify the implications of the aggregate base-case analysis.
- o To gain additional insights, especially through answers to "what if" questions asked of the analysis.
- o To illustrate the methodology so that other parties may examine the implications of different data and of different sets of value judgments felt to be appropriate for the problem.

The presentation of the base-case analysis is intended to indicate exactly what conclusions follow from which impact data and value judgments and why.

Table 4-9 uses the component disutility functions in Table 4-7 to convert the base-case estimates of impacts for each site to component disutilities. These can be easily substituted into the utility function (Equation 4-1) or the equivalent-consequence function (Equation 4-3) to evaluate the sites. The component disutilities are identical with the base-case estimates of impacts in Table 4-6 except for the environmental and socioeconomic performance measures. To calculate the equivalent consequence for a site, Equation 4-3 is used. For each site, the appropriate K_i value from Table 4-7 is multiplied by the appropriate C_i value from Table 4-9 to obtain the equivalent-consequence impacts for each performance measure in Table 4-10. The results are summed by using Equation 4-3 for each site to get the overall equivalent consequence shown at the bottom of Table 4-10. The expected utility calculated using Equation 4-1 for each site is also provided. Before examining these results, it is important to understand where they come from, which is illustrated by considering the consequence-equivalent numbers in Table 4-10 for the Richton Dome site.

In Table 4-9, the number of nonradiological public fatalities from transportation to Richton Dome, represented by performance measure X_8, is 5.3. In Table 4-7, the value tradeoff K_8 between units of this performance measure and costs is 4, indicating that 4 million dollars in additional cost is indifferent to a statistical nonradiological public fatality from

Table 4-9. Base-case component disutilities of nominated sites[a]

Performance measure	Richton Dome	Deaf Smith	Davis Canyon	Yucca Mt.	Hanford
X_1	2	2	2	4	9
X_2	0.7	0.5	0.1	0.1	0.7
X_3	27	29	27	18	43
X_4	0	0	0	0	0
X_5	0.52	0.64	0.73	0.81	0.90
X_6	2.4	2.9	3.5	4.1	4.3
X_7	1.3	1.6	2.1	2.5	2.7
X_8	5.3	6.7	8.4	10.2	11
X_9	33	33	100	33	3
X_{10}	6	12	56	23	6
X_{11}	15	12	29	10	12
X_{12}	20	16	20	6	3
X_{13}	9,000	9,500	10,400	7,500	12,900
X_{14}	970	1,120	1,240	1,400	1,450

[a]Component disutilities are calculated by substituting the base-case estimates of impacts shown in Table 4-6 into the component disutility function in Table 4-7.

transportation. Hence, the 5.3 fatalities is multiplied by the 4 million dollars per fatality to yield a 21.2 contribution to the equivalent-consequence impact associated with performance measure X_8 for the Richton Dome site (Table 4-10). Regarding the socioeconomic impact X_{12} at Richton, the performance measure level 2 in Table 4-5 describes that impact. This has a disutility of 20, as shown in Table 4-9. The value tradeoff K_{12} for a unit (i.e., percent) of socioeconomic impact is 5 million dollars, as indicated in Table 4-7. Multiplying 20 by 5 yields the contribution of 100 to the equivalent-consequence impact for performance measure X_{12} in Table 4-10. The rest of the entries in Table 4-10 in the column for the Richton Dome site can be calculated similarly. Summing the equivalent-consequence contributions for the Richton Dome site for the 14 preclosure performance measures yields the value 10,173 in Table 4-11.

It is clear from Table 4-10 that the Yucca Mountain site is the most favorable of the five sites. The salt sites follow in the order Richton Dome, Deaf Smith, and Davis Canyon. These four sites are all significantly more favorable in terms of equivalent consequences than the Hanford site. In interpreting the differences in equivalent consequences, recall that one unit is equal in value to 1 million dollars.

Table 4-11 aggregates the information in Table 4-10 in numerous ways to gain insights into the reasons for the relative site evaluations. The first four rows aggregate the implications of the sites for the performance measures on health and safety, environmental impacts, socioeconomics, and economic costs, respectively. For instance, the sum of the first eight rows in Table 4-10 provides the equivalent-consequence contribution from health-and-safety impacts (row 1). For Yucca Mountain, the equivalent consequence is 83. Row 5 of Table 4-11 aggregates all noneconomic impacts, and row 6 aggregates the environmental and socioeconomic impacts.

Row 7 aggregates the impacts that might be collectively considered as the detrimental impacts on the public living near the repository site. It includes the health-and-safety impacts and the environmental and socioeconomic impacts experienced by the public near the site. Row 8 includes the health-and-safety impacts on the workers at the repository. Hence, row 8 might be considered an aggregation of the total impact felt by all members of the community near a site.

Rows 9, 10, and 11 indicate different aspects of the health and safety implications. Specifically, row 9 refers to the equivalent-consequence impacts of worker fatalities, row 10 refers to the equivalent-consequence impacts of public fatalities, and row 11 refers to the equivalent-consequence impacts of radiological health effects.

Rows 12 and 13 are included because of their potential usefulness in sensitivity analysis. Row 12 aggregates all the health and safety and cost impacts of the different sites, and row 13 aggregates all the impacts except for facility costs X_{13}.

Table 4-10. Base-case equivalent-consequence impacts

Performance measure	Richton Dome	Deaf Smith	Davis Canyon	Yucca Mt.	Hanford
X_1	2	2	2	4	9
X_2	2.8	2	0.4	0.4	2.8
X_3	27	29	27	18	43
X_4	0	0	0	0	0
X_5	0.52	0.64	0.73	0.81	0.90
X_6	9.6	11.6	14	16.4	17.2
X_7	1.3	1.6	2.1	2.5	2.7
X_8	21.2	26.8	33.6	40.8	44
X_9	33	33	100	33	3
X_{10}	1.2	2.4	11.2	4.6	1.2
X_{11}	4.5	3.6	8.7	3.0	3.6
X_{12}	100	80	100	30	15
X_{13}	9,000	9,500	10,400	7,500	12,900
X_{14}	970	1,120	1,240	1,400	1,450
Total equivalent impact	10,173	10,813	11,940	9,054	14,492
Expected Utility	70.13	66.94	61.30	75.73	48.54

Table 4-11. Base-case equivalent-consequence impacts for various aggregations of performance measures[a]

Row	Performance measures	Richton Dome	Deaf Smith	Davis Canyon	Yucca Mt.	Hanford
1	Health and Safety: X_1-X_8	64	74	80	83	120
2	Environmental: X_9-X_{11}	39	39	120	41	8
3	Socioeconomics: X_{12}	100	80	100	30	15
4	Economic: X_{13}-X_{14}	9,970	10,620	11,640	8,900	14,350
5	Noncost: X_1-X_{12}	203	193	300	154	142
6	Environment and Socioeconomics: X_9-X_{12}	139	119	220	71	23
7	Public near Site: X_2, X_4, X_9-X_{12}	142	121	220	71	26
8	Site Impacts: X_1-X_4, X_9-X_{12}	171	152	249	93	78
9	Worker Fatalities: X_1, X_3, X_5, X_7	31	33	32	25	56
10	Public Fatalities: X_2, X_4, X_6, X_8	34	40	48	58	64
11	Radiological Fatalities: X_1, X_2, X_5, X_6	15	16	17	22	30
12	Fatalities and Costs: X_1-X_8, X_{13}-X_{14}	10,034	10,694	11,720	8,983	14,470
13	All except Repository Cost: X_1-X_{12}, X_{14}	1,173	1,313	1,540	1,554	1,592
14	All X_1-X_{14}	10,173	10,813	11,940	9,054	14,492

[a]The numbers in the table represent consequence-equivalent impacts rounded to the nearest unit.

4.5.3 SUMMARY OF THE BASE-CASE ANALYSIS

A few implications are readily apparent from the base-case analysis. From Table 4-9, the Richton Dome and the Deaf Smith sites dominate the Davis Canyon site on all performance measures except X_2 and X_3. This means that the ratings for both Deaf Smith and Richton Dome are at least as high and sometimes higher than the corresponding rating for the Davis Canyon site on all other performance measures. When the consequence-equivalent impacts are aggregated into health-and-safety, environmental, socioeconomic, and cost impacts, the Richton Dome site and the Deaf Smith site dominate the Davis Canyon site. Hence, the Davis Canyon site is the least favorable salt site given acceptance of the base-case impacts.

Another implication of the base-case analysis is that the Yucca Mountain site has a lower equivalent consequence than any of the salt sites. It is the equivalent of 1,119 million dollars more desirable than the most favorable salt site (i.e., Richton Dome) and 2,886 million dollars more desirable than the least favorable salt site (i.e., Davis Canyon). The Yucca Mountain site is the equivalent of 5,438 million dollars more favorable than the Hanford site.

Table 4-12 aggregates and ranks the sites in terms of performance-measure categories. The first column shows that the overall ranking of the sites is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford. The rankings in Table 4-12 clearly demonstrate that no changes in the value tradeoffs (i.e., scaling factors) between the different categories of performance measures could change the relative ranking of Davis Canyon as the least desirable of the salt sites. The Richton Dome site should be preferred to the Deaf Smith site unless a very high value is placed on environmental and socioeconomic impacts versus health-and-safety impacts and costs. Similarly, only an extremely high value on the environmental and socioeconomic impacts versus the others could possibly result in Hanford being anything but last.

However, one must be careful not to misinterpret the significance of a ranking. With the ranking, the difference in desirability between sites ranked first and third could be much less than the difference in desirability between sites ranked third and fifth. Indeed, this is the case with the rankings in Table 4-12, as can be seen from row 14 of Table 4-11. Here, the difference between the first-ranked Yucca Mountain site and the third-ranked Deaf Smith site is equivalent in value to 1,759 million dollars, whereas the difference between the third-ranked site (Deaf Smith) and the fifth-ranked Hanford site is equivalent in value to 3,679 million dollars.

4.6 SENSITIVITY ANALYSES

There are of course numerous sensitivity analyses that can be conducted to appraise which of the impacts and value judgments seem critical to any implications drawn from the analysis. Below several sensitivity analyses are presented to address the main factors that may influence these implications. The first set of sensitivity analyses focuses on changes in the impacts from

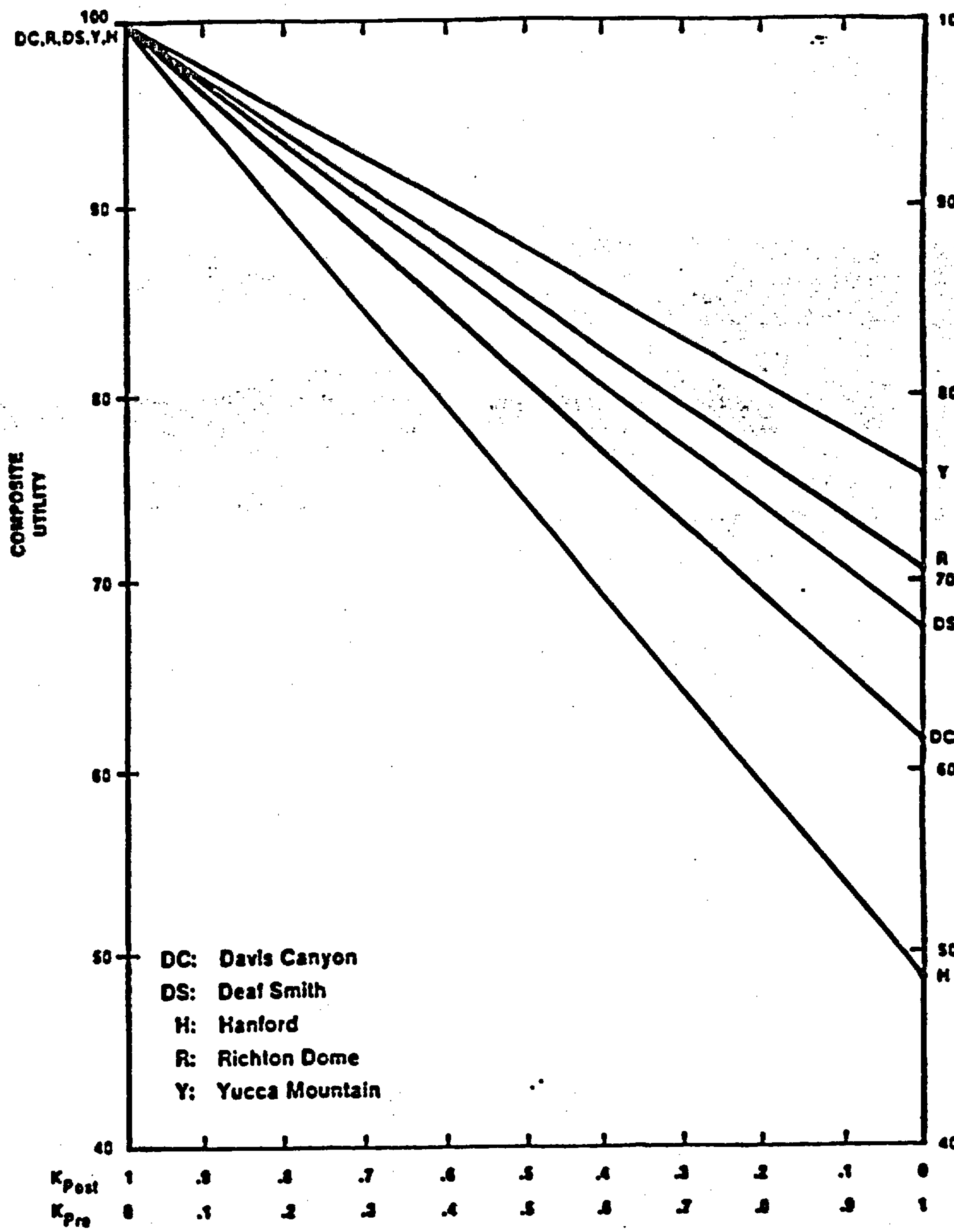

Figure 5.1. Site composite utilities for all possible preclosure-postclosure weightings calculated using base-case and nominal assumptions.

Figures 5-3 through 5-6 show composite utilities for the five sites when assumptions other than base-case assumptions are used. Figure 5-3 shows the results when optimistic assumptions (high scores and low probabilities for disruptive and unexpected features scenarios) are used for postclosure and optimistic assumptions (low impact levels) are used for preclosure. Figure 5-4 shows the results when pessimistic assumptions (low scores and high probabilities for disruptive and unexpected features scenarios) are used for postclosure and pessimistic assumptions (high impact levels) are used for preclosure. Figures 5-5 and 5-6 show the mixed cases in which optimistic or pessimistic assumptions are adopted for the postclosure analysis and the reverse assumption is adopted for preclosure.

Although the weights of k_{pre} and k_{post} at which the overall ranking changes depends on whether base-case, pessimistic, or optimistic assumptions are adopted, certain patterns are clear and stable under a wide range of assumptions. Most significantly, the Hanford site is in all cases ranked last (i.e., it has the lowest composite utility), regardless of the relative weight assigned to preclosure and postclosure. This is so because it is ranked last for all sets of assumptions in both preclosure and postclosure. The relative ranking among the salt sites (Richton Dome, Deaf Smith, Davis Canyon) remains the same regardless of whether base-case, optimistic, or pessimistic assumptions are adopted unless a very high weight is assigned to postclosure, in which case the salt sites have composite utilities that are nearly equal. Yucca Mountain is the site that is affected most significantly by the choice of pessimistic, base-case, or optimistic assumptions. Under pessimistic assumptions for postclosure performance, Yucca Mountain receives a lower expected postclosure expected utility due to the possibility of ~~relatively large~~ releases from a repository at the site under a disruptive scenario involving a magmatic event. If pessimistic assumptions are adopted for postclosure, then Yucca Mountain is ranked first only if the scaling factor k_{post} is less than about 0.2; it is ranked in the top three only if k_{post} is less than about 0.35. Under base-case or optimistic assumptions for postclosure, Yucca Mountain is ranked first across nearly the entire ranges of k_{pre} and k_{post}.

Because of the sensitivity of the ranking of Yucca Mountain to the relative weights of k_{pre} and k_{post}, it is of interest to consider the reasonableness of different weights. As in the case with the scaling factors used in Chapters 3 and 4, the scaling factors k_{pre} and k_{post} must be based on a value judgment; in this case a value tradeoff between performance in postclosure and performance in preclosure. To judge whether particular numerical values for k_{pre} and k_{post} are reasonable it is necessary to select convenient measures for summarizing preclosure and postclosure performance and to consider whether the tradeoffs between these measures are reasonable. This tradeoff is most conveniently considered in terms of preclosure and postclosure radiological safety. Specifically, if preclosure radiological safety is expressed in terms of public cancer fatalities and postclosure radiological safety is expressed in terms of cumulative releases, the value tradeoff may be expressed as postclosure releases y (occurring in the first 10,000 years) that would be just as undesirable as the occurrence of 10 additional preclosure cancer fatalities. Table 5.1 shows the weights k_{pre} and k_{post} corresponding to several different tradeoffs. These were calculated using the following steps:

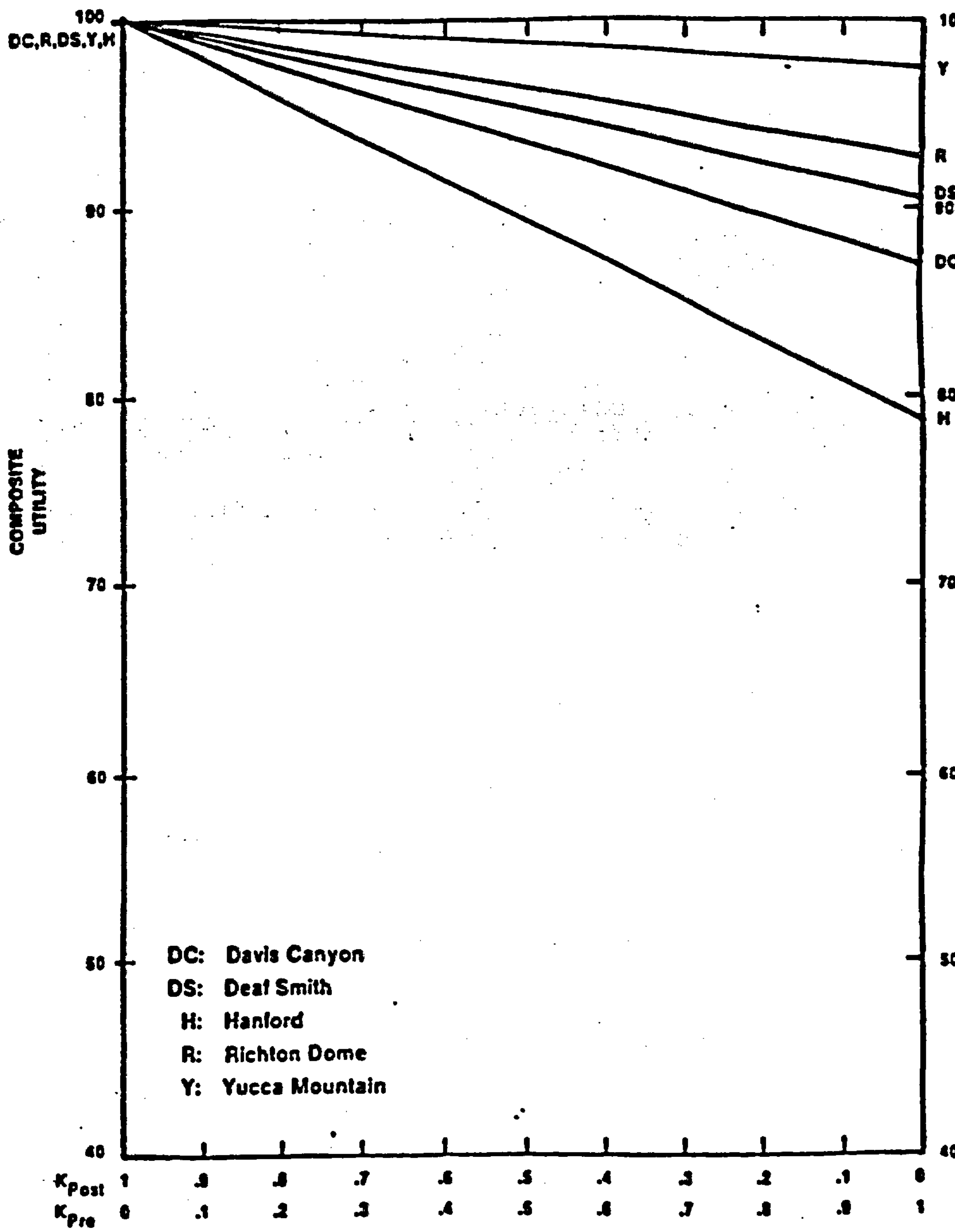

Figure 5.3. Site composite utilities calculated using optimistic assumptions for postclosure and preclosure.

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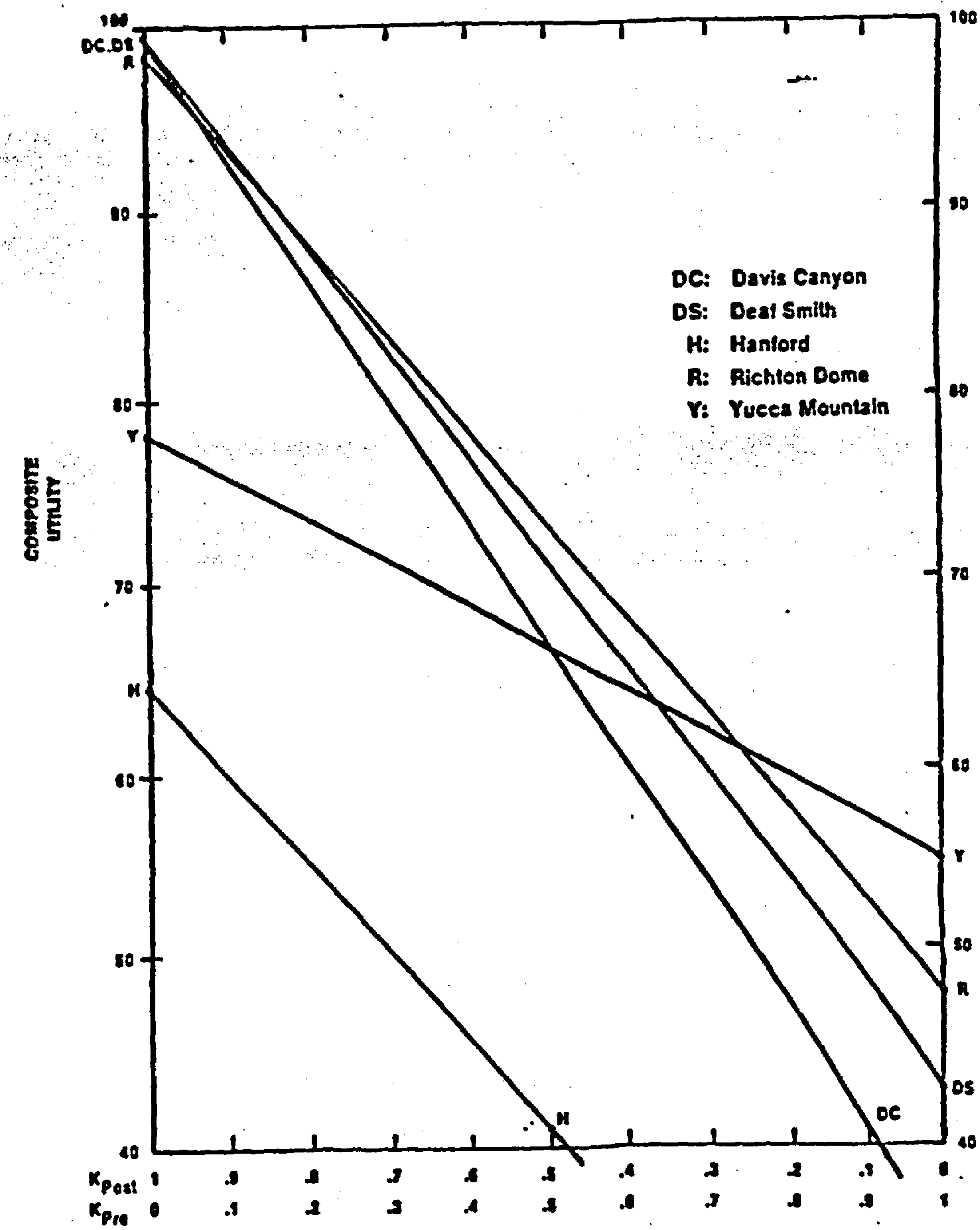

Figure 5.4. Site composite utilities calculated using pessimistic assumptions for postclosure and preclosure.

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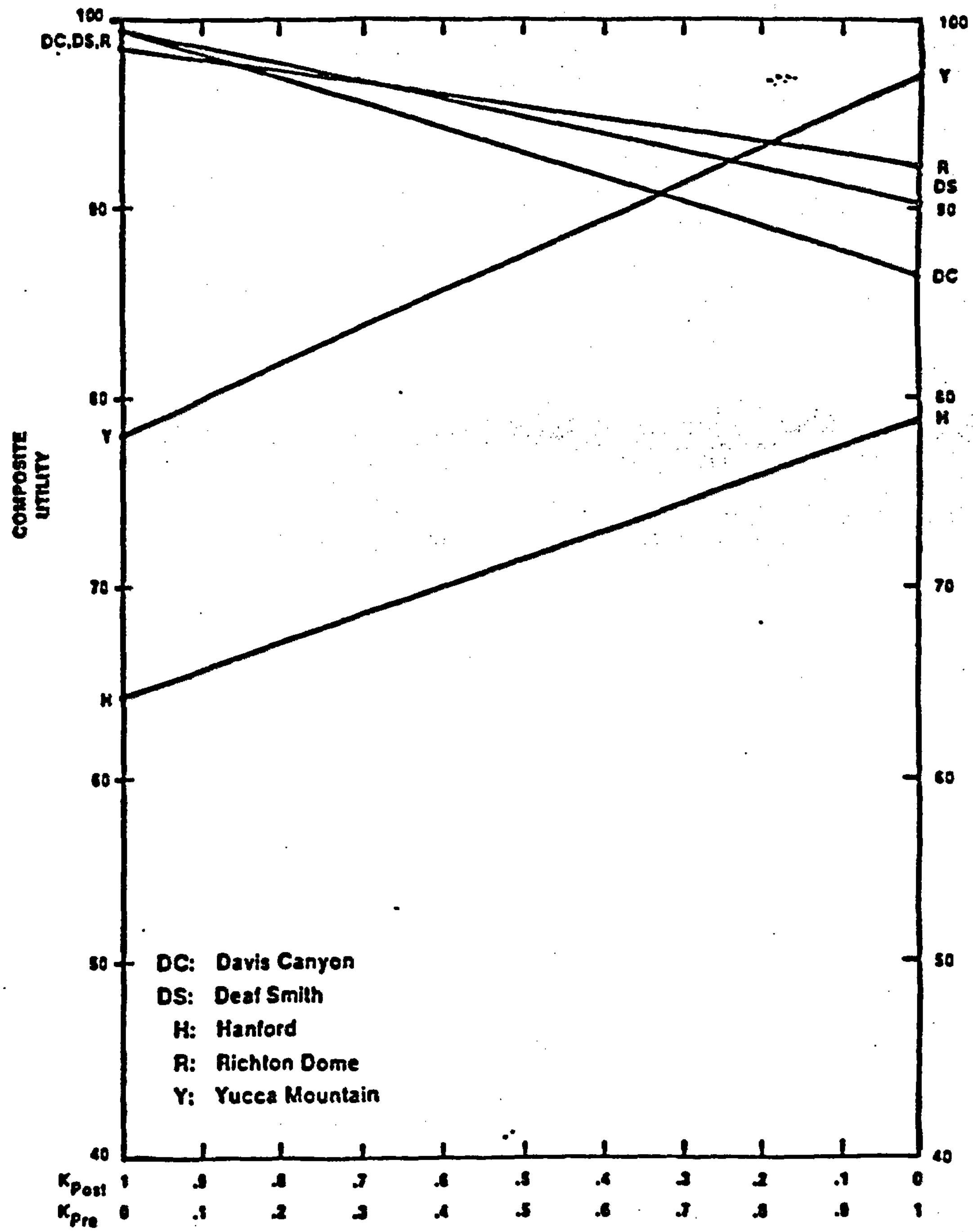

Figure 5.5. Site composite utilities calculated using pessimistic assumptions for postclosure and optimistic assumptions for preclosure.

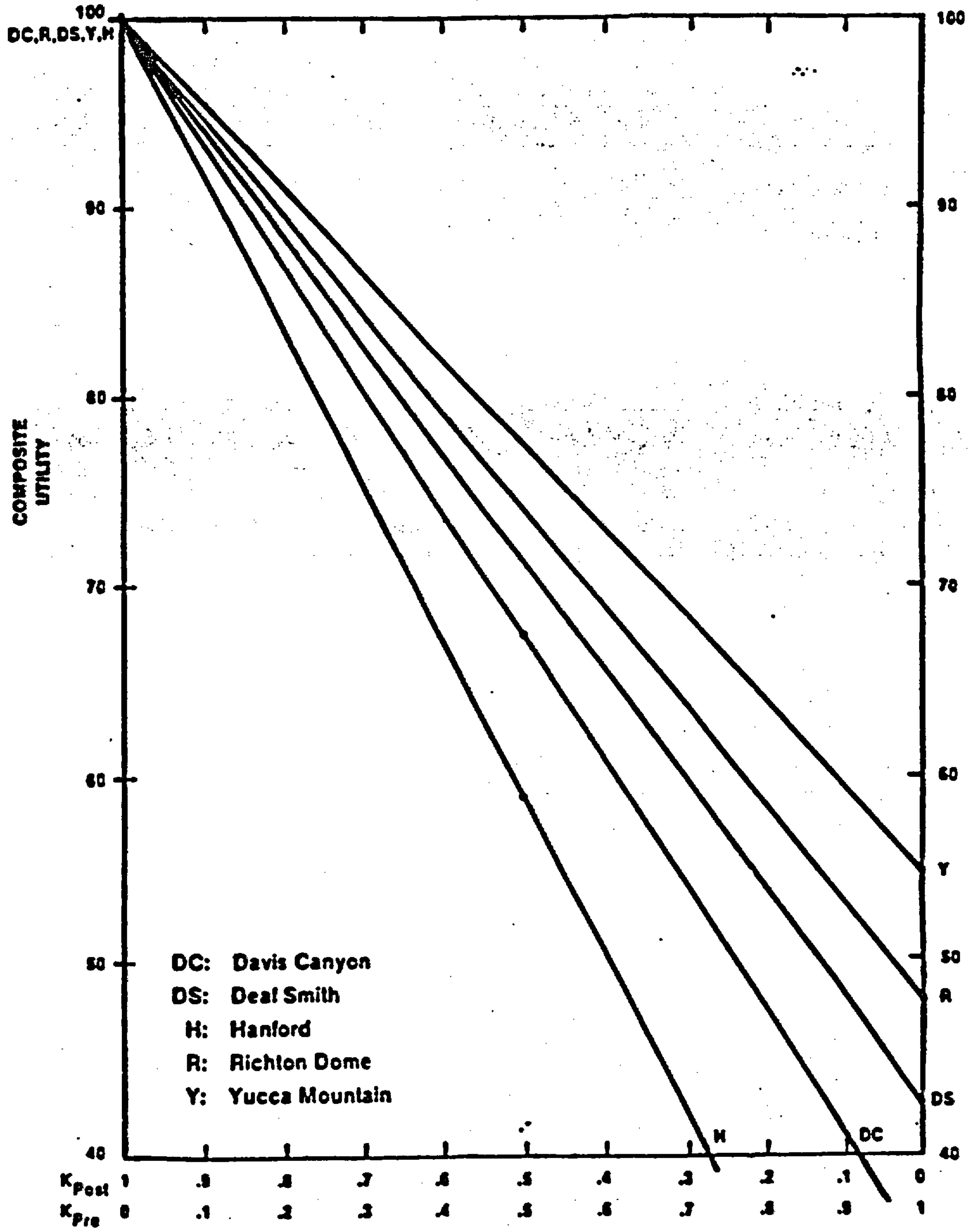

Figure 5.6. Site composite utilities calculated using optimistic assumptions for postclosure and pessimistic assumptions for preclosure.

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Table 5-1. Value Tradeoffs Between Preclosure Radiological Health Effects and Postclosure Releases Implied by Various k_{pre} and k_{post}

k_{pre}	k_{post} (= $1-k_{pre}$)	Postclosure releases y valued as undesirable as 10 preclosure public cancer fatalities (fraction of EPA standard)
1.0	0.0	-
0.99	0.01	0.38
0.9	0.1	0.03
0.8	0.2	0.02
0.7	0.3	0.01
0.6	0.4	0.006
0.5	0.5	0.004
0.4	0.6	0.003
0.3	0.7	0.002
0.2	0.8	0.001
0.1	0.9	0.0004
0.01	0.99	0.00004
0.0	1.0	-

1. The decrease in preclosure utility due to an additional ten public cancer fatalities is calculated using Equation 4-1 to be (1/200)(4)(10) = 0.2.

2. The decrease in postclosure utility due to an additional release y during the first 10,000 years is calculated using Equation 3-3 to be (0.526)(100)(y) = 52.6y.

3. The tradeoff of postclosure versus preclosure implies that each of the above changes produce the same decrease in composite utility. From Equation 5-1, therefore,

$$k_{pre}(0.2) = k_{post}(52.6y)$$

which implies

$$y = 0.0038 \frac{k_{pre}}{k_{post}}$$

The entries in Table 5-1 indicate the releases y (expressed as fractions of the EPA standard) that would be regarded as equally undesirable as 10 preclosure public radiological fatalities for various weights k_{pre} and k_{post}.

The reasonableness of the various value tradeoffs presented in Table 5-1 may be interpreted more easily if a relationship is assumed between postclosure releases to the accessible environment and postclosure health effects. As noted in Chapter 3, 40 CFR 190 adopted the assumption that for each 1,000 metric tons of heavy metal (MTHM), cumulative releases at the level allowed by the EPA standard would result in 10 premature cancer deaths. Because a repository at any of the nominated sites is assumed to be designed to hold 70,000 MTHM, releases at the level allowed by the standard would produce approximately 700 cancer fatalities. Table 5-2 shows the tradeoff between preclosure and postclosure cancer fatalities implied by various k_{pre} and k_{post} if the releases shown in Table 5-1 are converted to postclosure fatalities using the EPA assumption. Because the EPA relationship between postclosure releases and radiological fatalities likely overestimates these fatalities, the implied value tradeoff likely is a lower-bound on the actual relative significance given to postclosure fatalities.

As may be seen from Figures 5-1 to 5-3 and Figure 5-6, the composite utilities imply an overall site ranking of Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford for all $k_{post} \leq 0.99$ provided that postclosure impacts are assumed to be base-case or optimistic (regardless of the preclosure assumptions). Values of k_{post} greater than 0.99 would, according to Table 5-2, imply a willingness to accept more than 350 preclosure cancer fatalities to avoid one postclosure cancer fatality. Most people would probably view such a high postclosure weight to be unreasonable. If pessimistic assumptions are used for postclosure performance, Yucca Mountain falls out as the preferred overall site when the implied value tradeoff between postclosure and preclosure radiological fatalities is approximately one-to-one (i.e., $k_{post} = 0.21$). It drops from among the top three sites, under pessimistic assumptions, when this implied value tradeoff is such that approximately 2 preclosure fatalities would be accepted to avoid 1 postclosure fatality (i.e., $k_{post} = 0.35$).

Table 5-2. Value Tradeoffs Between Preclosure and Postclosure Radiological Health Effects Implied by Various k_{pre} and k_{post}

k_{pre}	k_{post} (= $1-k_{pre}$)	Implied Value Tradeoff Between Preclosure and Postclosure Cancer Fatalities
1.0	0.0	-
0.99	0.01	1:26
0.9	0.1	1:2.4
0.8	0.2	1:1.1
0.79	0.21	1:1
0.7	0.3	1.6:1
0.6	0.4	2.5:1
0.5	0.5	3.8:1
0.4	0.6	5.6:1
0.3	0.7	8.8:1
0.26	0.74	10:1
0.2	0.8	15:1
0.1	0.9	34:1
0.01	0.99	372:1
0.0	1.0	-

5.2 INITIAL ORDER OF PREFERENCE FOR SITES FOR RECOMMENDATION FOR CHARACTERIZATION

The overall rankings presented in the previous sections suggest that the initial order of preference for sites for recommendation for characterization is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford. This ranking is stable for all but the most extreme assumptions on postclosure performance and the most extreme weightings of postclosure considerations versus preclosure considerations, as explained below.

For all assumptions and weightings, the Hanford site remains ranked last. For all assumptions about postclosure conditions and the wide range assumed to be realistic for weights (i.e., $k_{post} \leq 0.8$), the relative ranking of the salt sites is stable; specifically, Richton Dome is preferred to Deaf Smith which is preferred to Davis Canyon. For pessimistic postclosure assumptions, Yucca Mountain drops from first ranked to fourth ranked as the postclosure weight increases from approximately 0.2 to 0.35 depending on the preclosure assumptions.

The clear implication from the composite analysis is that Yucca Mountain, Richton Dome, and Deaf Smith are the preferred set of sites for characterization. There are no realistic assumptions about either preclosure or postclosure expected performance or about the values used to evaluate performance that can result in the Hanford site being anything but the last ranked site. The significance of the performance differences between the Hanford site and all the other sites is substantial. Similarly, the Davis Canyon site is less preferred than the Richton Dome and Deaf Smith sites for essentially all realistic assumptions. The differences in performance of the Davis Canyon site and the other two salt sites is also substantial, even though the Davis Canyon is much preferred to the Hanford site in the analysis. Only for some extreme cases (i.e., pessimistic postclosure assumptions) could one argue directly from the analysis that the three sites to be characterized should be Richton Dome, Deaf Smith, and Davis Canyon. However, the Nuclear Regulatory Commission requires that at least one of the sites characterized not have salt as the host rock. Thus, it can be definitively stated that the results of the composite analysis strongly suggest characterization of the Yucca Mountain, Richton Dome, and Deaf Smith sites.

The combination of the Yucca Mountain, Richton Dome, and Deaf Smith sites offers maximum diversity in geohydrologic settings. The Yucca Mountain site is unique among these sites because a repository would be constructed in the unsaturated zone. The advantages of disposing waste in thick unsaturated zones have been noted in the literature for over a decade. A major advantage is the very slow flux of ground water that probably exists at Yucca Mountain. Another is that the underground facility can be designed so as to allow only minimal contact of the water with the waste packages. Still another is that underlying tuffs contain sorptive zeolites and clays that could act as additional barriers to the downward transport of radionuclides from a repository to the water table.

The geohydrologic settings associated with the Richton Dome and Deaf Smith sites are also clearly distinguishable from another, but not as obviously as from Yucca Mountain. Richton Dome is similar in many respects to

Deaf Smith because both have salt as a host rock, but Richton Dome is a piercement structure of uniform properties surrounded by sedimentary materials. The dome is surrounded by aquifers at different depths. The bedded-salt setting at the Deaf Smith site is underlain by relatively horizontal bedded sedimentary rocks capped by the Ogallala Formation. The geohydrologic system is dominated by the High Plains aquifer. Minor aquifers of poor water quality occur in deeper strata, nearer to the salt units. The advantages of salt as a host rock for the disposal of radioactive waste have been documented elsewhere many times, including those summarized in Section 1.2.2.

The Yucca Mountain, Richton Dome, and Deaf Smith sites do not offer maximum diversity in rock type. They do, however, meet the requirement of the Nuclear Regulatory Commission for diversity. As was explained in Section 2.1, the site-recommendation decision is analogous to a portfolio problem since the DOE must choose, not a single site for repository development, but three from five well-qualified sites for site characterization and related nongeologic data gathering. Combinations of three sites possess properties that cannot be attributable to single sites (e.g., diversity of geohydrologic settings and rock types). Thus, the set of three sites indicated as most preferable by the multiattribute utility analysis may not be the preferred set when these portfolio effects are taken into account together with the implications of this analysis. For the sites recommended for characterization to change from those suggested in the composite analysis, the relative advantages of the portfolio effects for the changed set would have to be judged to be greater than the relative advantages of the expected superior performances of the Yucca Mountain, Richton Dome, and Deaf Smith sites over the Davis Canyon and Hanford sites. These differences in performance range from the equivalent of 1 to 5 billion dollars in preclosure impacts in addition to postclosure impacts. These considerations are examined in the site-recommendation letter report accompanying this report.

Chapter 4

PRECLOSURE ANALYSIS OF THE NOMINATED SITES

This chapter presents a preclosure analysis of the five sites nominated as suitable for characterization. Section 4.1 presents the objectives defined for the evaluation of the sites. Section 4.2 defines a performance measure for each objective to indicate the degree to which the five sites achieve the objectives. Section 4.3 describes the performance of each site in terms of a set of performance measures. Section 4.4 discusses the multiattribute utility function assessed to integrate the ratings on the different performance measures into an overall evaluation of the sites. The results of the base-case evaluation and numerous sensitivity analyses are presented in Sections 4.5 and 4.6, respectively.

4.1 THE OBJECTIVES HIERARCHY

The perspective taken in this analysis is that the sites should be evaluated in terms of minimizing adverse preclosure impacts. This requires that the set of objectives characterize in an operational manner the meaning of "adverse preclosure impacts." Specifically, the preclosure guidelines (10 CFR 960.5) specify the factors to be considered in evaluating and comparing sites on the basis of expected repository performance before closure. The preclosure guidelines specify three categories of factors: radiological safety; environment, socioeconomics, and transportation; and ease and cost of siting, construction, operation, and closure.

The preclosure guidelines were used as the basis for constructing the set of objectives represented by the objectives hierarchy in Figure 4-1. A combination of a top-down and botton-up approach was used to develop the objectives hierarchy shown. In the top-down approach, members of DOE management identified in Appendix A were asked to make explicit the most general objectives bearing on the ranking of the sites for the site-characterization decision. These general objectives pertained to health and safety, environmental quality, socioeconomic welfare, and economic costs. The general objectives were then made more specific by asking what was meant by each, why it was important, how it might be affected by site selection, and so forth. Criteria of completeness, nonredundancy, significance, operationality, and decomposability were then applied to refine and improve the specification of lower-level objectives. The bottom-up approach involved working with DOE technical staff to generate lists of evaluation criteria using the siting guidelines and the "Supplementary Information" and Appendix IV to the guidelines. The identified criteria were then integrated into the initial version of the objectives hierarchy developed from the top-down approach.

As is readily evident, the minimization of preclosure impacts is defined to be equivalent to achieving to the degree possible the following four major objectives:

ranges estimated for possible impacts, the relative ranking of sites obtained in the base case is totally insensitive to any changes in the level of impacts, except for costs. The ranking is insensitive to any reasonable changes in the value judgments or in the form of the utility function.

Because the differences among costs at different sites are in the billions of dollars, costs have a strong influence on the overall preclosure ranking. Hence it seems prudent to examine the potential for significant overlap in total costs among the sites. For example, if the costs associated with the Hanford site could be at low levels while the costs for the other sites simultaneously were at their high levels, then the Hanford site would be a competitor. The probability of this occurrence with regard to transportation costs is obviously extremely low since costs are a strong function of distance and Hanford is the farthest from the sources of waste. Other highly correlated components of transportation costs include fuel and labor rates. The positive relationship of repository costs at different sites is less obvious because of uncertainty in subsurface conditions and consequently repository design prior to the sinking of exploratory shafts. However, some major repository costs are positively correlated among the sites. Future labor rates and costs for power are direct components of costs that would likely have a similar influence on repository costs at all sites. Indirectly, technological advances for sinking large-diameter shafts or waste package design and changes in regulatory requirements are examples of causes that lead to correlated repository costs. Thus, the likelihood that the relative repository costs at Hanford, for example, would be lower than those at any other site would likely be very low.

With the insight provided by the analysis, it is easy to explain and understand the results. All of the sites have some undesirable health and safety, environmental, and socioeconomic impacts. Because any such impacts are important, the sites have been selected and screened to reduce such potential impacts and mitigation procedures would attempt to minimize them at any given site. This tends to reduce both the level of impacts and the differences in such impacts among sites. No analogous procedures have been conducted for costs which do have very significant differences (i.e., billions of dollars) in estimates.

Hanford is the least desirable site because of its enormously greater costs and greater health effects can not be made up for by its relatively miniscule favorability in environmental and socioeconomic impacts.

Yucca Mountain is the most desirable site because of the other four sites it has the best environmental and socioeconomic impacts and is more than 1 billion dollars less expensive than any other site. These advantages far outweigh its slightly greater health and safety impacts.

The salt sites must fall between Yucca Mountain and Hanford. Davis Canyon is dominated by both Richton Dome and Deaf Smith meaning that it is least desirable in terms of health and safety impacts, environmental and socioeconomic impacts, and costs. Thus, Davis Canyon is the least desirable salt site, and hence, it is the fourth-ranked site. Richton Dome is slightly preferable to Deaf Smith in terms of health and safety and slightly less desirable in terms of environmental and socioeconomic impacts, but Deaf Smith costs are 650 million dollars greater than Richton Dome. Thus, Richton Dome is the number two ranked site and Deaf Smith is ranked third.

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4.6.4 OTHER SENSITIVITY ANALYSES OF THE SET OF OBJECTIVES

Sections 4.1 and 4.2 presented the basis for selecting the objectives and associated performance measures used in this analysis. As explained in Appendix G, other potential objectives were not included because it was felt that their inclusion would not affect the implications of the analysis. Some objectives concerned nonfatal health-and-safety ~~impacts~~ effects, ~~less serious than fatalities~~ (e.g., illness and injuries), and another objective concerned the socioeconomic impacts of the transportation system. The possible implications of including these objectives in the analysis are now considered with a knowledge of the study results.

The nonfatal health-and-safety ~~impacts~~ effects are likely to be highly correlated with the fatality ~~impacts~~. ~~Thus~~ their inclusion would have implications similar to those from a greater value being placed on fatality ~~impacts~~. Thus, as illustrated in Table 4-18, the inclusion of nonfatal health-and-safety effects ~~impacts~~ should not affect the implications of the analyses.

The socioeconomic impacts of waste transportation are probably directly related to the total number of miles traveled to deliver waste to the repository and hence to the transportation impacts. These impacts, represented by performance measures X_5 through X_8 and X_{14}, have the same ranking as the overall impacts for the salt sites and Hanford. The socioeconomic impacts of waste transportation to Yucca Mountain could be slightly greater than those associated with the salt sites. Given the overall differences in desirability as indicated by the equivalent-consequence impacts in Table 4-10, it is unlikely that there would be any change in the ranking of the sites.

4.7 CONCLUSIONS FROM ~~THE PRECLOSURE~~ ANALYSIS

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Before discussing the conclusions for the overall preclosure analysis, we review the insights from aggregations of certain performance-measure categories. Much of this information was presented in Section 4.5.2, in particular in Tables 4-11 and 4-12, but it is nonetheless repeated here to provide context for the discussion of the overall preclosure results. Table 4-23 repeats selected information from Table 4-11.

Row 1 of Table 4-23 shows that the relative ranking of the nominated sites on preclosure radiological safety is Richton Dome, Deaf Smith, Davis Canyon, Yucca Mountain, and Hanford. The difference between the first-ranked site and the fifth-ranked site is equivalent to 15 ~~worker~~ radiological fatalities in workers, a difference largely attributable to ~~the influence of~~ transportation.

Row 2 of Table 4-23 shows that the relative ranking of sites on worker fatalities (radiological ~~plus~~ and nonradiological) is Yucca Mountain, Richton Dome, Davis Canyon, Deaf Smith, and Hanford. The Yucca Mountain site is slightly preferred to the three salt sites, which are barely distinguishable from one another, while the Hanford site is significantly less favorable. This significant difference is attributable to nonradiological fatalities ~~to~~ in repository workers (mostly from mining accidents), which, in turn, reflects the larger labor requirements ~~associated with~~ for repository construction and operation at the Hanford site.

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Table 4-23. Base-Case equivalent-consequence impacts for various aggregations of performance measures[a]

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Row	Performance-Measure Category	Richton Dome	Deaf Smith	Davis Canyon	Yucca Mountain	Hanford
1	Radiological Fatalities (X_1, X_2, X_3, X_4)	15	16	17	22	30
2	Worker Fatalities (X_1, X_3, X_5, X_7)	31	33	32	25	56
3	Public Fatalities (X_2, X_4, X_6, X_8)	34	40	48	58	64
4	Health and Safety $(X_1 - X_8)$	64	74	80	83	120
5	Environment and Socioeconomics $(X_9 - X_{12})$	139	119	220	71	23
6	Public Near Site $(X_2, X_4, X_6 - X_{12})$	142	121	220	71	26
7	Site Impacts $(X_1 - X_4, X_9 - X_{12})$	171	152	249	93	78
8	Noncosts $(X_1 - X_{12})$	203	193	300	154	142
9	Repository Costs (X_{13})	9000	9,500	10,400	7500	12,900
10	Total Costs $(X_{13} - X_{14})$	9970	10,620	11,640	8900	14,350

[a]The numbers in the tables represent equivalent-consequence impacts rounded to the nearest unit.

sites ranked

Row 4 of Table 4-23 shows that the relative ranking of sites against all health-and-safety impacts is Richton Dome, Deaf Smith, Davis Canyon, Yucca Mountain, and Hanford. In terms of equivalent-consequence impacts, the difference between the first and fourth ~~ranked sites~~ (19 equivalent worker fatalities) is about half the difference between the fourth ~~ranked~~ and ~~the~~ fifth ~~ranked sites~~ (37 equivalent worker fatalities). sites ranked

Row 5 of Table 4-23 shows that the relative ranking of sites on ~~the~~ all of the ~~collection of~~ environmental and socioeconomics performance measures is Hanford, Yucca Mountain, Deaf Smith, Richton Dome, and Davis Canyon. The difference between the fourth ~~ranked Richton Dome site~~ and ~~the~~ fifth ~~ranked~~ ~~Davis Canyon~~ site is most significant, equivalent to 81 million dollars (about ~~70%~~ 70 percent of the difference between the first- and the fourth-ranked sites). (Richton Dome and Davis Canyon)

Row 6 of Table 4-23 shows that the relative ranking of sites on the impacts that would ~~occur to~~ affect the public in close proximity to the site is Hanford, Yucca Mountain, Deaf Smith, Richton Dome, and Davis Canyon—the same ranking that obtained by considering only environmental and socioeconomic impacts. The most significant difference is between the fourth ~~ranked Richton Dome site~~ and ~~the~~ fifth ~~ranked Davis Canyon site~~. If ~~impacts to~~ workers are included, the ranking remains the same (row 7, Table 4-23). (that is, Richton Dome and Davis Canyon.

If all noncost performance measures are aggregated, as in Row 8 of Table 4-23, the relative ranking is Hanford, Yucca Mountain, Deaf Smith, Richton Dome, and Davis Canyon. Again, the most significant difference is between the fourth ~~ranked Richton Dome site~~ and ~~the~~ fifth ~~ranked Davis Canyon site~~, equal to 97 million dollars. This difference is larger than between the first four ranked sites (equivalent to 61 million dollars). This ranking is changed ~~by~~ drastically by ~~inclusion~~ the addition of costs. When transportation costs are added, the ranking becomes Richton Dome, Deaf Smith, Davis Canyon, Yucca Mountain, and Hanford. When repository costs are added, the ranking becomes Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford (Row 9, Table 4-23). This ranking remains the same when both ~~the~~ transportation and repository costs are added (Row 10, Table 4-23). (Richton Dome and Davis Canyon),

With these rankings ~~in~~ performance-measure categories in mind, the conclusions for the overall base-case analysis and ~~numerous~~ the sensitivity analyses ~~may~~ can be summarized.

The base-case analysis, summarized in Table 4-24, shows ~~indicates~~ that the relative ranking of sites ~~considering~~ on all preclosure ~~impacts~~ is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford. In terms of equivalent-consequence impacts, the difference between Yucca Mountain and Richton is the equivalent of 1,119 million dollars, between Richton Dome and Deaf Smith 640 million dollars, between Deaf Smith and Davis Canyon 1,127 million dollars, and between Davis Canyon and Hanford 2,552 million dollars. Thus, the largest difference ~~between~~ among the five sites is between the fourth-ranked Davis Canyon and the fifth-ranked Hanford site.

The stability of the base-case results was examined by sensitivity analyses involving changes in the level of impacts, in the value judgments, and in the form of the multiattribute utility function itself. Within the ranges estimated for possible impacts, the relative ranking of sites obtained in the base case is totally insensitive to any changes in the level of impacts, except for costs. The ranking is insensitive to any reasonable changes in the value judgments or in the form of the utility function.

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With these rankings in performance-measure categories in mind, the conclusions for the overall base-case analysis and numerous sensitivity analyses may be summarized.

The base-case analysis summarized in Table 4-24 indicates that the relative ranking of sites considering all preclosure impacts is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford. In terms of equivalent-consequence impacts, the difference between Yucca Mountain and Richton is the equivalent of 1,119 million dollars, between Richton Dome and Deaf Smith 640 million dollars, between Deaf Smith and Davis Canyon 1,127 million dollars, and between Davis Canyon and Hanford 2,552 million dollars. Thus, the largest difference between the five sites is between the fourth-ranked Davis Canyon and the fifth-ranked Hanford site.

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Table 4-24. Summary of the ~~Base-Case Analysis~~

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Site	Expected ~~Utility~~	~~Equivalent-Consequence-Impacts~~
Yucca Mountain	75.7	9,054
Richton Dome	70.1	10,173
Deaf Smith	66.9	10,813
Davis Canyon	61.3	11,940
Hanford	48.5	14,492

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Because the cost differences among ~~costs at different~~ sites are in the billions of dollars, costs have a strong influence on the overall preclosure ranking. Hence it seems prudent to examine the potential for significant overlap in total costs among the sites. For example, if the costs ~~associated~~ ~~with~~ for the Hanford site could be at low levels while the costs for the other sites simultaneously were at their high levels, then the Hanford site would be a competitor. The probability of this occurrence with regard to transportation costs is obviously extremely low because ~~since~~ costs ~~are a~~ strongly depend ~~function of~~ on distance, and Hanford is the farthest from the sources of waste. Other highly correlated components of transportation costs include fuel and labor rates. The positive relationship of repository costs at different sites is less obvious because of greater uncertainty ~~in~~ about ~~subsurface~~ site conditions and consequently repository design. ~~prior to the sinking of exploratory shafts.~~ However, some major repository costs are positively correlated among the sites. Future labor rates and costs for power are direct components of costs that would likely have a similar influence on repository costs at all sites. Indirectly, technological advances for sinking large-diameter shafts or changes in regulatory requirements are examples of causes that lead to correlated repository costs. Thus, the likelihood that the relative repository costs at Hanford, for example, would be lower than those at any other site is also ~~likely~~ probably very low.

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Chapter 4

PRECLOSURE ANALYSIS OF THE NOMINATED SITES

This chapter presents a preclosure analysis of the five sites nominated as suitable for characterization. Section 4.1 presents the objectives defined for the evaluation of the sites. Section 4.2 defines a performance measure for each objective to indicate the degree to which the five sites achieve the objectives. Section 4.3 describes the performance of each site in terms of a set of performance measures. Section 4.4 discusses the multiattribute utility function assessed to integrate the ratings on the different performance measures into an overall evaluation of the sites. The results of the base-case evaluation and numerous sensitivity analyses are presented in Sections 4.5 and 4.6, respectively. Section 4.7 discusses the conclusions of the preclosure analysis of sites.

4.1 THE OBJECTIVES HIERARCHY

The perspective taken in this analysis is that the sites should be evaluated in terms of minimizing adverse preclosure impacts. This requires that the set of objectives characterize in a useful way the meaning of "adverse preclosure impacts." Specifically, the preclosure guidelines (10 CFR 960.5) specify the factors to be considered in evaluating and comparing sites on the basis of expected repository performance before closure. The preclosure guidelines specify three categories of factors: radiological safety; environment, socioeconomics, and transportation; and ease and cost of siting, construction, operation, and closure.

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As is readily evident, the minimization of preclosure impacts is defined to be equivalent to achieving to the degree possible the following four major objectives:

The Hanford site is least favorable in the categories of public health, worker health, and economic cost; it is most favorable in terms of environmental and socioeconomic impacts. However, in comparison with Yucca Mountain, a tremendous relative weight would need to be placed on equivalent socioeconomic impacts for the sites to be close to equally desirable. Specifically, for Hanford to be competitive with Yucca Mountain, it would be necessary for the value tradeoffs to indicate a willingness to increase total fatalities by over 30 and costs by over 5 billion dollars in order to decrease the equivalent socioeconomic impact by 9 percent of the maximum impact. For Hanford to be competitive with any of the salt sites, the value tradeoffs would need to indicate a willingness to increase total fatalities by over 25 and costs by over 2.5 billion dollars to reduce socioeconomic impacts by 39 percent of the maximum impact. The necessary value tradeoffs would need to be even more extreme to compete with the best two of the three sites in salt. The implication is that, given the impact data on the sites, a wide range of value tradeoffs indicates that Hanford is not a competitive site on preclosure considerations.

The same logic as above suggests that on preclosure considerations the most favorable of the five nominated sites is Yucca Mountain. Of the four remaining sites (i.e., all candidates except Hanford), Yucca Mountain is most favorable in terms of worker fatalities, environmental and socioeconomic impacts, and economic costs. Because of the possibility of transportation accidents involving the public, Yucca Mountain has six more statistical public fatalities than has the site with the fewest public fatalities (i.e., Richton Dome). When public and worker fatalities are combined, Yucca Mountain has the fewest (equal to the number at Richton Dome) of all sites. Hence, if the value tradeoffs indicate that six public fatalities from transportation accidents are less important than (1) six worker fatalities, (2) over 10 percent additional equivalent socioeconomic impact relative to the maximum, and (3) over 1 billion dollars of cost, the most favorable site is Yucca Mountain.

As a consequence of the above, the salt sites would be expected to fall between the most favorable site (Yucca Mountain) and the least favorable site (Hanford). Among these, the Davis Canyon site is dominated by the Richton Dome site and essentially dominated by the Deaf Smith site. That is to say, Davis Canyon is less favorable than Richton Dome in terms of public fatalities, worker fatalities, environmental and socioeconomic impacts, and economic costs. Davis Canyon is less favorable than Deaf Smith in terms of public fatalities, environmental and socioeconomic impacts, and economic costs and only very slightly more favorable in terms of worker fatalities. Regardless of the value tradeoffs among these categories, Davis Canyon must be less preferred on preclosure considerations than the other salt sites for almost any set of values.

Comparing Richton Dome and Deaf Smith, it is clear that Richton Dome is preferred to Deaf Smith with respect to both public and worker fatalities and economic costs, whereas Deaf Smith is preferred on environmental and socioeconomic impacts. If the 4 percent of equivalent socioeconomic impacts by which Richton Dome exceeds Deaf Smith is less important than (1) two additional public fatalities, (2) two additional worker fatalities, and (3) 650 million dollars, then the Richton Dome site is preferred to Deaf Smith.

In summary, with the aggregation of impacts shown in Table 4-8, which are based on relatively noncontroversial value tradeoffs, a preclosure ranking that is likely to be consistent with a wide variety of viewpoints is Yucca Mountain first, followed by Richton Dome, Deaf Smith, Davis Canyon, and Hanford.

4.5.2 BASE-CASE ANALYSIS

The aggregate analysis may, for many individuals, produce sufficient insight to develop a reasonable ranking of the nominated sites. It is nevertheless worthwhile to present the complete base-case analysis for three reasons:

- To verify the implications of the aggregate base-case analysis.
- To gain additional insights, especially through answers to "what if" questions asked of the analysis.
- To illustrate the methodology so that other parties may examine the implications of different data and of different sets of value judgments felt to be appropriate for the problem.

The presentation of the base-case analysis is intended to indicate exactly what conclusions follow from which impact data and value judgments and why.

Table 4-9 uses the component disutility functions in Table 4-7 to convert the base-case estimates of impacts for each site to component disutilities. These can be easily substituted into the utility function (Equation 4-1) or the equivalent-consequence function (Equation 4-3) to evaluate the sites. The component disutilities are identical with the base-case estimates of impacts in Table 4-6 except for the environmental and socioeconomic performance measures. To calculate the equivalent consequence for a site, Equation 4-3 is used. For each site, the appropriate K_i value from Table 4-7 is multiplied by the appropriate C_i value from Table 4-9 to obtain the equivalent-consequence impacts for each performance measure in Table 4-10. The results are summed by using Equation 4-3 for each site to get the overall equivalent consequence shown at the bottom of Table 4-10. The expected utility calculated for each site with Equation 4-1 is also provided. Before examining these results for all five sites, let us look at the calculations for the Richton Dome site.

In Table 4-9, the number of nonradiological public fatalities from transportation to Richton Dome, represented by performance measure X_8, is 5.3. In Table 4-7, the value tradeoff K_8 between units of this performance measure and costs is 4, indicating that 4 million dollars in additional cost is indifferent to a statistical nonradiological public fatality from transportation. Hence, the 5.3 fatalities is multiplied by the 4 million at Richton Dome

dollars per fatality to yield a 21.2 contribution to the equivalent-consequence impact associated with performance measure X_8 for the Richton Dome site (Table 4-10). Regarding socioeconomic impacts (X_{12}), impact level 2 in Table 4-5 describes that impact. This has a disutility of 20, as shown in Table 4-9. The value tradeoff K_{12} for a unit (i.e., percent) of socioeconomic impacts is 5 million dollars, as indicated in Table 4-7. Multiplying 20 by 5 yields the contribution of 100 to the equivalent-consequence impact for performance measure X_{12} in Table 4-10. The rest of the entries in Table 4-10 in the column for the Richton Dome site can be calculated similarly. Summing the equivalent-consequence contributions for the Richton Dome site for the 14 preclosure performance measures yields the value 10,173 in Table 4-10.

It is clear from Table 4-10 that the Yucca Mountain site is the most favorable of the five sites. The salt sites follow in the order Richton Dome, Deaf Smith, and Davis Canyon. These four sites are all significantly more favorable in terms of equivalent consequences than the Hanford site. In interpreting the differences in equivalent consequences, the reader should recall that one unit is equal in value to 1 million dollars.

Table 4-11 aggregates the information in Table 4-10 in numerous ways to gain insights into the reasons for the relative site rankings. The first four rows aggregate the implications for health and safety, environmental impacts, socioeconomics, and economic costs, respectively. For instance, the sum of the first eight rows in Table 4-10 provides the equivalent-consequence contribution from health-and-safety impacts (row 1). For Yucca Mountain, the equivalent consequence is 83. Row 5 of Table 4-11 aggregates all noneconomic impacts, and row 6 aggregates the environmental and socioeconomic impacts.

Row 7 aggregates the impacts that might be collectively considered as the detrimental impacts on the public living near the repository site. It includes the health-and-safety impacts and the environmental and socioeconomic impacts experienced by the public near the site. Row 8 includes the health-and-safety impacts on the workers at the repository. Hence, row 8 might be considered an aggregation of the total impact felt by all members of the community near a site.

Rows 9, 10, and 11 indicate different aspects of the health-and-safety implications. Specifically, row 9 refers to the equivalent-consequence impacts of worker fatalities, row 10 refers to the equivalent-consequence impacts of public fatalities, and row 11 refers to the equivalent-consequence impacts of radiological fatalities.

Rows 12 and 13 are included because of their potential usefulness in sensitivity analysis. Row 12 aggregates all the health-and-safety and cost impacts of the different sites, and row 13 aggregates all the impacts except for repository costs X_{13}.

4.5.3 SUMMARY OF THE BASE-CASE ANALYSIS

A few implications are readily apparent from the base-case analysis. From Table 4-9, the Richton Dome and the Deaf Smith sites dominate the Davis Canyon site on all performance measures except X_2 and X_3. This means that the ratings for both Deaf Smith and Richton Dome are at least as high and sometimes higher than the corresponding rating for the Davis Canyon site on all other performance measures. When the equivalent-consequence impacts are aggregated into health-and-safety, environmental, socioeconomic, and cost impacts, Richton Dome and Deaf Smith dominate Davis Canyon. Hence, Davis Canyon is the least favorable salt site given the base-case impacts.

Another implication of the base-case analysis is that the Yucca Mountain site has a lower equivalent consequence than any of the salt sites. It is the equivalent of 1,119 million dollars more desirable than the most favorable salt site (i.e., Richton Dome) and 2,886 million dollars more desirable than the least favorable salt site (i.e., Davis Canyon). Yucca Mountain is the equivalent of 5,438 million dollars more favorable than the Hanford site.

Table 4-12 aggregates and ranks the sites in terms of performance-measure categories. The first column shows that the overall ranking of the sites is Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford. The rankings in Table 4-12 clearly demonstrate that no changes in the value tradeoffs (i.e., scaling factors) between the different categories of performance measures could change the ranking of Davis Canyon as the least desirable of the salt sites. The Richton Dome site should be preferred to the Deaf Smith site unless a very high value is placed on environmental and socioeconomic impacts versus health-and-safety impacts and costs. Similarly, only an extremely high value on the environmental and socioeconomic impacts versus the others could possibly result in Hanford's being ranked anything but fifth.

However, one must be careful not to misinterpret the significance of a ranking. With the ranking, the difference in desirability between sites ranked first and third could be much less than the difference in desirability between sites ranked third and fifth. Indeed, this is the case with the rankings in Table 4-12, as can be seen from row 14 of Table 4-11. Here, the difference between the first-ranked Yucca Mountain site and the third-ranked Deaf Smith site is equivalent in value to 1,759 million dollars, whereas the difference between the third-ranked site (Deaf Smith) and the fifth-ranked Hanford site is equivalent in value to 3,679 million dollars.

4.6 SENSITIVITY ANALYSES

Many sensitivity analyses can be conducted to determine which of the impacts and value judgments are critical to any implications drawn from the analysis. This section presents several sensitivity analyses to determine the main factors that may influence these implications. The first set of sensitivity analyses focuses on changes in the impacts from

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- The relative values of units of environmental and socioeconom impacts are provided by the assessed value tradeoffs in Table

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Table 4-8. Aggregate description of base-case impacts[a]

Site	Health and safety: Statistical public fatalities	Health and safety: Statistical worker fatalities	Environment and socioeconomics[b] (equivalent % of maximum socioeconomic impact)	Economic cost (millions of dollars)
Richton Dome	8 (1)	31 (2)	28 (4)	9,970 (2)
Deaf Smith	10 (2)	33 (4)	24 (3)	10,620 (3)
Davis Canyon	12 (3)	32 (3)	44 (5)	11,640 (4)
Yucca Mountain	14 (4)	25 (1)	14 (2)	8,900 (1)
Hanford	16 (5)	56 (5)	5 (1)	14,350 (5)

[a] The base-case estimates from Table 4-6 are calculated with Equations 4-5 through 4-8 and rounded to the nearest unit for each impact category. The numbers in parentheses represent the ranking of the site for each impact category.

[b] The aggregations in this column use Equation 4-7 first to convert site environmental impacts into equivalent socioeconomic impacts by using the relative value tradeoffs between each environmental performance measure and the socioeconomics performance measure and then to add these to estimated socioeconomic impacts. The result is the "equivalent percent of maximum socioeconomic impact," which, when combined with the 0 levels of environmental impacts, has the same desirability as the set of estimated environmental and socioeconomic impacts.

- The relative values of units of environmental and socioeconom[...] impacts are provided by the assessed value tradeoffs in Table [...]

Using these value tradeoffs, the utility function (Equation 4-1) is red[...]

$$u(x_1,\ldots,x_{14}) = 121 - 1/200[K_{PH}C_{PH}(x_2,x_4,x_6,x_8) + K_{WH}C_{WH}(x_1,x_3,x_5,x_7$$

$$+ K_{ES}C_{ES}(x_9,x_{10},x_{11},x_{12}) + K_{\$}C_{\$}(x_{13},x_{14})],$$

where the C represent the aggregate impacts on public health (PH), work[...] health (WH), the environment and socioeconomics (ES), and costs ($),

$$C_{PH}(x_2,x_4,x_6,x_8) = x_2 + x_4 + x_6 + x_8,$$

$$C_{WH}(x_1,x_3,x_5,x_7) = x_1 + x_3 + x_5 + x_7,$$

$$C_{ES}(x_9,x_{10},x_{11},x_{12}) = \frac{1}{5}C_9(x_9) + \frac{0.2}{5}C_{10}(x_{10}) + \frac{0.3}{5}C_{11}(x_{11}) + C_{12}(x_{12})$$

$$C_{\$}(x_{13},x_{14}) = x_{13} + x_{14},$$

and K_{PH}, K_{WH}, K_{ES}, and $K_{\$}$ concern the value tradeoffs among the impact categories. It is the latter value tradeoffs that are so difficult to [...] agree on. Because the utility function (Equation 4-1) is additive, the Equations 4-5 through 4-8 provides a logical way of aggregating impacts informative categories, and Equation 4-4 provides a consistent way of combining these impacts.

4.5 EVALUATION OF THE NOMINATED SITES

The impacts of the five sites in terms of the performance measures [...] combined with the value judgments expressed in the multiattribute utilit[...] function to provide an overall evaluation of the desirability of the sit[...] The first part of this section presents the aggregate base-case analysis. [...] complete base-case analysis follows in the second part. Numerous sensit[...] analyses involving changes in the possible impacts and also changes in t[...] multiattribute utility function for evaluating these impacts are present[...] Section 4.6. Aggregation of numerous [illegible] of objectives [illegible] additional [illegible] [illegible] the sites

Move to [illegible]

4.5.1 AGGREGATE BASE-CASE ANALYSIS

The aggregate base-case analysis uses the base-case impact estimates [...] Table 4-6 and the aggregate utility function represented in Equations 4-[...] through 4-8. The first step is to combine the base-case estimates in Tab[...] 4-6 by using the categories represented by Equations 4-5 through 4-8. Th[...] result of this is given in Table 4-8. Directly from this table some rath[...] ~~powerful~~ insights can be drawn.

The Hanford site is least favorable in the categories of public he. worker health, and economic cost; it is most favorable in terms of environmental and socioeconomic impacts. ~~However, in comparison with Y Mountain, a tremendous relative weight would need to be placed on equiv socioeconomic impacts for the sites to be close to equally desirable. Specifically,~~ For Hanford to be competitive with Yucca Mountain, it wou. necessary for the value tradeoffs to indicate a willingness to increase fatalities by over 30 and costs by over 5 billion dollars in order to de the equivalent socioeconomic impact by 9 percent of the maximum impact. Hanford to be competitive with ~~any of~~ the salt sites, the value tradeof would need to indicate a willingness to increase total fatalities by ove and costs by over 2.5 billion dollars to reduce socioeconomic impacts b percent of the maximum impact. ~~The necessary value tradeoffs would nee far more extreme to compete with the best two of the three sites in sa. The implication is that, given the impact data on the sites, a wide ran value tradeoffs indicates that Hanford is not a competitive site on pre considerations.~~

The ~~same~~ logic ~~as~~ above suggests that on preclosure considerations ~~most favorable of~~ the five nominated sites is Yucca Mountain. ~~Of the f remaining sites (i.e., all candidates except Hanford),~~ Yucca Mountain is ~~favorable in terms~~ of worker fatalities, environmental and socioeconomic impacts, and economic costs. Because of the possibility of transportat: accidents involving the public, Yucca Mountain has six more statistical fatalities than has the site with the fewest public fatalities (i.e., R: Dome). When public and worker fatalities are combined, Yucca Mountain h fewest (equal to the number at Richton Dome) of all sites. Hence, if t value tradeoffs indicate that six public fatalities from transportation accidents are less important than (1) six worker fatalities, (2) over 10 percent additional equivalent socioeconomic impact relative to the maxi and (3) over 1 billion dollars of cost, the most favorable site is Yucca Mountain.

As a consequence of the above, the salt sites would be expected to between the most favorable site (Yucca Mountain) and ~~the least favorabl~~ (Hanford). Among these, the Davis Canyon site is dominated by the Rich Dome site and essentially dominated by the Deaf Smith site. That is to Davis Canyon is less favorable than Richton Dome in terms of public fatalities, worker fatalities, environmental and socioeconomic impacts, economic costs. Davis Canyon is less favorable than Deaf Smith in term public fatalities, environmental and socioeconomic impacts, and economi and only very slightly more favorable in terms of worker fatalities. Regardless of the value tradeoffs among these categories, Davis Canyon less preferred on preclosure considerations than the other salt sites f almost any set of values.

Comparing Richton Dome and Deaf Smith, ~~it is clear that~~ Richton Do preferred to Deaf Smith with respect to both public and worker fataliti economic costs, whereas Deaf Smith is preferred on environmental and socioeconomic impacts. If the 4 percent of equivalent socioeconomic im by which Richton Dome exceeds Deaf Smith is less important than (1) two additional public fatalities, (2) two additional worker fatalities, and 650 million dollars, then the Richton Dome site is preferred to Deaf Sm

In summary, with the aggregation of impacts shown in Table 4-8, ~~based on relatively noncontroversial value tradeoffs,~~ a preclosure r
that is likely to be consistent with a wide variety of viewpoints is
Mountain first, followed by Richton Dome, Deaf Smith, Davis Canyon,
Hanford.

While the base case [illegible] provides a [illegible] for composite ordering with regard to preclosure, additional insights

4.5.2 BASE-CASE ANALYSIS

are gained by examining the [illegible]

The aggregate analysis may, for many individuals, produce suffi
insight ~~to develop a reasonable~~ ranking of the nominated sites. It
nevertheless worthwhile to present the ~~complete~~ base-case analysis f
reasons:

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measures. To calculate the equivalent consequence for a site, Equat
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by the appropriate C_i value from Table 4-9 to obtain the
equivalent-consequence impacts for each performance measure in Table
The results are summed by using Equation 4-3 for each site to get th
equivalent consequence shown at the bottom of Table 4-10. The expec
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measure and costs is 4, indicating that 4 million dollars in additio
is indifferent to a statistical nonradiological public fatality from
transportation. Hence, the 5.3 fatalities is multiplied by the 4 mi

Table 4-9. Base-case component disutilities of nominated sites*

		Performance Measure	Richton Dome	Deaf Smith	Davis Canyon	Yucca Mt.	
X_1	=	repository worker radiological fatalities	2	2	2	4	
X_2	=	public radiological fatalities from repository	0.7	0.5	0.1	0.1	
X_3	=	repository-worker non-radiological fatalities	27	29	27	18	
X_4	=	public nonradiological fatalities from repository	0	0	0	0	
X_5	=	transportation-worker radiological fatalities	0.52	0.64	0.73	0.81	
X_6	=	public radiological fatalities from transportation	2.4	2.9	3.5	4.1	
X_7	=	transportation-worker non-radiological fatalities	1.3	1.6	2.1	2.5	
X_8	=	public nonradiological fatalities from transportation	5.3	6.7	8.4	10.2	
X_9	=	aesthetic impacts	33	33	100	33	
X_{10}	=	archaeological impacts	6	12	56	23	
X_{11}	=	biological impacts	15	12	29	10	
X_{12}	=	socioeconomic impacts	20	16	20	6	
X_{13}	=	repository cost	9,000	9,500	10,400	7,500	12,
X_{14}	=	transportation cost	970	1,120	1,240	1,400	1

*Component disutilities are calculated by substituting the base-case estimates of im shown in Table 4-6 into the component disutility function in Table 4-7.

dollars per fatality to yield a 21.2 contribution to the equivalent consequence impact associated with performance measure X_6 for the R Dome site (Table 4-10). Regarding socioeconomic impacts (X_{12}), imp. 2 in Table 4-5 describes that impact at Richton Dome. This has a d. of 20, as shown in Table 4-9. The value tradeoff K_{12} for a unit (1 percent) of socioeconomic impacts is 5 million dollars, as indicate 4-7. Multiplying 20 by 5 yields the contribution of 100 to the equivalent-consequence impact for performance measure X_{12} in Table 4 The rest of the entries in Table 4-10 in the column for the Richton can be calculated similarly. Summing the equivalent-consequence con for the Richton Dome site for the 14 preclosure performance measures the value 10,173 in Table 4-10.

It is clear from Table 4-10 that the Yucca Mountain site is the favorable of the five sites. The salt sites follow in the order Ric Deaf Smith, and Davis Canyon. These four sites are all significantl favorable in terms of equivalent consequences than the Hanford site. interpreting the differences in equivalent consequences, the reader recall that one unit is equal in value to 1 million dollars.

Table 4-11 aggregates the information in Table 4-10 in numerous gain insights into the reasons for the relative site rankings. The f rows aggregate the implications for health and safety, environmental socioeconomics, and economic costs, respectively. For instance, the the first eight rows in Table 4-10 provides the equivalent-consequenc contribution from health-and-safety impacts (row 1). For Yucca Mount equivalent consequence is 83. Row 5 of Table 4-11 aggregates all non impacts, and row 6 aggregates the environmental and socioeconomic imp

Row 7 aggregates the impacts that might be collectively consider the detrimental impacts on the public living near the repository site includes the health-and-safety impacts and the environmental and soci impacts experienced by the public near the site. Row 8 includes the h and-safety impacts on the workers at the repository. Hence, row 8 mig considered an aggregation of the total impact felt by all members of t community near a site.

Rows 9, 10, and 11 indicate different aspects of the health-and- implications. Specifically, row 9 refers to the equivalent-consequenc impacts of worker fatalities, row 10 refers to the equivalent-conseque impacts of public fatalities, and row 11 refers to the equivalent-cons impacts of radiological fatalities.

Rows 12 and 13 are included because of their potential usefulness sensitivity analysis. Row 12 aggregates all the health-and-safety and impacts of the different sites, and row 13 aggregates all the impacts for repository costs X_{13}.

Table 4-11 illustrates dominance of Costs
i.e. (5) all but costs
gives H Y DS RD
other
needs more specific discussion of impacts

Table 4-10. Base-case equivalent-consequence impacts

Performance Measure	Richton Dome	Deaf Smith	Davis Canyon	Yucca Mt.	H
X_1 = repository—worker radiological fatalities	2	2	2	4	
X_2 = public radiological facilities from repository	2.8	2	0.4	0.4	
X_3 = repository—worker non-radiological fatalities	27	29	27	18	
X_4 = public nonradiological fatalities from repository	0	0	0	0	
X_5 = transportation-worker radiological fatalities	0.52	0.64	0.73	0.81	.
X_6 = public radiological fatalities from transportation	9.6	11.6	14	16.4	:
X_7 = transportation—worker nonradiological fatalities	1.3	1.6	2.1	2.5	2
X_8 = public nonradiological fatalities from transportation	21.2	26.8	33.6	40.8	4
X_9 = aesthetic impacts	33	33	100	33	3
X_{10} = archaeological impacts	1.2	2.4	11.2	4.6	1
X_{11} = biological impacts	4.5	3.6	6.7	3.0	3
X_{12} = socioeconomic impacts	100	80	100	30	1!
X_{13} = repository cost	9,000	9,500	10,400	7500	12
X_{14} = transportation cost	970	1,120	1,240	1400	1
Total equivalent impact	10,173	10,813	11,940	9054	1-
Expected utility — 2/0	70.13	66.94	61.30	75.73	4ε

$1/2

This is confusing
need to make
separate numbers
9 & 11 — ?
Geographic and not
9 — 11
defense units.
Exp —

Table 4-11. Base-case equivalent-consequence impacts for various aggregations of performance measures[a]

Row	Performance measure	Richton Dome	Deaf Smith	Davis Canyon	Yucca Mt.	H
1	Health and safety (X_1 through X_8)	64	74	80	83	
2	Environment (X_9 through X_{11})	39	39	120	41	
3	Socioeconomics (X_{12})	100	80	100	30	
4	Costs (X_{13} through X_{14})	9970	10,620	11,640	8900	1
5	Noncosts (X_1 through X_{12})	203	193	300	154	
6	Environment and socioeconomics (X_9 through X_{12})	139	119	220	71	
7	Public near site (X_2, X_4, X_9 through X_{12})	142	121	220	71	
8	Site impacts (X_1 through X_4, X_9 through X_{12})	171	152	249	93	
9	Worker fatalities (X_1, X_3, X_5, X_7)	31	33	32	25	
10	Public fatalities (X_2, X_4, X_6, X_8)	34	40	48	58	
11	Radiological fatalities (X_1, X_2, X_3, X_4)	15	16	17	22	
12	Fatalities and costs (X_1 through X_8, X_{13} through X_{14})	10,034	10,694	11,720	8963	14
13	All except repository cost (X_1 through X_{12}, X_{14})	1173	1313	1540	1554	
14	All measures (X_1 through X_{14})	10,173	10,813	11,940	9054	14,

[a]The numbers in this table represent equivalent-consequence impacts rounded to th nearest unit.

#1

explain

4.5.3 SUMMARY OF THE BASE-CASE ANALYSIS

Contrast this with discussion on 4-31

A few implications are readily apparent from the base-case analys[is]. From Table 4-9, the Richton Dome and the Deaf Smith sites ~~dominate~~ the [Davis] Canyon site on all performance measures except X_1 and X_3. This means [that] the ratings for both Deaf Smith and Richton Dome are at least as high [as, and] sometimes higher than the corresponding rating for the Davis Canyon si[te on] all other performance measures. When the equivalent-consequence impac[ts are] aggregated into health-and-safety, environmental, socioeconomic, and c[ost] impacts, Richton Dome and Deaf Smith ~~dominate~~ Davis Canyon. Hence, Da[vis] Canyon is the least favorable salt site given the base-case impacts.

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Table 4-12 aggregates and ranks the sites in terms of performance-[measure] categories. The first column shows that the overall ranking of the sit[es is] Yucca Mountain, Richton Dome, Deaf Smith, Davis Canyon, and Hanford. T[he] rankings in Table 4-12 clearly demonstrate that no changes in the value tradeoffs (i.e., scaling factors) between the different categories of performance measures could change the ranking of Davis Canyon as the le[ast] desirable of the salt sites. The Richton Dome site ~~should be preferred~~ [to the] Deaf Smith site unless a very high value is placed on environmental and socioeconomic impacts versus health-and-safety impacts and costs. Simi[larly,] only an extremely high value on the environmental and socioeconomic imp[acts] versus the others could possibly result in Hanford's ~~being~~ ranked an[ything but] fifth.

Costs dominate weights from 4-31

However, one must be careful not to misinterpret the significance o[f the] ranking. With the ranking, the difference in desirability between sites ranked first and third could be much less than the difference in desirab[ility] between sites ranked third and fifth. Indeed, this is the case with the rankings in Table 4-12, as can be seen from row 14 of Table 4-11. Here [the] difference between the first-ranked Yucca Mountain site and the third-ra[nked] Deaf Smith site is equivalent in value to 1,759 million dollars, whereas [the] difference between the third-ranked site (Deaf Smith) and the fifth-rank[ed] Hanford site is equivalent in value to 3,679 million dollars.

4.6 SENSITIVITY ANALYSES

Many sensitivity analyses can be conducted to determine which of the impacts and value judgments are critical to any implications drawn from t[he] analysis. This section presents several sensitivity analyses to determi[ne the] main factors that may influence these implications. The first set of sensitivity analyses focuses on changes in the impacts from

4.6.4 OTHER SENSITIVITY ANALYSES OF THE SET OF OBJECTIVES

Sections 4.1 and 4.2 presented the basis for selecting the obj associated performance measures used in this analysis. As explaine Appendix C, other potential objectives were not included because it that their inclusion would not affect the implications of the analys objectives concerned nonfatal health-and-safety effects (e.g., illne injuries), and another objective concerned the socioeconomic impacts transportation system. The possible implications of including these objectives in the analysis are now considered with a knowledge of th results.

The nonfatal health-and-safety effects are likely to be highly with the fatalities. Their inclusion would therefore have implicati similar to those from a greater value being placed on fatalities. T illustrated in Table 4-18, the inclusion of nonfatal health-and-safe should not affect the implications of the analyses.

The socioeconomic impacts of waste transportation are probably related to the total number of miles traveled to deliver waste to the repository and hence to the transportation impacts. These impacts, represented by performance measures X_8 through X_8 and X_{14}, have the s ranking as the overall impacts for the salt sites and Hanford. The socioeconomic impacts of waste transportation to Yucca Mountain could slightly greater than those associated with the salt sites. Given th differences in desirability as indicated by the equivalent-consequenc in Table 4-10, it is unlikely that there would be any change in the r the sites.

Do

4.7 CONCLUSIONS FROM THE PRECLOSURE ANALYSIS

It is useful to review the

Before discussing the conclusions for the overall preclosure ana ~~review the insights from aggregations of certain performance-measure categories. Much of this~~ information was presented in Section 4.5.2, particular in Tables 4-11 and 4-12, bu~~t it is nonetheless repeated he~~ provide context ~~for the discussion of~~ the overall preclosure results. ~~4-23 repeats selected information from~~ Table 4-11.

Row 1 of Table 4-23 shows that the relative ranking of the nomina sites on preclosure radiological safety is Richton Dome, Deaf Smith, D Canyon, Yucca Mountain, and Hanford. The difference between the first site and the fifth-ranked site is equivalent to 15 radiological fatali workers, a difference largely attributable to transportation.

Row 2 of Table 4-23 shows that the relative ranking of sites on w fatalities (radiological and nonradiological) is Yucca Mountain, Richt Davis Canyon, Deaf Smith, and Hanford. The Yucca Mountain site is sli preferred to the three salt sites, which are barely distinguishable fr another, while the Hanford site is ~~[illegible]~~ less favorable. This significant difference is attributable to nonradiological fatalities i repository workers (mostly from mining accidents), which, in turn, ref the larger labor requirements for repository construction and operatio Hanford site.

Table 4-23. Base-case equivalent-consequence impacts for various aggregations of performance measures[a]

Row	Performance-measure category	Richton Dome	Deaf Smith	Davis Canyon	Yucca Mountain
1	Radiological fatalities (X_1, X_2, X_5, X_6)	15	16	17	22
2	Worker fatalities (X_1, X_3, X_5, X_7)	31	33	32	25
3	Public fatalities (X_2, X_4, X_6, X_8)	34	40	48	58
4	Health and safety (X_1 through X_8)	64	74	80	83
5	Environment and socioeconomics (X_9 through X_{12})	139	119	220	71
6	Public near site (X_2, X_4, X_9 through X_{12})	142	121	220	71
7	Site impacts (X_1 through X_4, X_9 through X_{12})	171	152	249	93
8	Noncosts (X_1 through X_{12})	203	193	300	154
9	Noncosts and transportation costs (X_1 through X_{12}, X_{14})	1173	1313	1540	1554
10	Noncosts and repository costs (X_1 through X_{12}, X_{13})	9203	9693	10,700	7654
11	Noncosts and total costs, i.e., all measures (X_1 through X_{14})	10,173	10,813	11,940	9054

[a]The numbers in this table represent the equivalent-consequence impacts rounded to unit.

explain units

repeat [illegible]

ranges estimated for possible impacts, the relative ranking of sites in the base case is totally insensitive to any changes in the level o impacts, except for costs. The ranking is insensitive to any reasona changes in the value judgments or in the form of the utility function

Because the cost differences among sites are in the billions of costs have a strong influence on the overall preclosure ranking. Hen seems prudent to examine the potential for significant overlap in tot ----- the sites. For example, if the costs estimated for the Hanford

Hanford is the farthest from the sources of waste. Other highly corr components of transportation costs include fuel and labor rates. The relationship of repository costs at different sites is less obvious b present uncertainty about underground conditions and consequently rep design. However, some major repository costs are positively correlat the sites. Future labor rates and costs for power are direct compone costs that would likely have a similar influence on repository costs . sites. Indirectly, technological advances for sinking large-diameter or changes in regulatory requirements are examples of causes that lea correlated repository costs. Thus, the likelihood that the relative repository costs at Hanford, for example, would be lower than those a other site is also probably very low.

With the insight provided by the analysis, it is easy to explain understand the results. All of the sites have some undesirable health-and-safety, environmental, and socioeconomic impacts. Because impacts are important, a larger number of potential sites have been p screened to reduce such potential impacts from a repository, and miti measures would be implemented to minimize them at any site developed repository. Both the screening and mitigation tend to reduce both th of impacts and the differences in such impacts among sites. No analo procedures have been employed for costs, which do have very significa differences (i.e., billions of dollars) in estimates.

Hanford is the least desirable site because its enormously great and greater health effects are not compensated for by its relatively advantage in environmental and socioeconomic impacts.

Yucca Mountain is the most desirable site of the other four site. It has the lowest environmental and socioeconomic impacts and is less expensive by more than 1 billion dollars. These advantages far outwe slightly greater health-and-safety impacts.

The salt sites must fall between Yucca Mountain and Hanford. De Canyon, the fourth-ranked site, is least desirable in terms of health-and-safety impacts, environmental and socioeconomic impacts, a costs. Richton Dome is slightly preferable to Deaf Smith in terms of health-and-safety impacts and slightly less desirable in terms of environmental and socioeconomic impacts, but the costs estimated for Smith are 650 million dollars higher than those for Richton Dome. Th Richton Dome is the site ranked second, and Deaf Smith is the site ra third.

The most important factors that affect the number of postclosure he effects are the number of people exposed (the population at risk) and th radiation doses each person receives. Radiation doses are assumed to de on radionuclide releases to the accessible environment and the transport retardation, dispersion, accumulation, and uptake of the released radionuclides along a variety of environmental pathways. These pathways determine the doses received by people from ingestion, inhalation, or immersion and are the factors designated 19, 21, 22, 23, etc., in Figure

Although the ingestion, inhalation, and immersion dose pathways in accessible environment are shown on the influence diagram for completene evaluations of the factors influencing the accessible environment over th next 10,000 to 100,000 years are impractical. ~~Although there may be clea differences among the accessible environments of the nominated sites now, is not clear that these differences will have any bearing on site perform far into the future. For this reason there was no attempt to compare sit the basis of these environmental factors, and, instead, DOE has adopted a approach that is based on~~ postulated releases that ~~may occur to the acces environment.~~

Factors 23, 24, 31, 37, and 38 in Figure 8-2 represent a simplified illustration of the defense in depth provided by the multiple barriers of geologic repository. The right-hand side of the performance measure scal was developed to provide a basis for estimating cumulative releases by evaluating the factors that influence the release and transport of radionuclides through the engineered and natural barriers of a geologic repository. For example, cumulative releases to the accessible environme are influenced by the quantities of radionuclides that are transported th the natural barriers in the controlled area to the accessible environment during the period of interest.

The types and quantities of radionuclides transported and the period time over which transport occurs depend chiefly on the radionuclide-travel time, the ground-water flux, and the geochemical conditions of the geohydrologic units in which transport occurs. The radionuclide-travel t may depend on the ground-water-travel time if ground water is the princip transporting medium and on the processes that retard the movement of the dissolved radionuclides in relation to the movement of the ground water. of these factors is determined by the type and characteristics of the ground-water pathway and the postclosure characteristics of the natural barriers (e.g., hydraulic gradients, conductivity, effective porosity, an geochemistry).

The radionuclides transported through the natural barriers originate releases from the engineered-barrier system. The types and quantities of radionuclides released from the engineered-barrier system are related to behavior of the engineered-barrier system and the rate of release for individual radionuclides. The behavior of the engineered-barrier system (e.g., the response to the thermal pulse introduced by the emplaced waste. related to the design of the engineered-barrier system (e.g., waste-packa spacing) and any changes in the engineered-barrier system that are induced disruptive processes and events (e.g., the breach of waste packages by fa displacement).

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Chapter 3

POSTCLOSURE ANALYSIS OF THE NOMINATED SITES

As described in Chapter 2, the formal decision-analysis method known as multiattribute utility analysis was applied to obtain a quantitative comparison of the five sites nominated as suitable for characterization. The application independently evaluated the estimated performance of a repository at each potential site before and after closure. This chapter describes the analysis of postclosure performance.

The components of the postclosure analysis are presented in the various sections of this chapter. Section 3.1 describes the objectives selected to guide the analysis. Section 3.2 summarizes the performance measures defined to quantify the degree to which these objectives are achieved. Section 3.3 discusses the scenarios, or sequences of processes and events, that could affect the postclosure performance of a repository and the judgmental probabilities assigned for each scenario at each site. Section 3.4 describes the performance estimated for each site, expressed in terms of performance measures, for each applicable scenario. Section 3.5 describes the multiattribute utility function developed to integrate the various assessments into an overall postclosure evaluation and the various value judgments for the analysis. Numerical results and sensitivity analyses are presented in Section 3.6. Finally, the conclusions derived from the postclosure analysis are summarized in Section 3.7.

3.1 OBJECTIVES

As noted in Chapter 2, a multiattribute utility analysis is based on the premise that the relative desirability of a site is determined by the extent to which the selection of that site would achieve the siting objectives. The implementation of this logic requires that site-selection objectives be made explicit. For this reason, specific statements of performance objectives for the long-term period after repository closure were developed. Postclosure objectives establish the basis for judging the suitability of a site after repository closure and guide the specification of quantitative performance measures.

Objectives may be stated as very broad and general goals, such as minimizing adverse impacts on the health and safety of the public after closure, or as specific objectives that must be achieved in order for the general objectives to be achieved, such as minimizing the number of health effects attributable to radionuclide releases from a repository. For the application of a multiattribute utility analysis, specific and relatively detailed objectives are required.

Although there may be clear differences among the nominated sites in pathways to the biosphere, the preliminary performance assessments reported in the environmental assessments (DOE, 1986a-e) show that the releases to the accessible environment over the next 10,000 to 100,000 years should be relatively insignificant. Indeed, the ground-water travel times estimated in the environmental assessments indicate that radionuclides released from the engineered-barrier system are not expected to reach the ground surface or discharge into surface-water bodies during this time period. Likely pathways to the biosphere would, therefore, consist of wells or borings drilled for water or for mineral exploration. For both of these pathways, releases beyond the controlled area have been evaluated in the ~~environmental assessments as well as the~~ postclosure analysis described here and in Chapter 3. ~~For this reason and for~~ Consistency that with the EPA and the NRC regulations, the DOE's an approach to site evaluations is based on comparing the cumulative radionuclide releases to the accessible environment against the EPA release limits. Accordingly, the DOE has not evaluated differences among the sites with respect to pathways to the biosphere within the accessible environment.

Table 4-24. Summary of the base-case analysis

Site	Expected utility	Equivalent-consequence impacts
Yucca Mountain	75.7	9,054
Richton Dome	70.1	10,173
Deaf Smith.	66.9	10,813
Davis Canyon	61.3	11,940
Hanford	48.5	14,492

Row 3?

Row 4 of Table 4-23 shows that the relative ranking of sites ag
health-and-safety impacts is Richton Dome, Deaf Smith, Davis Canyon,
Mountain, and Hanford. In terms of equivalent-consequence impacts, t
difference between the sites ranked first and the fourth (19 equivale
fatalities) is about half the difference between the sites ranked fou
fifth (37 equivalent worker fatalities).

Row 5 of Table 4-23 shows that the relative ranking of sites on
the environmental and socioeconomics performance measures is Hanford,
Mountain, Deaf Smith, Richton Dome, and Davis Canyon. The difference
the sites ranked fourth and fifth, Richton Dome and Davis Canyon,
respectively, is most significant, equivalent to 81 million dollars (
percent of the difference between the first- and the fourth-ranked si

Row 6 of Table 4-23 shows that the relative ranking of sites on t
impacts that would affect the public in close proximity to the site is
Hanford, Yucca Mountain, Deaf Smith, Richton Dome, and Davis Canyon—t
ranking as that obtained by considering only environmental and socioec
impacts. The most significant difference is between the sites ranked
and the fifth—that is, Richton Dome and Davis Canyon. If effects on
are included, the ranking remains the same (row 7, Table 4-23).

If all noncost performance measures are aggregated, ~~as in Row 8 o~~
~~4-23,~~ the relative ranking is Hanford, Yucca Mountain, Deaf Smith, Ric
Dome, and Davis Canyon. ~~Again,~~ The most significant difference is bet
sites ranked fourth and fifth; this difference is equivalent in value
million dollars. This difference is larger than that between the firs
the fourth ranked sites (equivalent to 61 million dollars). This rank
changed drastically by the addition of costs. When transportation cos
combined with the noncost performance measures, the ranking becomes Ri
Dome, Deaf Smith, Davis Canyon, Yucca Mountain, and Hanford (row 9, Tal
4-23). When repository costs are combined with the noncost performanc
measures, the ranking becomes Yucca Mountain, Richton Dome, Deaf Smith
Canyon, and Hanford (row 10, Table 4-23). When both transportation an
repository costs are combined with the noncost performance measures (i
performance measures are considered), the ranking is Yucca Mountain, R.
Dome, Deaf Smith, Davis Canyon, and Hanford (row 11, Table 4-23).

With these rankings on performance-measure categories in mind, the
conclusions for the overall base-case analysis and the sensitivity anal
can be summarized.

The base-case analysis, summarized in Table 4-24, shows that the r
ranking of sites on all preclosure is Yucca Mountain, Richton Dome, Dea
Smith, Davis Canyon, and Hanford. In terms of equivalent-consequence i
the difference between Yucca Mountain and Richton is the equivalent of
million dollars, between Richton Dome and Deaf Smith 640 million dollar
between Deaf Smith and Davis Canyon 1,127 million dollars, and between
Canyon and Hanford 2,552 million dollars. ~~Thus, the largest difference~~
~~the five sites is between the fourth-ranked Davis Canyon and the fifth~~
~~Hanford site~~.

The stability of the base-case results was examined by sensitivity
analyses involving changes in the level of impacts, in the value judgme
and in the form of the multiattribute utility function itself. Within

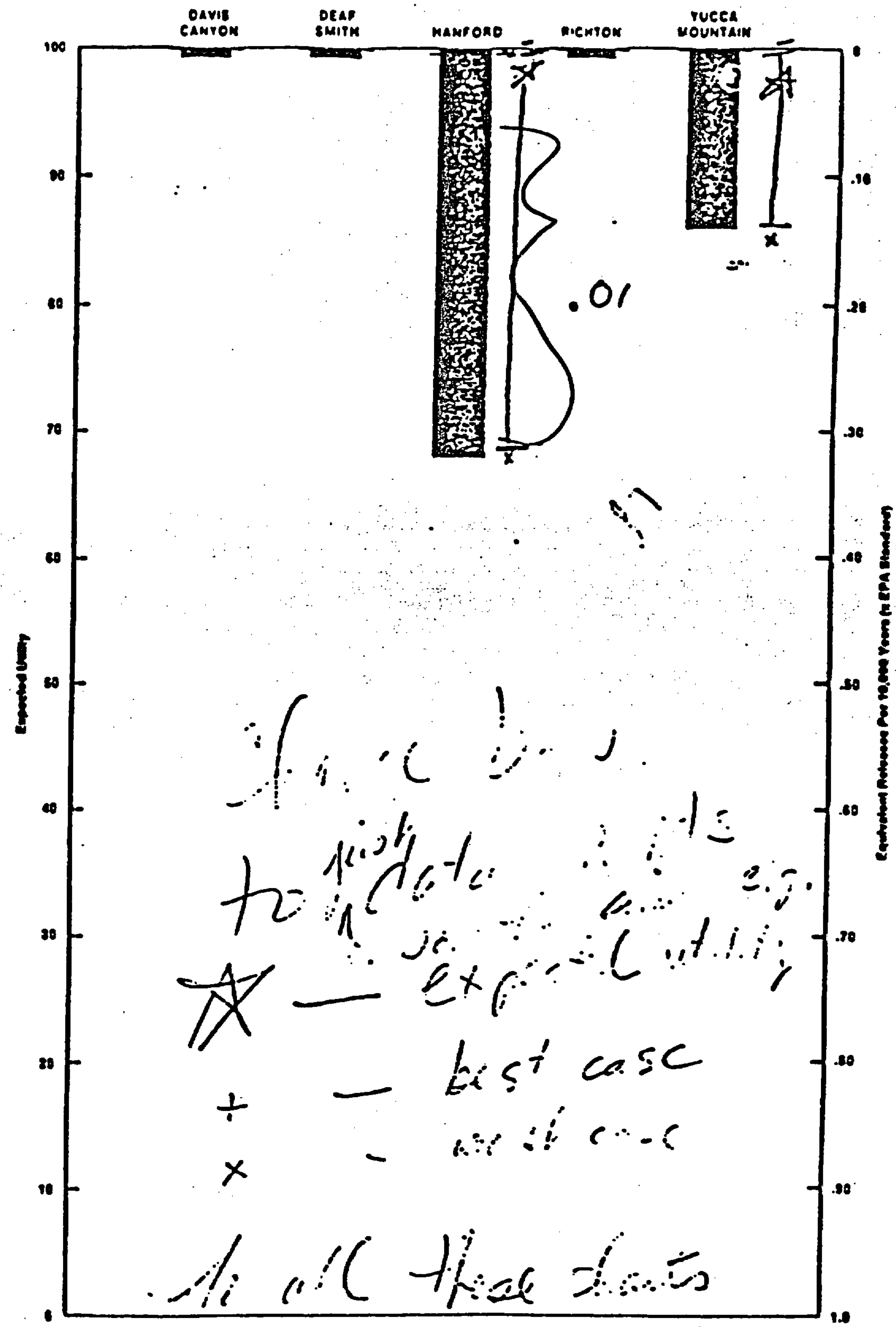

Figure 3.9. Ranges illustrating uncertainty in postclosure releases and utilities. Tick marks indicate base-case expected utilities.

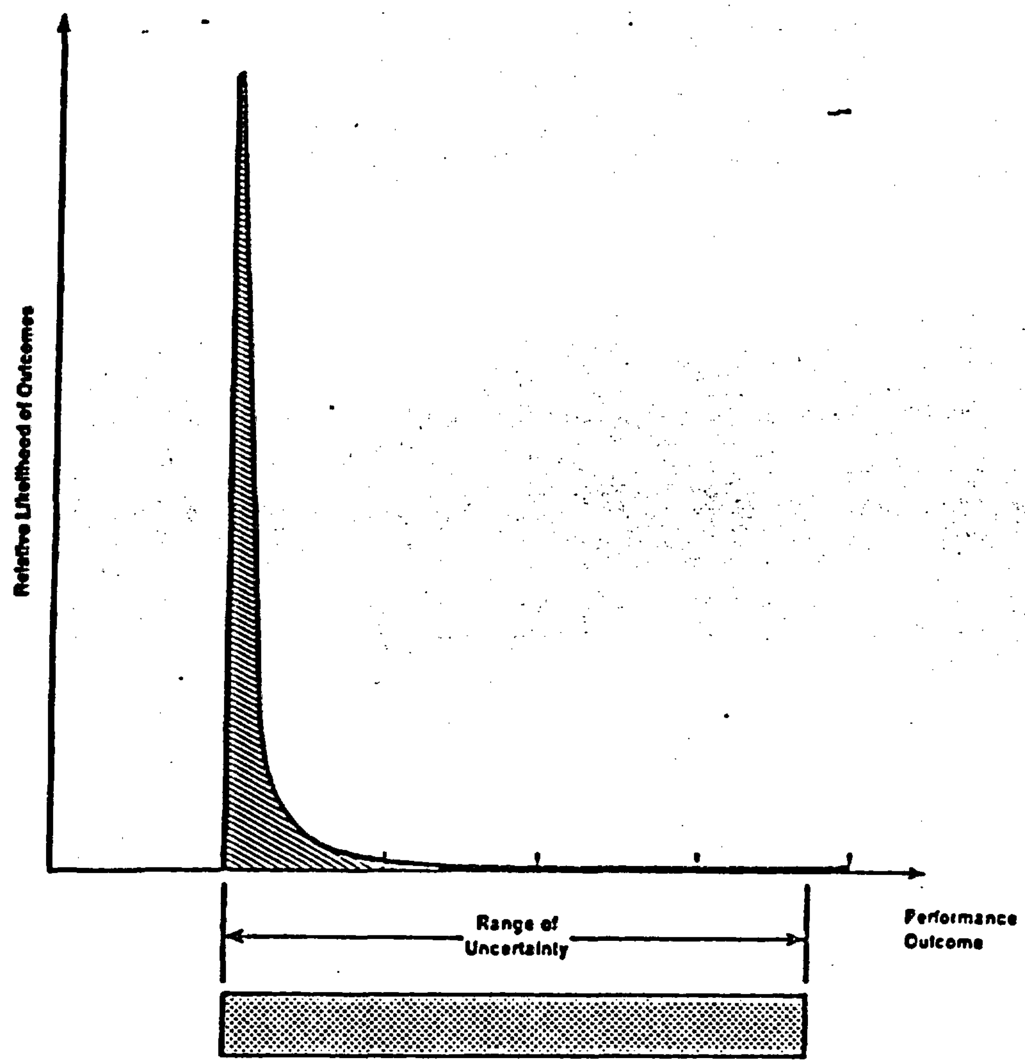

Figure 3.10. Approximate relative likeihood of outcomes within a range of uncertainty.

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Figures 3-11, 3-12, and 3-13 show how the expected postclosure utilit: for each site depend on basic uncertainties and value assumptions. Figure 3-11 shows the range of expected postclosure utilities as the scores for ea site are simultaneously varied from the high to the low estimates in Table with the probabilities of scenarios kept at the base-case estimates. Figur 3-12 shows the range of the expected postclosure utilities as the probabilities of disruptive and unexpected-feature scenarios are simultaneously varied from the high to the low estimates given in Table 3-3 with the scores kept at base-case values. Figure 3-13 shows the range of t expected postclosure utilities as scores and probabilities are simultaneous varied from optimistic assumptions (high scores for the sites and low probabilities for disruptive and unexpected-feature scenarios) to pessimist: assumptions (low scores for the sites and high probabilities for disruptive and unexpected-feature scenarios).

Figure 3-14 shows the effect of assuming increasing aversion to risk. obtain these results, possible outcomes involving high releases were given greater weight through the use of an exponential function whose effect is determined by a parameter called the "risk-aversion constant." Chapter 4 describes the method in more detail. When the constant is set to zero, no risk aversion is assumed, and the results are identical with the expected-value calculation. Increasing the value for the coefficient adjust the utilities to account for greater aversions to the possibilities involvin high releases. Although risk aversion alters the relative utilities, it doe not change the site rankings. The y-axis in the figure is expressed in term of equivalent releases.

Figure 3-15 shows the effect of changing the assumption that the single-attribute utility functions are linear in cumulative releases. The effect is to intensify (or reduce) the impact of scenarios, but the ranking sites is not changed. Thus, if the utility function is curved in such a way that the marginal value of reducing releases is greater when releases are lo than it is when they are high, the sites with smaller nominal releases attai more favorable expected utilities. Sensitivity analysis shows that the effects of such curvatures on expected utilities are extremely small.

As explained in Section 3.3.1, scenarios involving disruptive processes and events considered only the processes or events that might occur during t: first 10,000 years after repository closure. To check the effect of relaxing this assumption, the expected postclosure utilities of the sites were recomputed with the probabilities of disruptive scenarios increased by a factor of 10. Such an assumption would tend to overestimate the effects of disruptive processes and events that might occur during the first 100,000 years because, although this period is 10 times as long, disruptions occurrin 10,000 to 100,000 years after closure are unlikely to produce cumulative releases as large as they would if they were to occur in the first 10,000 years. The results, shown in Figure 3-16, thus provide a conservative estimate of the effect of considering disruptions beyond the first 10,000 years. As indicated, there is little effect on the expected postclosure utilities.

The scaling constants k_1 and k_2 for early and late releases, respectively, reflect a value judgment about the relative importance of early and late releases. As shown by Figure 3-17, the Davis Canyon and the Richton

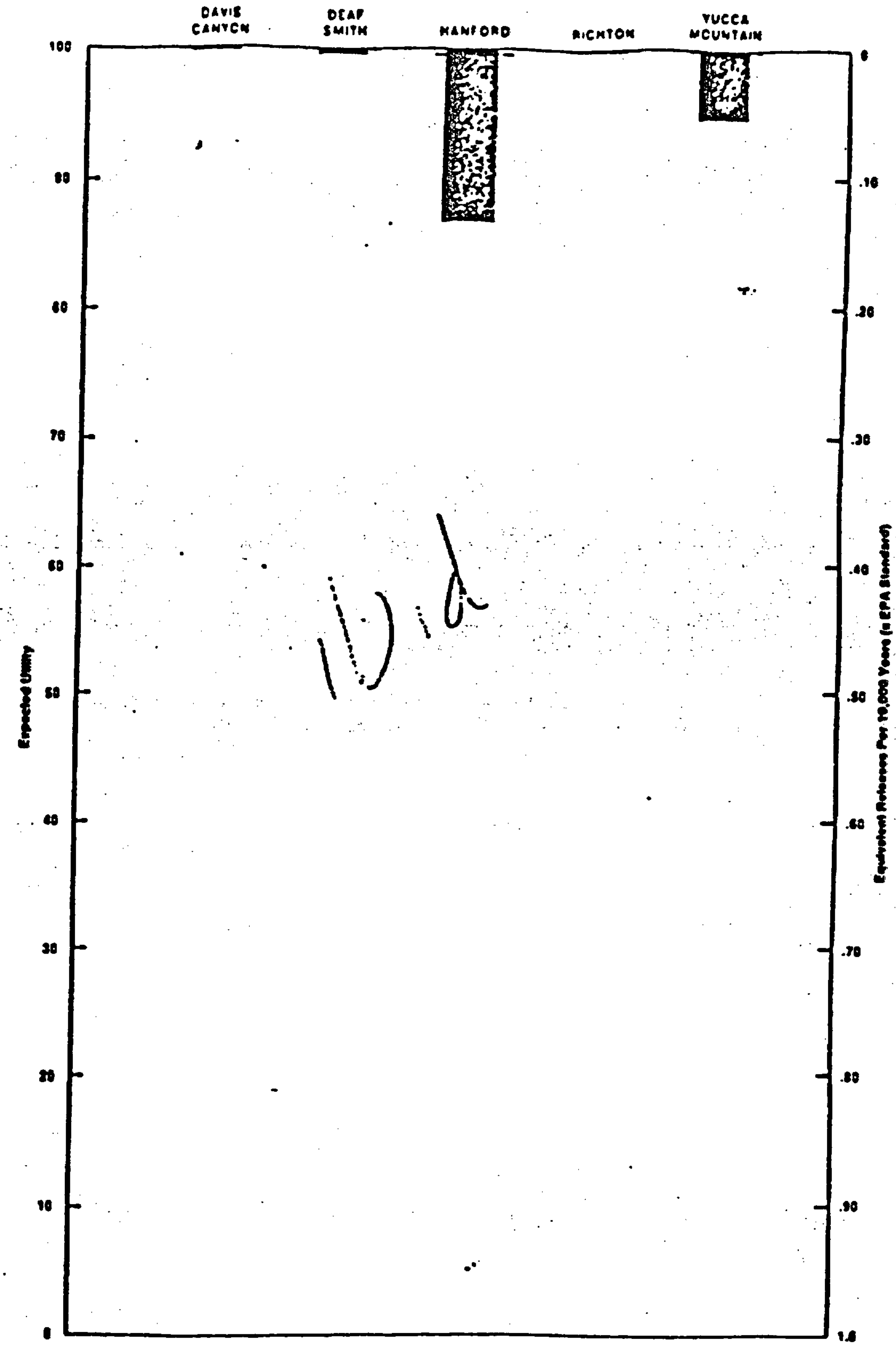

Figure 3.11. Sensitivity of expected postclosure utility and equivalent releases to varying site scores from high to low judgmental estimates. Tick marks indicate base-case expected utilities.

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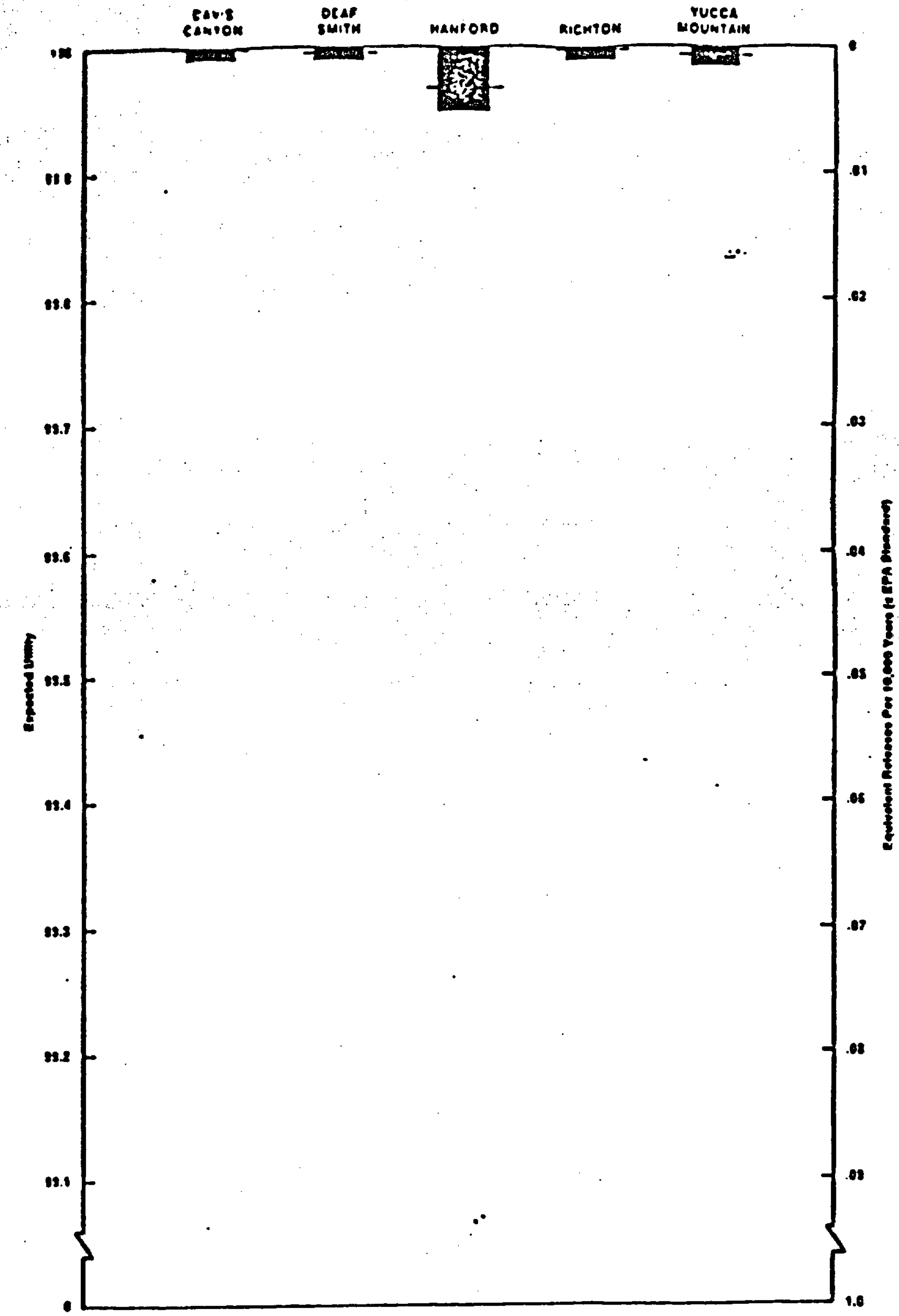

Figure 3.12. Sensitivity of expected postclosure utility and equivalent releases to varying site scenario probabilities. Tick marks indicate base-case expected utilties.

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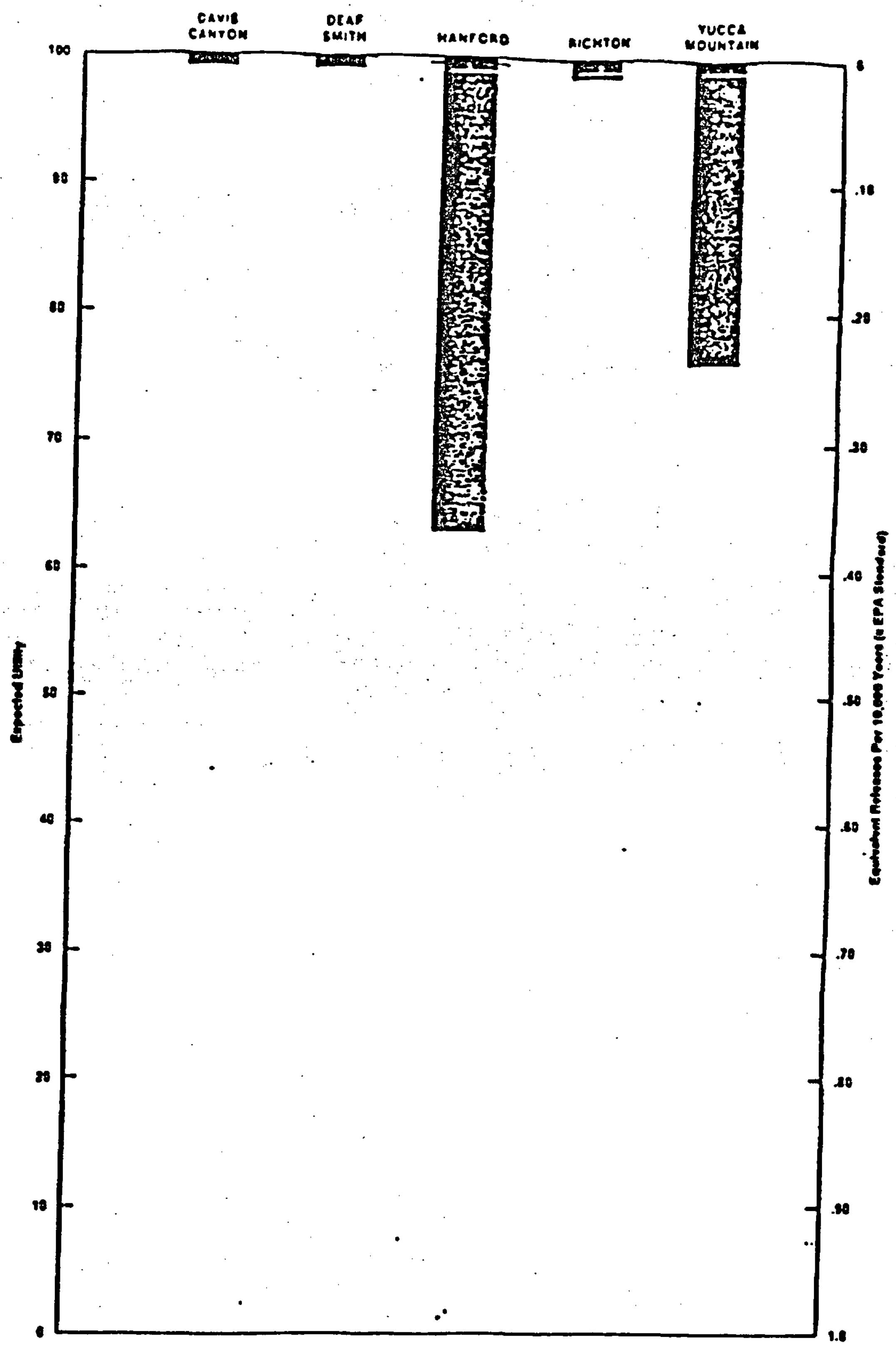

Figure 3.13. Sensitivity of expected postclosure utility and equivalent releases to varying scores and scenario probabilities from optimistic (high scores and low probabilities for disruptive and unexpected features scenarios) to pessimistic (low scores and high probabilities for disruptive and unexpected features scenarios) assumptions. Tick marks indicate base-case expected utilities.

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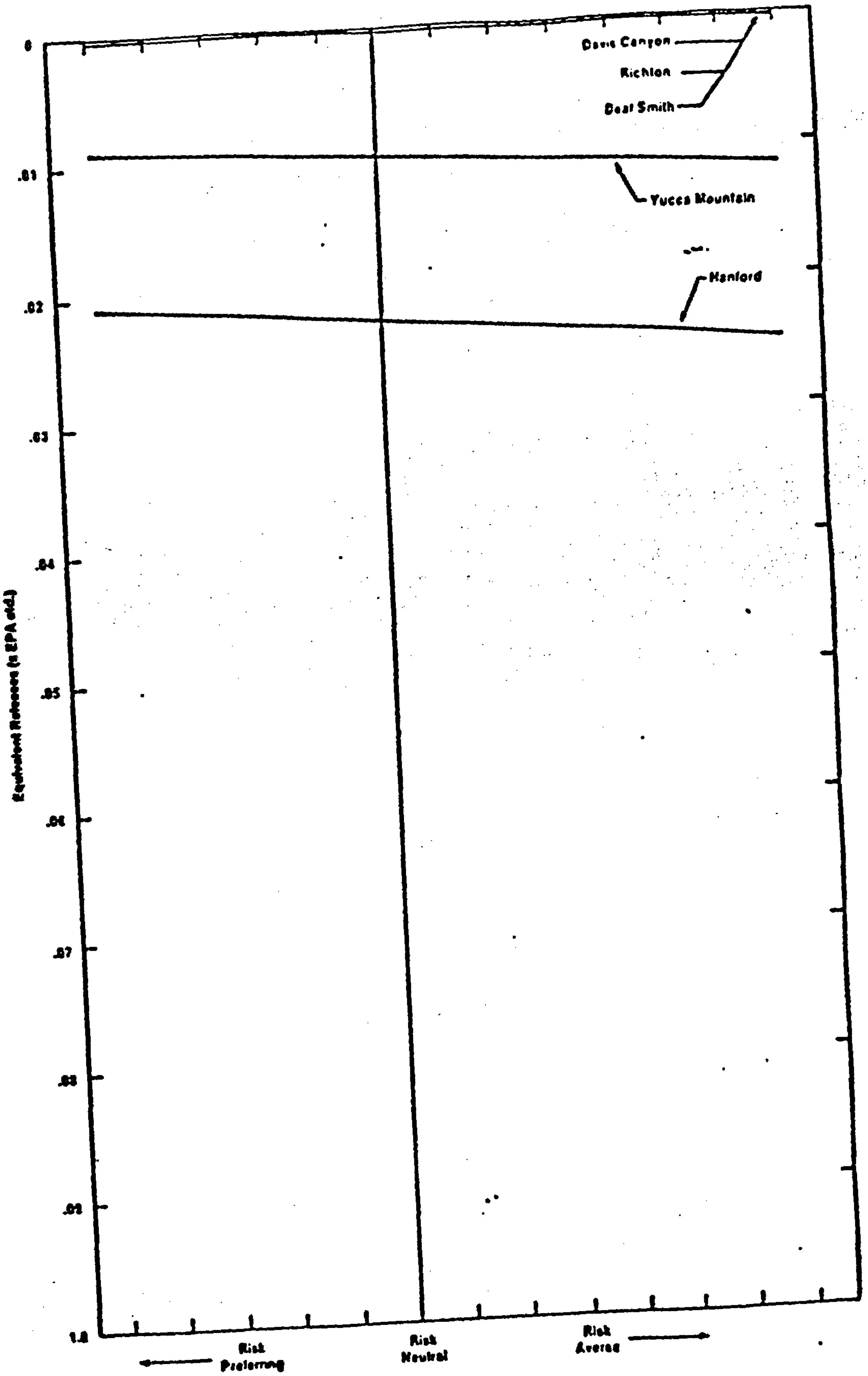

Figure 3.14. Sensitivity of postclosure certain equivalent release to risk attitude.

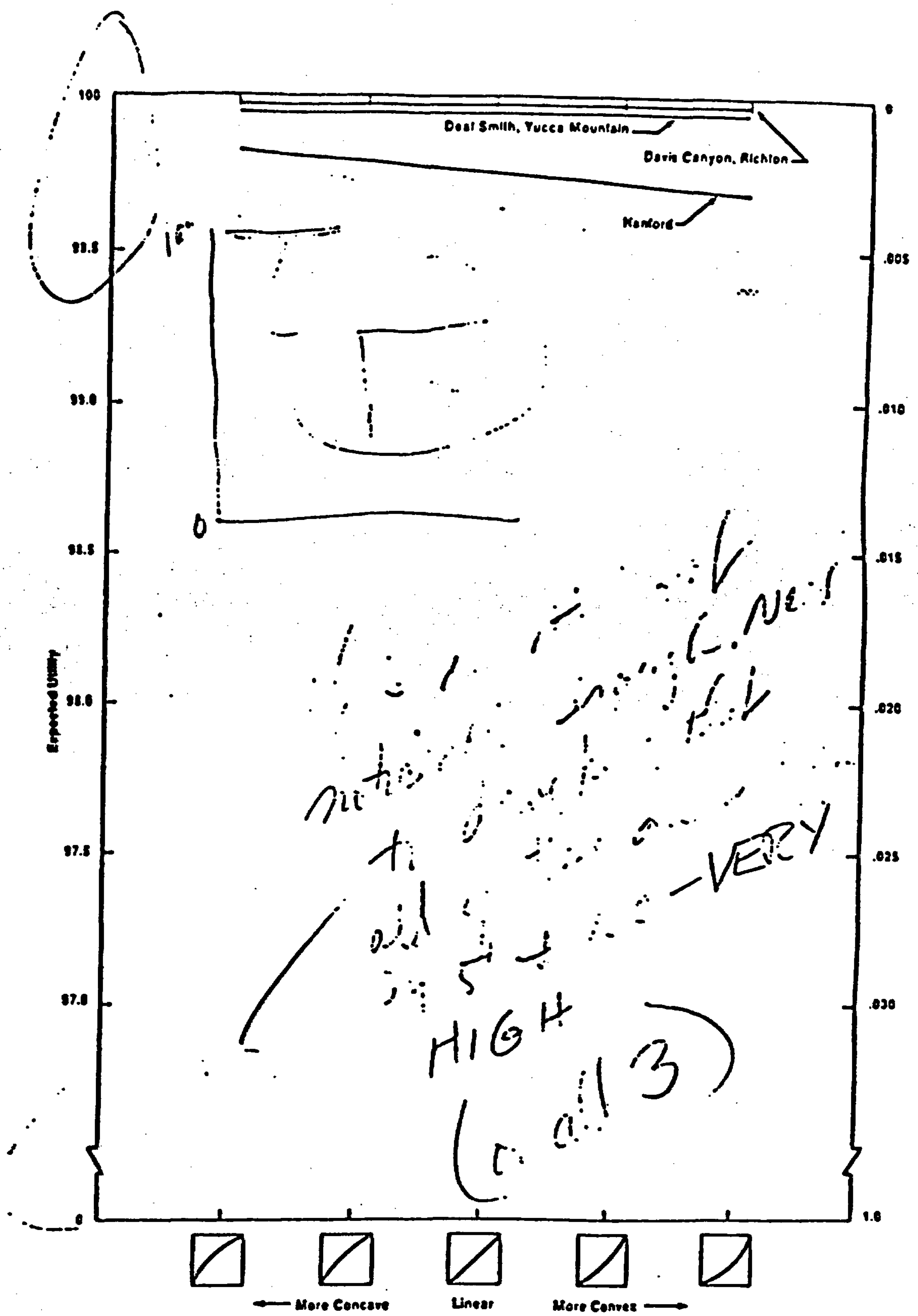

Figure 3.15. Sensitivity of expected postclosure utility and equivalent releases to varying assumptions on the curvature of the single-attribute utility function.

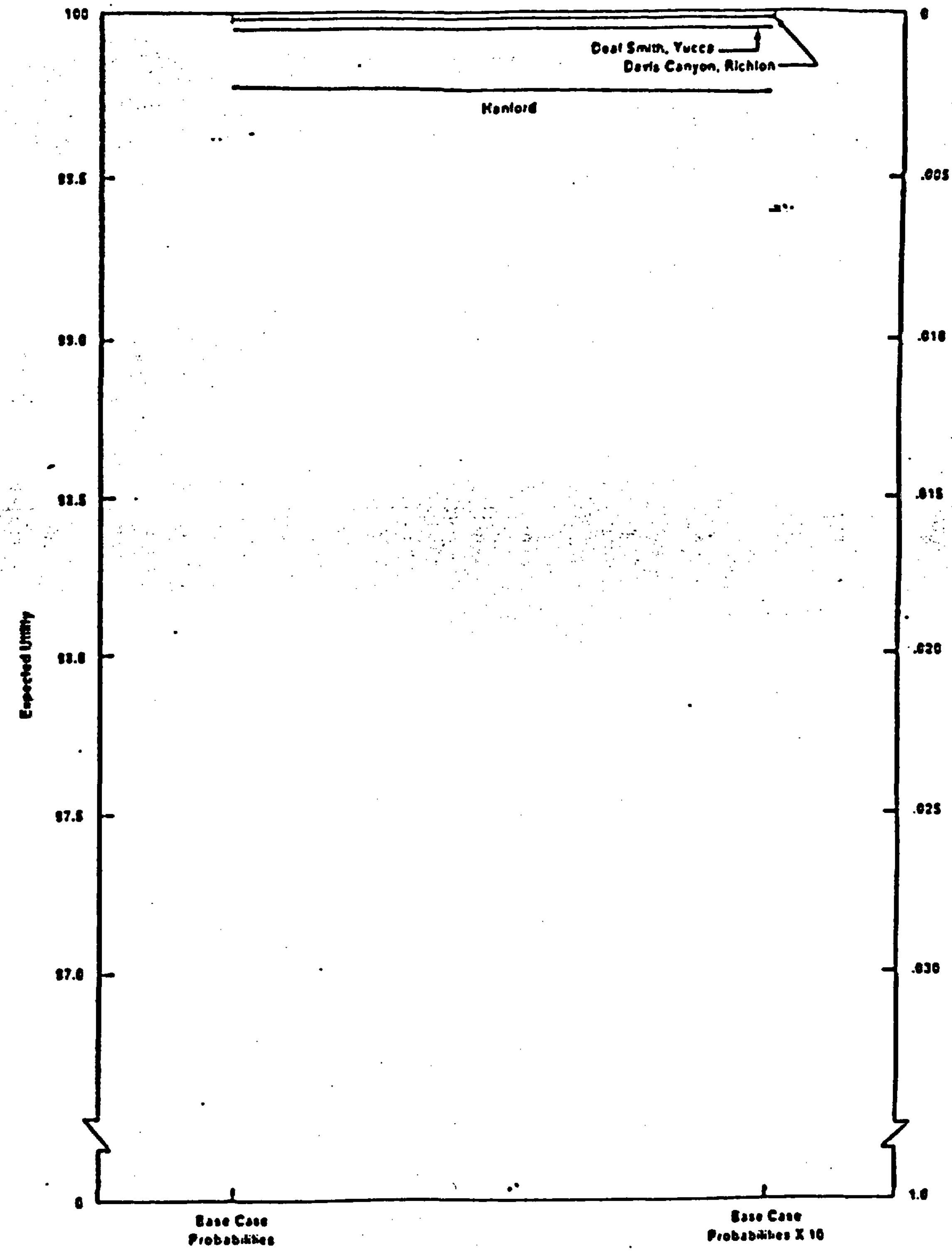

Figure 3.16. Sensitivity of expected postclosure utility and equivalent releases to scaling the probabilities of disruptive scenarios.

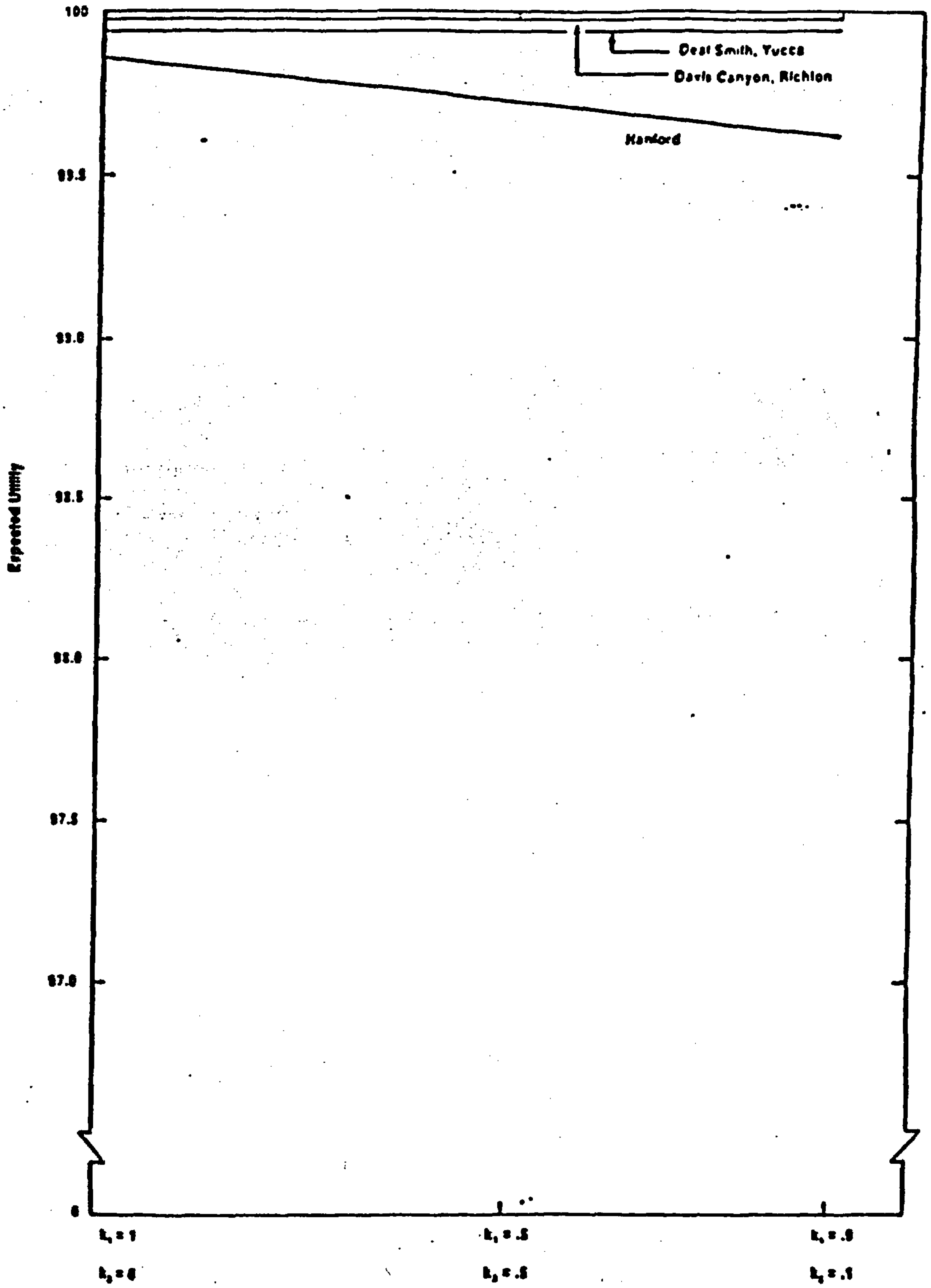

Figure 3.17. Sensitivity of expected postclosure utility and equivalent releases to varying scaling factors.

Dome sites are not significantly affected by the values of the scaling constants, since estimated releases per 10,000-year interval are approximatc constant. The Deaf Smith and the Yucca Mountain sites are slightly affectec and the Hanford site is more strongly affected. As the scaling factors are changed to increase the importance of later releases (i.e., from $k_1 = 1$ and $k_2 = 0$ to $k_1 = 0.1$ and $k_2 = 0.9$), the latter three sites decrease in expected utility. However, the rankings do not change, and the relative differences between the sites are not significantly affected. The magnitude of the effects is much less than that produced by varying the probabilities scenarios or the scores of the sites.

As explained in Section 3.4.1, the releases from a repository at variou sites were estimated with the aid of constructed scales (Figures 3-3 and 3-4). These scales establish a correspondence between the hydrologic, geochemical, and geomechanical characteristics of a site and the radionuclid releases. As noted in the discussion of these scales, the releases corresponding to any given set of site characteristics could be 10 times higher or lower than the estimates given in the scales. Figure 3-18 shows th effect on the expected utility for each site as the releases are varied by a factor of 10 above and below the levels shown in Figures 3-3 and 3-4. Although the differences among the expected utilities change, the ranking of the sites does not change.

3.7 CONCLUSIONS FROM THE POSTCLOSURE ANALYSIS

A number of conclusions can be derived from the base-case expected utilities, the ranges of uncertainty in releases, and the sensitivity analysis. ~~Perhaps~~ Most striking is that all of the sites are expected to perform extremely well and are capable of providing exceptionally good waste isolation for at least 100,000 years after repository closure. As already mentioned, this finding is consistent with other studies of repository performance at carefully selected sites. When placed on a scale where a 0 ca be interpreted as performance at the minimum level required by the primary-containment requirements of the EPA standards and 100 is perfection, all of the sites have expected utilities of 99.7 or higher. This corresponds to an assessment that all of the sites are as desirable as a site with an average release rate that is less than 0.003 of the EPA limit for 10,000 year

The analysis shows that, under some unlikely but possible disruptive scenarios and pessimistic assumptions, it is possible for a site to have releases that are a significan fraction of the EPA limit. At the salt sites, releases could be as high as one-tenth or so of the limit; at the nonsalt sites, releases could be equal tc or greater than the limit. However, the probabilities of scenarios producing these higher releases are judged to be extremely low, only a few chances in a thousand at most.

From the relative ranking of the sites and estimates of uncertainty, it appears that the postclosure performance of a repository at the Hanford site would be slightly less favorable than that of a repository at the salt sites or at the Yucca Mountain site. The principal bases for this conclusion are technical judgments regarding the potential for waste dissolution, radionuclide travel time, and the possibility of the existence of unexpected

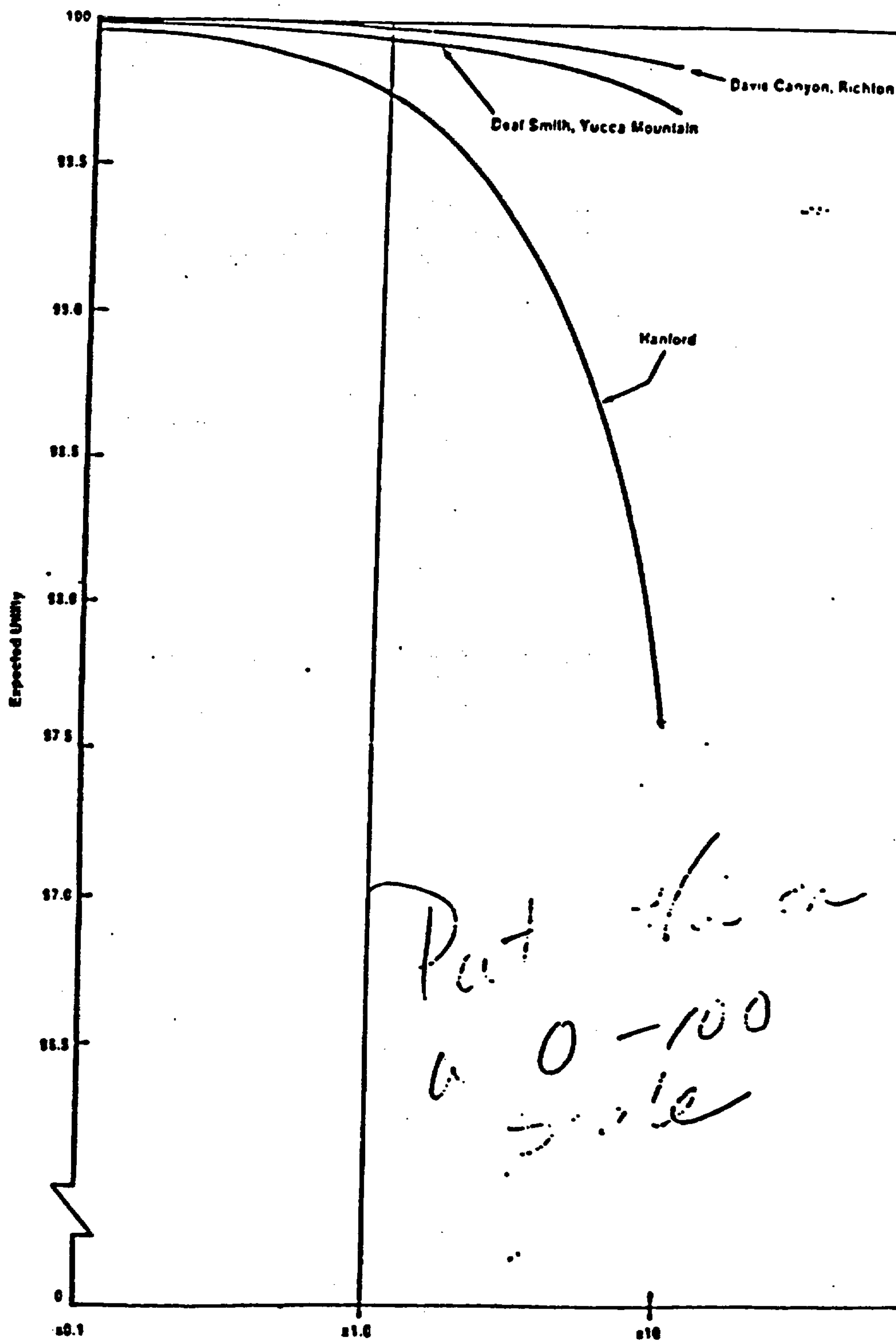

Figure 3.18. Sensitivity of expected postclosure utility to uncertainty in correspondence between site characterizatics and releases.

features at the site. It must be kept in mind, however, that the release estimates are very low, and the utility differences among the sites are extremely small. The probabilities of the various possible postclosure releases and utilities (Figure 3-9) indicate that there is one chance in fi to one chance in ten that a repository at the Hanford site would actually h a lower level of releases than a repository at any of the salt sites.

Thus, there is greater confidence in the salt sites than in the nonsal sites, and there is more confidence in the Yucca Mountain site than in the Hanford site. This is because of greater uncertainty in the performance of the nonsalt sites (especially the Hanford site) under expected conditions a a higher probability of significant disruptive scenarios and unexpected features at the nonsalt sites. Despite these differences, however, it is clear that the confidence in all sites is extremely high.

The postclosure rankings produced by the analysis are relatively insensitive to variations in assumptions, the uncertainty represented by the range of release estimates, and alternative value judgments. The difference in the expected postclosure utilities estimated for the sites, which quantif the relative postclosure desirabilities of the sites, are extremely small. Uncertainties not accounted for in the analysis, such as errors associated with the limits of human judgments or the possibility of unidentified mechanisms for releases, may be greater than the small postclosure differenc identified by the analysis.

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Chapter C-7

Other Considerations

The Department has described the siting process to be used in selection of a site for development as the nation's first geologic repository in Sectio 960.3-2 of its General Guidelines for the Recommendation of Sites for the Nuclear Waste Repositories; Final Siting Guidelines (10 CFR Part 960). Withi the siting process, the recommendation of three sites to the President for detailed site characterization is described in Section 960.3-2-3. That section states that:

> "The recommendation decision shall be based on the available geophysical, geologic, geochemical, and hydrologic data; other information (emphasis added); associated evaluations and findings reported in the environmental assessments accompanying the nominations; and the considerations specified below ..."

These considerations include:

> "the sites nominated as suitable for characterization shall be considered as to their order of preference as candidate sites for characterization. Subsequently, the siting provisions specifying diversity of geohydrologic settings, diversity of rock types ... shall be considered to determine a final order of preference for the characterization of such sites."

Accordingly, the recommendation decision can be represented diagramatically as follows:

FINAL ORDER OF
PREFERENCE

INITIAL ORDER OF PREFERENCE | DIVERSITY OF GEOHYDRO-LOGIC SETTINGS | DIVERSITY OF ROCK TYPES

SITE RANKING DETERMINED USING DECISION-AIDING METHODOLOGY | OTHER INFORMATION

AVAILABLE DATA IN ENVIRONMENTAL ASSESSMENTS | EVALUATIONS AND FINDINGS IN ENVIRONMENTAL ASSESSMENTS

No currently available methodology, including the one described and applied in the previous chapters, is capable of completely and accurately accounting for all factors relevant to the site recommendation decision. Consequently, it is prudent to supplement the results obtained through the application of the methodology with "other information" or "other considerations" bearing on the site recommendation decision. These "other considerations" are described in this chapter.

C-7.1 Identification of Other Considerations

In order to identify subjects that may constitute "other considerations" which have not been addressed in the evaluations and findings within the environmental assessments or the formal decision-aiding methodology, the Department reviewed (1) the records of the EA scoping hearings, (2) comment: received during development of the Siting Guidelines, (3) comments received the Mission Plan, (4) programmatic objectives identified in the Siting Guidelines and the Mission Plan, (5) comments received on the draft environmental assessments (including verbal comments at public hearings), an (6) comments received from the National Academy of Sciences Board on Radioactive Waste Management during their review of the formal decision-aidi methodology. These items were reviewed specifically with respect to (1) any commitments that the Department may have made with respect to "other information" that could be considered, and (2) any issues raised that are not addressed in the evaluations and findings within the environmental assessment or the formal decision-aiding methodology but may have a significant bearing on the recommendation of sites for detailed site characterization. In reviewing all of the above-listed items, the Department exercised caution to avoid any double-counting of issues, such as repository costs or land ownership, which are already counted explicitly in the evaluations and findings within the environmental assessments or the formal decision-aiding methodology.

EA Scoping Hearing Comments

Review of the comments received at the EA scoping hearings identified a long list of issues, such as documented in ONWI-505, Summary of Issues and Concerns Expressed During the April-May 1983 U.S. Department of Energy Public Hearings on Proposed Nomination of Sites for Site Characterization and

Recommendation of Issues for Environmental Assessments and Site Characterization Plans. Some of these issues have been covered by the EPA standard (such as individual dose limits), some of the issues have been covered by the Siting Guidelines (such as availability of water sources, the impact of off-site facilities, or the estimated value of mineral resources), and many of the issues have been addressed in the environmental assessments (such as salt disposal, impact of the work force on the socioeconomic framework of the community, fragility of the environment, or re-location impacts on existing population during site acquisition). Issues raised that may be suitable as "other considerations" include:

1. distinction between nuclear and non-nuclear host States,
2. presence of other national programs, e.g. defense programs or the strategic petroleum reserves,
3. relative differences in the productivity (food and fiber) of the accessible environment, and
4. the presence of major surface water systems in the accessible environment, e.g. the Columbia and Colorado Rivers, which are relied upon regionally for water supply, food supply, and recreation.

With respect to the distinction between nuclear and non-nuclear host States, the Department does not believe that Congress, in attempting to provide a remedy to a national nuclear waste disposal problem by enacting the Nuclear Waste Policy Act of 1982, intended to restrict the disposal of spent fuel and high-level radioactive wastes to those states whose citizens derive direct benefits from the use of electricity generated by nuclear energy. Likewise, the Department does not believe that Congress intended to restrict the geologic repositories to those states which have not previously shared a substantial burden for activities or facilities serving the national interest. a

With respect to productivity or major surface water systems in the accessible environment, the EPA has established a general standard for the management and disposal of high-level wastes and spent fuel that restricts potential releases to the accessible environment in order to avoid the obviou: problem of projecting the characteristics of the accessible environment, specifically factors like population distribution, types of crops, and water use, over periods of tens of thousands of years. The Department agrees with this approach; and, the post-closure performance measures employed in the formal decision-aiding methodology are based on cumulative releases to the accessible environment.

Based on this review, no issues that may have a significant bearing on the recommendation of sites for detailed site characterization were identified in the records of the EA scoping hearings which were not addressed in the findings and evaluations in the environmental assessments or the decision-aiding methodology.

Siting Guidelines Comments

Review of the comments received on the Siting Guidelines identified issues that have been covered by the final EPA standard, 40 CFR Part 191 (such as ground-water sources within the controlled area or the consideration of individual doses); issues covered in revisions to the Siting Guidelines bef they were finalized (such as the presence of ground-water sources along flo paths to the accessible environment or the resource potential of the host rock); issues that are addressed in the formal decision-aiding methodology (such as explicit weighting factors among the separate guideline groups, the consideration of potential radionuclide releases to the accessible environme for periods of time up to 100,000 years, or adoption of a formal, numerical decision methodology); and issues that the Department does not consider discriminators among sites in the site selection process (such as adoption o a zero-release standard, application of ALARA, or the assessment of differences between sites based on perceived risks). Finally, the Department identified a set of issues (such as differences among sites in retrievabilit) or the availability of a water supply for construction and operation) which would be double-counted if treated separately under "other considerations." As a result, the Department did not find any additional issues in the comment received on the Siting Guidelines which were not evaluated in the environmental assessments or may have a significant bearing on the recommendation of sites for detailed site characterization and, therefore, should be treated explicitly under "other considerations."

Mission Plan Comments

The review of comments on the Mission Plan centered on the synopses of comments in DOE/RW-0005, Volume 2, Record of Responses to Public Comments on the Draft Mission Plan for the Civilian Radioactive Waste Management Program.

Since the comments received were addressed to the text of the draft Mission Plan, they tended to be very specific with respect to that document and revisions which the Department should make in finalizing the document. Nea all of the issues raised in the comments that may have an influence on the site recommendation have been addressed in the Siting Guidelines, the environmental assessments, and the formal, decision-aiding methodology. Issues that may be suitable as "other considerations" include:

1. the differences among the sites in the ability, as part of the decontamination and decommissioning of any site during or after sit characterization, to re-vegetate a site to its original condition, a
2. the methods that would be used to obtain land and mineral right ownership (e.g., federal title transfer, eminent domain for private land, and severed mineral rights).

The first of these issues has been considered in the evaluation of sites against the potentially adverse conditions on unavoidable and unmitigatible changes in environmental quality in the environmental assessments and the evaluation of the sites against performance measures related to environmenta quality in the decision-aiding methodology. The second of these issues is highly speculative at this time because, as pointed out in the response to th issue in the record of responses to public comments, there are a variety of options available with widely varying degrees of difficulty. Further, the Department cannot speculate, at this time, on the relative differences in degree of difficulty between negotiating sales of land or mineral rights, taking land or mineral rights through eminent domain proceedings, or obtaining

Congressional approval for the transfer of title for federal land. Accordingly, the Department did not identify any "other considerations" in t comments on the Mission Plan that are not already considered in the environmental assessments or decision-aiding methodology and that may have a significant effect on the site recommendation decision.

Mission Plan Programmatic Objectives

The major programmatic objectives identified in the Mission Plan relate to public health and safety, program schedule, waste disposal system costs, and the likelihood of success in the disposal of high-level wastes, spent fuel, and defense wastes. In addition, Section 960.3-2-3 of the Siting Guidelines defines the objective for the recommendation of sites as:

> "the sites recommended as candidate sites for characterization shall offer, on balance, the most advantageous combination of characteristics and conditions for the successful development of repositories at such sites."

From these programmatic objectives, the Department identified the following issues for possible inclusion as "other considerations":

1. the timing of the preliminary determination,
2. the licensability of the site,
3. the number of sites to be recommended for detailed site characterization,
4. the risk of disqualification during site characterization or construction,

5. the potential for schedule delays during site characterization or construction so as to seriously impair the Department's ability tc maintain the program schedule,

6. the potential for significant cost increases beyond the estimated ranges in the environmental assessments,

7. the ability to co-locate a test and evaluation facility (TEF) at tl repository site,

8. the presence of issues which may not be reasonably resolvable durir site characterization given the time available or the state-of-the-art in testing, and

9. the effect of an improved performance waste disposal system, dependent upon Congressional authorization of the Monitored Retrievable Storage facility (MRS).

Several of the issues (e.g., items 1, 3, 7, and 9) can be grouped together under the subject of investment strategy. For example, the timing o the preliminary determination is significant primarily from the viewpoint of whether the Department should focus on success (i.e., the best set of sites from which to develop a geologic repository) or on the avoidance of failure (i.e., the need to have reasonable expectation that all three recommended sites will "survive" detailed site characterization and will be shown suitable for development as geologic repositories after characterization). The former approach allows the Department to evaluate not only the median scores for each site, but also to consider the ranges of scores and the differing levels of uncertainty that may be associated with the maximum and minimum scores. The latter approach forces the Department to focus on the median scores and to avoid sites with a wide range of uncertainty. In either case, the Departmen has clearly delineated its position that the Act permits the preliminary determination of the suitability of the sites for development as geologic repositories shortly after the recommendation of sites for detailed site characterization. The Department will make a final determination of the suitability of the site for development as a geologic repository after characterization in the license application for construction authorization.

The number of sites to be recommended for detailed site characterization is also primarily an investment decision. Based on the Department's position on the preliminary determination, the Department will recommend three sites for detailed site characterization - at a projected cost of $500 million per site for site characterization studies and $500 million per site for other studies (such as waste package development, repository design, and advancement of performance assessment capabilities). Other examples of investment issues are the ability, after receipt of a construction authorization, to co-locate a test and evaluation facility at the repository site, and the adoption of an improved performance waste disposal system.

Several of the issues (e.g., items 2, 5, and 8) can also be grouped together under the subject of program schedule, namely the licensability of the site, the potential for schedule delays during site characterization or construction, and the presence of issues that may be unresolvable during site characterization. The licensability of the sites is largely determined by the composite of the findings and guideline-by-guideline evaluations in the environmental assessments. With respect to the potential for schedule delays during site characterization, there is concern that any one site, although not demonstrably unsuitable or disqualified, may fall substantially behind the other sites during characterization and thereby not be available in a reasonable timeframe for consideration as alternative sites in the Environmental Impact Statement. The Department, however, has taken the position that in such an instance, the Secretary can declare site characterization sufficiently completed so as to proceed with the selection of one site for development as the nation's first geologic repository. As examples of potentially unresolvable issues during the time allotted for site characterization, the Department may not be able to definitively characterize either the mechanism of ground-water flow over large distances in bedded or domal salt or the amount and temporal or spatial distribution of flux through the unsaturated tuff at the Yucca Mountain site. In these cases, the Department has adopted the approach to conservatively bound the phenomena in its calculations in order to demonstrate adequate ground-water travel time and isolation capability. In this manner, the inability to resolve an issue during site characterization has been taken into account in the evaluations in the environmental assessments and in the treatment of uncertainty within the formal, decision-aiding methodology.

The programmatic objective for cost-effectiveness raises the issue of potential cost increases beyond the estimated ranges in the environmental assessments (item 6). This issue can be dropped using the double-counting criterion, however, since the scoring process included a wide error band (≈ 35%) for the repository costs.

Finally, the programmatic objective of success raises the issue of possible disqualification of a site(s) during site characterization and construction (item 4). This issue has been addressed previously by the application of the Hurwitz procedure.

Draft EA Comments

The review of comments received on the draft environmental assessment focused on the summary of comments in Appendix C of the final environmental assessment. Specifically, this review focused on comments that may apply across all repository sites in Sections C.2, Policy Issues, and C.3, Siting Process and Decisions. Site-specific comments in Sections C.3 through C.8 were not reviewed for potential use as "other considerations." Nearly all of the issues raised by the comments that may affect the recommendation decision have been addressed in the final environmental assessments or the decision-aiding methodology. For example, on the issues of the decrease in property values near sites (federal land vs. private land) and the difficulty in land requisition (Congressional approval of title transfer vs. condemnation of private land), the Department has addressed these issues under the socioeconomic and site ownership and control evaluations.

Issues that may be suitable as "other considerations" include:

1. compliance with State and local regulations,
2. route-specific transportation analyses from the reactors to each site, and
3. productivity and quality of the accessible environment.

With respect to compliance with State and local regulations, the Department does not believe it is appropriate to attempt to characterize the anticipated difficulty in obtaining State and local permits or to base the recommendation decision on that difficulty, except where there is a definitive technical basis to do so such as in the evaluation of projected air quality degradation. In these cases, the Department has presented and used the technical evaluations in the final environmental assessments and the decision-aiding methodology, respectively.

With respect to route-specific transportation analyses from the reactors to each site, the Department believes that the general methods and national average data used are adequate at this stage of the siting process and are consistent with Appendix IV of the Siting Guidelines. Route-specific analyses and an evaluation of the impacts on host States and States or Indian tribes along transportation corridors will be included in the environmental impact statement.

With respect to productivity and quality of the accessible environment (e.g., prime farmland or nearby rivers), this issue was discussed previously under EA scoping hearing comments. Accordingly, the Department did not identify any "other considerations" in the comments on the draft environmental assessments or decision-aiding methodology and that may have a significant effect on the site recommendation decision.

National Academy of Science Comments

Finally, the Department considered comments received from the National Academy of Sciences Board on Radioactive Waste Management on the formal decision-aiding methodology. The comment the Department considers appropriate for possible use as an "other consideration" is the issue of differences among sites in the quality of where potential releases of radionuclides in the accessible environment may occur, e.g., the differences between a highly productive potable aquifer and a low yield, brackish or saline aquifer or the differences between a surface water body depended upon for water supply or sustenance and a playa lake. As indicated previously in the discussion of EA scoping hearing comments, the Department agrees with the EPA approach of restricting releases to the accessible environment rather than attempting to characterize the quality or other factors (such as population distribution, crop type, or water use) describing the accessible environment for periods of tens of thousands of years.

C-7.2 Discussion of Other Considerations

Based on the identification of issues possibly suitable for use as "other considerations" described in the previous section of this chapter, the Department was able to identify ___ issues that were not addressed in the findings and evaluations in the environmental assessments or the formal decision-aiding methodology but may have a significant bearing on the recommendation of sites for detailed site characterization. This section describes these ___ issues and qualitatively describes the differences among the sites for each issue.

The additional issues for possible use as other considerations are:

1. the licensability of the site,
2. the risk of disqualification during site characterization or construction,
3. the potential for schedule delays during site characterization or construction so as to seriously impair the Department's ability to maintain the program schedule,
4. the ability to co-locate a test and evaluation facility (TEF) at the repository site,
5. the improved performance disposal system, dependent upon Congressional authorization of the MRS,
6. (ADD OTHER ISSUES AS APPROPRIATE).

The issue of differences among the sites based on the relative licensability of the sites may be summed up in the statement that a "good" site that takes an inordinate number of years to license is probably not a "good" site. Such a site would place in jeopardy not only the Department's commitment to acceptance of wastes for disposal in 1998 but also the Mission Plan objective on cost-effectiveness.

Relative differences in licensability among the sites can arise from many different factors, some of which can be evaluated at this time (such as the presence of potentially adverse conditions) and others which cannot be determined at this time, such as the ability to obtain applicable state and local permits. Other factors, such as ground-water travel times that are only slightly above the 1,000 year disqualifier, cannot be evaluated as to their effects on licensability until a performance allocation among the various engineered and natural barrier subsystems has been established or the results of site characterization studies are available.

With respect to the presence of potentially adverse conditions, the Department can review previous experience in licensing nuclear facilities to develop insight as to which potentially adverse conditions have become highly contentious and resulted in major delays in licensing. In this manner, the presence of a particular potentially adverse condition(s) may be demonstrated as more significant than the presence of others. The Department can supplement this insight by placing a relative order of significance on the potentially adverse conditions that have a closely-associated disqualifying guideline than on the potentially adverse conditions that do not have a closely-associated disqualifying guideline. In the following discussion, the Department has used this approach to develop insight into what are likely to be the most contentious potentially adverse conditions at each site.

The Davis Canyon site has eleven potentially adverse conditions that have a closely associated disqualifying guideline. Of these, the next significant are related to environmental quality and include significant adverse environmental impacts that cannot be avoided or mitigated, proximity to or significant environmental impacts on specified national lands, and proximity to and significant environmental impacts on specified State or regional areas. Each of these potentially adverse conditions related to environmental quality may be expected to be major subjects of contention and delay in the approval of the environmental impact statement and the issuance of necessary State and local permits for site characterization and construction at the site.

The Deaf Smith County site has eight potentially adverse conditions that have closely associated disqualifying guidelines. The potentially adverse condition related to geomechanical properties of the host rock is likely to b a contentious issue; however, this issue may be addressed in large part durin site characterization prior to licensing. In addition, environmental impacts on the Ogallala Aquifer is a major concern which can be addressed in large part during site characterization prior to licensing.

The Richton Dome site has nine potentially adverse conditions that have closely associated disqualifying guidelines. Of these, there are two potentially adverse conditions that are highly likely to introduce major contention and delay during licensing. One potentially adverse condition is the proximity to the town of Richton; it may be expected to be a major issue in the approval of the environmental impact statement and the issuance of necessary State and local permits for site characterization and construction at the site. The second potentially adverse condition is the presence of exploitable natural resources, which is intrinsic to the nature of the dome and will not change as a result of site characterization studies.

The Hanford site has seven potentially adverse conditions that have closely associated disqualifying guidelines. Of these, three potentially adverse conditions may be expected to be major subjects of contention and delay. These are potentially hazardous offsite installations and activities; Quaternary faulting, and pre-closure ground-water conditions that may require complex engineering measures beyond reasonably available technology. This latter potentially adverse condition can be evaluated in large part during site characterization and is therefore expected to be largely resolved prior to licensing of the site.

The Yucca Mountain site has five potentially adverse conditions that ha· closely associated disqualifying guidelines. These include for the post-closure period, Quaternary igneous activity and the correlation of earthquakes with tectonic activity, and for the pre-closure period, potentially hazardous offsite activities, host-rock flexibility, and active faulting. Of these, two of the potentially adverse conditions, the correlation of earthquakes with tectonic features such that the frequency or magnitude may be expected to increase in the post-closure period and the presence of active faulting in the pre-closure period have been major subject. of contention and delay in licensing of other nuclear facilities.

As a second approach to licensability, the NRC regulation 10 CFR Part 60 indicates that the presence of any potentially adverse condition can lead to a presumption of unsuitability of the site if the potentially adverse condition may result in significant radionuclide releases, and any of the following are valid:

1) the potentially adverse condition cannot be readily characterized or modeled,
2) the potentially adverse condition cannot be offset by favorable conditions, or
3) the potentially adverse condition cannot be mitigated by reasonably available technology.

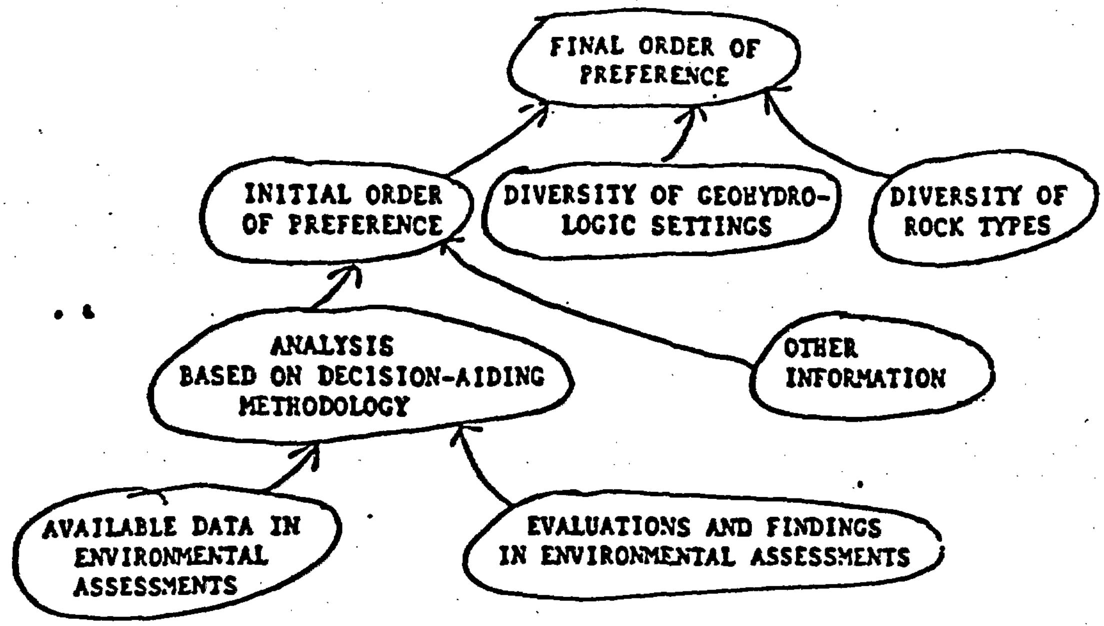
Chapter C-7

Other Information

The process to be used in selecting a site for the first geologic repository is described in Section 960.3-2 of the DOE's siting guidelines (10 CFR Part 960). As specified in Section 960.3-2-3, the recommendation of site for site characterization is to be based on "the available geophysical, geologic, geochemical, and hydrologic data; other information (emphasis added); associated evaluations and findings reported in the environmental assessments accompanying the nominations; and the considerations specified below, unless the Secretary certifies that such available data will not be adequate to satisfy applicable requirements of the Act in the absence of further preliminary borings or excavations."

The "considerations specified below" include "... the sites nominated as suitable for characterization shall be considered as to their order of perferences as candidate sites for characterization. Subsequently, the siting provisions specifying diversity of geohydrologic settings, diversity of rock types, shall be considered to determine a final order of preference for the characterization of such sites."

Accordingly, the recommendation decision can be represented diagrammatically as follows:



The analysis based on the decision-aiding methodology is intended to provide as many insights as possible for evaluating sites for geologic repositories. To do this, it focuses on the major factors of the decision problem since attempting to address all possible information and impacts would be counterproductive and impractical. The "other information" not included in the analysis are still, of course, relevant to the decision process. This "other information" is described in this chapter, and its implications are combined with the results of the analysis based on the decision-aiding methodology to determine an initial order of preference among the sites.

C-7.1 Identification of Other Information

In order to identify "other information" that has not been addressed in the environmental assessments (EAs) or the decision-aiding methodology, the DOE reviewed (1) comments received during the EA scoping hearings, (2) comments on the siting guidelines, (3) comments on the draft Mission Plan,

(4) the programmatic objectives identified in the siting guidelines and the Mission Plan, (5) comments on the draft environmental assessments (including verbal comments at public hearings), and (6) comments from the Board on Radioactive Waste Management of the National Academy of Sciences during its review of the decision-aiding methodology. These items were reviewed specifically for (1) any DOE commitments on "other information" that could be considered and (2) any issues that may have a significant bearing on the recommendation of sites and are not addressed in the environmental assessment or the decision-aiding methodology. In reviewing all of the above-listed items, the DOE exercised caution to avoid including issues, such as repositor costs or land ownership, that are already explicitly included in the environmental assessments or the decision-aiding methodology; including such issues would lead to double counting.

Comments received in EA scoping hearings

The review of the comments received at the EA scoping hearings identifie a long list of issues, such as those documented for the salt sites (ONWI-505). Some of these issues are covered by the EPA standards (e.g., individual dose limits), some are covered by the siting guidelines (e.g., the availability of water sources, the impact of offsite facilities, or the estimated value of mineral resources), and many of the issues have been addressed in the environmental assessments (e.g., the disposal of the mined salt, the impacts of the work force on the socioeconomic framework of the community, the fragility of the environment, or the relocation of people during land acquisition). The issues that may qualify as "other information" include

1. The distinction between "nuclear" and "nonnuclear" host States.

2. Equity among the States in terms of the presence of other national programs (e.g., defense programs or the Strategic Petroleum Reserve

3. Differences in the productivity (food and fiber) of the accessible environment.

4. The presence of major surface-water systems in the accessible environment (e.g., the Columbia and Colorado Rivers) that are reliec on regionally for water, food, and recreation.

With respect to the distinction between "nuclear" and "nonnuclear" host States -- that is, States that contain commercial nuclear power plants and those that do not -- the DOE does not believe that Congress, in attempting to provide a remedy to a national waste-disposal problem by enacting the Nuclear Waste Policy Act of 1982, intended to restrict the disposal of spent fuel and high-level waste to the States whose citizens derive direct benefits from the use of electricity generated by nuclear energy. In fact, "nonnuclear" States derive substantial indirect benefits from the nuclear industry. With respect to the presence of other national programs, the DOE does not believe that Congress intended to restrict geologic repositories to only the States that have not borne the burden of activities or facilities serving national interests. Indeed, all States share the overall benefits and burdens of being part of the United States.

With respect to the productivity or the presence of major surface-water systems in the accessible environment, the EPA standards restrict potential releases to the accessible environment in order to avoid the obvious problem of projecting the characteristics of the accessible environment -- specifically factors like population distribution, types of crops, and water use -- over tens of thousands of years. The DOE agrees with this approach, and the postclosure performance measures employed in the decision-aiding methodology are therefore based on cumulative releases to the accessible environment.

This review of the comments received at the EA scoping hearings did not identify any issues that may have a significant bearing on the recommendation of sites for characterization and were not addressed in the environmental assessments or the decision-aiding methodology.

Comments on the siting guidelines

The review of the comments on the siting guidelines identified (1) issue that have been covered by the final EPA standards (e.g., ground-water sources in the controlled area or limits on individual radiation doses); (2) issues submitted in comments on revisions of the siting guidelines before they were issued in final form (e.g., the presence of ground-water sources along flow paths to the accessible environment or the resource potential of the host rock); (3) issues that are addressed in the decision-aiding methodology (e.g. explicit weighting factors for the various guideline groups, the consideration of potential radionuclide releases to the accessible environment for periods of up to 100,000 years, or the adoption of a numerical decision methodology); and (4) issues that do not discriminate among sites in the site-selection process (e.g., the adoption of a zero-release standard, the application of the "as-low-as-reasonably achievable" principle, emergency response and liability for accidents during transportation, or the assessment of fear and perceived risks). Finally, the DOE identified a set of issues (e.g., differences among sites in waste retrievability or the availability of a water supply for construction and operation) that would be double-counted if treated separate: under "other information." As a result, in the comments on the siting guidelines the Department did not find any additional issues that may have a significant bearing on the recommendation of sites and were not evaluated in the environmental assessments or the decision-aiding methodology.

Comments on the Mission Plan

The review of comments on the Mission Plan focused on the synopses of comments in the Record of Responses to Public Comments on the Draft Mission Plan (DOE, 1985, Vol. II). These comments tended to be very specific in the issues they raised or the recommendations they made.

Nearly all of the issues raised in the comments that may have a significant bearing on site recommendation have been addressed in the siting guidelines, the environmental assessments, and the decision-aiding methodology. The two issues that may qualify as "other information" are the following:

1. The differences among the sites in the ease of revegetating a site to its original condition after site characterization or repository closure.
2. The methods that would be used to obtain the ownership of land and mineral rights (e.g., transfer of title between Federal agencies, exercise of eminent domain for private land, and severed mineral rights).

The first of these issues has been considered in the environmental assessments (in the evaluations of the sites against the guidelines on environmental quality) and in the decision-aiding methodology (in the evaluation of the sites against the performance measures related to environmental quality). The second issue has also been considered, in part, in the evaluation of socioeconomic impacts. The second issue is uncertain at this time because, as pointed out in the record of responses (DOE, 1985), a variety of options is available to establish Federal ownership, and these options vary in difficulty. Furthermore, the DOE cannot speculate, at present, on the relative differences in difficulty between negotiating sales of land or mineral rights, taking land or mineral rights through eminent-domain proceedings, or obtaining Congressional approval for the transfer of title for Federal land.

Accordingly, the DOE did not identify in the comments on the Mission Plan any "other information" that may have a significant effect on site recommendation and have not been considered and reasonably accounted for in the environmental assessments or the decision-aiding methodology.

Programmatic objectives

The programmatic objectives identified in the Mission Plan and in the siting guidelines were examined for the presence of "other information." The major programmatic objectives in the Mission Plan relate to the protection of public health and safety, program schedule, the costs of waste disposal, and the likelihood of success in the repository program. In the siting guidelines, Section 960.3-2-3 defines the following objective for the recommendation of sites: "The sites recommended as candidate sites for characterization shall offer, on balance, the most advantageous combination c characteristics and conditions for the successful development of repositories at such sites."

From these programmatic objectives, the DOE identified the following issues as candidates for "other information":

1. The number of sites to be recommended for site characterization.
2. The risk of disqualification during site characterization or repository construction.
3. The presence of issues that may not be reasonably resolvable during site characterization given the time allotted or the state of the art in testing.
4. The potential for significant cost increases beyond the ranges estimated in the environmental assessments.
5. The potential, during site characterization or repository construction, for schedule delays that would seriously impair the DOE's ability to maintain the program schedule.
6. The potential for schedule delays due to contentious licensing proceedings.

The first issue, the number of sites to be recommended for site characterization, is essentially a strategic investment decision regarding the appropriate degree of diversification of resources to retain flexibility for site selection. As required by the NRC regulations, the DOE will recommend three sites, at least one of which is not a salt site. For each site, the DOE projects a cost of $500 million for site characterization and $500 million fo concurrent studies (e.g., waste-package development, repository design, and advancement of performance-assessment capabilities). The DOE has evaluated the option of recommending more than three sites, but has not found a sufficient programmatic or technical basis to justify the additional costs.

Issues 2 and 3 can be grouped together under the subject of site licensability. The relative licensability of sites is largely determined by the findings and evaluations in the environmental assessments, but it is also affected by two other factors: (1) the potential for being disqualified during site characterization and repository construction and (2) the presence of issues that may not be resolvable during the time allotted for site characterization. For example, the DOE may not be able to definitively characterize the mechanism of ground-water flow over large distances in bedded or dome salt or the amount and temporal or spatial distribution of ground-water flux through the unsaturated tuff at the Yucca Mountain site. In these cases, the DOE has adopted the approach of conservatively bounding the phenomenon in its calculations in order to demonstrate adequate ground-water travel time and waste-isolation capability. Thus, the inability to resolve an issue during site characterization has been taken into account in the evaluations in the environmental assessments and in the decision-aiding methodology.

Issues 4, 5, and 6 can be grouped together under the programmatic objective for cost-effectiveness. The issue of potential cost increases beyond the estimated ranges in the environmental assessments has been included in the decision-aiding methodology and would be double-counted if treated under "other information." The issue of potential schedule delays during site characterization is the concern that any one site, though not demonstrably unsuitable or disqualified, may fall substantially behind the other sites during characterization and thus not be available on schedule as one of the alternative sites evaluated in the environmental impact statement. This issue has been considered in part in the environmental assessments, in evaluations against guidelines on the ease and cost of siting and construction. In addition, the DOE has taken the position that, in such an instance, the Secretary of Energy can declare site characterization sufficiently completed to proceed with the selection of one site for development as the nation's first geologic repository.

The issue of potential schedule delays due to contentious licensing proceedings can be summed up simply: a "good" site that needs an inordinate number of years for licensing is probably not a "good" site. Such a site would place in jeopardy not only the Mission Plan objective on cost-effectiveness but also the DOE's commitment to accept wastes for disposal in 1998.

Comments on the draft EAs

The review of comments received on the draft environmental assessments focused on the summary of comments in Appendix C of the final environmental assessments. Specifically, this review focused on comments that generally apply to the repository program rather than specific sites (Section C.2, Policy Issues, and Section C.3, Siting Process and Decisions). Site-specific comments in Sections C.4 through C.8 were not reviewed for issues that may qualify as "other information," but those comments are specifically directed at the evaluations of the site against the guidelines, the description of the site and the repository, or the discussions of potential impacts. Nearly all of the issues raised by the comments that may significantly affect the recommendation decision have been addressed in the final environmental assessments or the decision-aiding methodology. For example, the DOE has addressed decreases in property values near sites and difficulties in land acquisition in the evaluations against the guidelines on socioeconomic conditions and site ownership and control.

Three issues that were identified in the general comments on the draft EAs as possible suitable for "other information":

1. Compliance with State and local regulations.
2. Lack of route-specific analyses of transportation from the reactors to each site.
3. Productivity and quality of the accessible environment.

With respect to issue 1, the DOE does not believe that it is appropriate to attempt to characterize the expected difficulty in obtaining State and local permits or to base the recommendation decision on that difficulty unless there is a technical basis for so doing, such as in the assessment of air-quality effects in the environmental assessments.

With respect to issue 2, the DOE believes that the general transportation analysis and national average data used in the final environmental assessments are adequate at this stage of the siting process and are consistent with

Appendix IV of the siting guidelines. Route-specific analyses and an evaluation of the impacts on host States and States or Indian Tribes along transportation corridors will be included in the environmental impact statement. With respect to issue 3, the productivity and quality of the accessible environment (e.g., prime farmland or nearby rivers) were discussed previously under the comments on the EA scoping hearings.

Accordingly, the DOE did not identify in the comments on the draft environmental assessments any "other information" that may have a significant effect on site recommendation and are not covered in the final environmental assessments nor the decision-aiding methodology.

Comments from the National Academy of Sciences

Finally, the DOE considered the comments submitted by the Board on Radioactive Waste Management of the National Academy of Sciences on the decision-aiding methodology. Among these comments was the issue of differences among sites in some quality of the accessible environment where radionuclides may occur (e.g., the differences between a highly productive aquifer that bears potable water and a low-yield aquifer that carries brackish or saline water or the differences between a surface-water body used for water or sustenance and a playa lake). This issue was examined as a possible candidate for "other information." However, it was dismissed because, as indicated previously, the DOE agrees with the EPA approach of restricting releases to the accessible environment rather than attempting to characterize the quality or other characteristics of the accessible environment (e.g., population distribution, productivity, ~~of~~ or water use) for periods of tens of thousands of years.

C-7.2 Discussion of "Other Information"

Having considered the issues that were candidates for "other information," the DOE was able to identify three issues that may significantly affect the recommendation of sites and were not addressed in the environmental assessments or the decision-aiding methodology. These issues are discussed in this section, which also qualitatively describes the differences among the sites for each issue.

The issues that qualify as "other information" are the following:

1. The risk of disqualification during site characterization or repository construction.
2. The potential during site characterization or repository construction for schedule delays that would seriously impair the DOE's ability to maintain the program schedule.
3. The potential for schedule delays due to contentious licensing issues.

Risk of disqualification during site characterization or repository construction

A review of the seventeen disqualifying conditions in the siting guidelines, as documented in the final environmental assessments, showed either Level 1A findings (the evidence does not support a finding that the site is disqualified) or Level 2A findings (the evidence supports a finding that the site is not disqualified on the basis of that evidence and is not likely to be disqualified). The findings in the final environmental assessments for the disqualifying conditions were all Level 1A findings, wit the following exceptions where Level 2A findings were made: Davis Canyon, each of the three population density and distribution disqualifying conditions; Deaf Smith County, each of the three population density and distribution disqualifying conditions; Hanford, the erosion, dissolution, and each of the three population density and distribution disqualifying conditions; Richton Dome, each of the three population density and distribution disqualifying conditions; and Yucca Mountain, the dissolution an two of the three population density and distribution disqualifying conditions

Further, the sites were compared against each other on a guideline-by-guideline basis in Sections 7.2 and 7.3 of the final environmental assessments. The intercomparisons among sites, however, did no attempt to describe the relative likelihood or probability that site conditions identified during site characterization or repository construction may, in extreme cases, support either the Level 1B finding (the evidence supports a finding that the site is disqualified) or Level 2B finding (the evidence supports a finding that the site is disqualified or is likely to be disqualified).

As part of the evaluation of "other information," the DOE has looked at each site and the seventeen disqualifying conditions in order to identify any sites where there is a reasonable likelihood that extremely poor site conditions could result in a small, but significant, probability of disqualification (Level 1B or 2B finding) for any disqualifying condition. It should be noted that many of the seventeen disqualifying conditions (primarily the preclosure disqualifying conditions) permit the use of mitigative measures or reasonably available technology to offset the adverse effects leading to potential disqualification.

For the Davis Canyon site, all three of the disqualifying conditions related to environmental quality have a reasonable likelihood that extremely poor site conditions could result in a small, but significant, probability of disqualification. For the Deaf Smith County site, the disqualifying condition related to inadequate protection or mitigation of environmental quality and the socioeconomic disqualifying condition on degradation of the quality of ground water for offsite supplies have a reasonable likelihood that extremely poor site conditions could result in a small, but significant, probability of disqualification. For the Hanford site, there is a small, but significant, probability of disqualification resulting from extremely poor site conditions assocated with the disqualifying conditions for ground-water travel time, irreconcilable conflict with atomic energy defense activities, rock conditions beyond reasonably available technology which present a significant risk to worker safety, ground-water conditions beyond reasonably avalable technology, and ground motion which requires engineering beyond reasonably availbale technology. For the Richton site, the disqualifying conditions related to loss of waste isolation due to inadvertent offsite resource recovery and the location of the surface facility adjecent to a 1 square mile area having a population greater than 1,000 persons have a reasonable likelihood that extremely poor site conditions sould result in a small, but significant, probability of disqualification. For the Yucca Mountain site, there is a small, but significant, probability of disqualification resulting from extremely poor site conditions associated with the disqualifying condition for ground-water travel time, postclosure tectonics, irreconcilable confli with atomic energy defense activities, and ground motion which requires engineering beyond reasonably available technology.

Based on this review of disqualifying conditions, the Davis Canyon sit and the Hanford site appear to be the least favorable sites. The Deaf Smitl County site and the Richton Dome sites appear to be the most favorable sites and the Yucca Mountain site should fall between these two groupings.

Potential Schedule delays during Site Characterization and Repository contruction

(TO BE PROVIDED)

Potential schedule delays due to licensing issues

Relative differences in licensability among the sites can arise from many different factors. Some can be evaluated at this time (e.g., the presence of potentially adverse conditions), while others cannot (e.g., the ability to obtain applicable State and local permits). Other factors (such as ground-water travel times that are only slightly higher than the 1,000-year disqualifier) cannot be evaluated as to their effects on licensability until performance goals for the various components of the engineered and natural barrier systems have been allocated or the results of site characterization studies are available.

With respect to potentially adverse conditions that can be evaluated at this time, the DOE reviewed the licensing experience of nuclear facilities to determine which types of potentially adverse conditions have become highly contentious and resulted in major licensing delays. This allows the DOE to ascertain that a particular potentially adverse condition is more significant to the program schedule than other conditions. Accordingly, the DOE can supplement the decision-aiding methodology by placing a higher significance on the potentially adverse conditions that may become highly contentious and result in major delays. In addition, the DOE believes that the potentially adverse conditions that are closely associated with the disqualifying condition of a siting guideline have a higher potential for contention and licensing delay than do the potentially adverse conditions that are not closely associated with a disqualifying condition. In the discussion that follows, these two approaches were combined to identify the potentially adverse conditions that are likely to be the most contentious for each site.

The Davis Canyon site has 11 potentially adverse conditions that are closely associated with a disqualifying condition. The three most significant are related to environmental quality; they are significant adverse environmental impacts that cannot be avoided or mitigated to an acceptable degree; proximity to, or significant environmental impacts on, specified national lands; and proximity to, and significant environmental impacts on, specified State or regional resources. Each of these three potentially adverse conditions can be expected to cause major contention and potential delay in the approval of the environmental impact statement and the issuance of the applicable State and local permits for site characterization and repository construction.

The Deaf Smith site has eight potentially adverse conditions that are closely associated with a disqualifying condition, and two are likely to be contentious. One is related to the geomechanical properties of the host rock; this issue, however, can be largely resolved before licensing, during site characterization. The second is potential impacts on the Ogallala aquifer; this issue can also be largely resolved during site characterization.

The Richton Dome site has nine potentially adverse conditions that are closely associated with a disqualifying condition, and two can be expected to cause major contention and potential delay. The first is proximity to the town of Richton; it can be expected to be a major issue in the approval of the environmental impact statement and the issuance of the applicable State and local permits. The second is the presence of exploitable natural resources. The mineral-resource value of the salt is intrinsic to the dome, and the resource value of hydrocarbons on the periphery of the dome will be evaluated during site characterization.

The Hanford site has seven potentially adverse conditions that are closely associated with a disqualifying condition. Of these, three can be expected to cause major contention and potential delay: (1) potentially hazardous offsite installations and activities, (2) Quaternary faulting, and

(3) preclosure ground-water conditions that may require complex engineering measures beyond reasonably available technology. The presence of Quarternary faulting has been a major source of contention and delay during licensing proceedings for other nuclear facilities at the Hanford site; however, this previous experience may be expected to limit any potential delay on this issue during licensing of the repository. The third condition can be evaluated in large part during site characterization and is therefore expected to be largely resolved before licensing.

The Yucca Mountain site has five potentially adverse conditions that are closely associated with a disqualifying condition, two for postclosure and three for preclosure. The postclosure conditions are Quaternary igneous activity and the correlation of earthquakes with tectonic activity; the preclosure conditions are potentially hazardous offsite activities, host-rock flexibility, and active faulting. Of these, the correlation of earthquakes with tectonic features such that their frequency or magnitude can be expected to increase in the postclosure period and the presence of active faulting in the preclosure period have been major subjects of contention and delay in the licensing of other nuclear facilities.

Based on this review of potentially adverse conditions with closely associated disqualifying conditions that may introduce contention and potential delay, the Davis Canyon site and the Yucca Mountain site appear to be the least favorable sites. The Deaf Smith County site and the Richton Do site appear to be most favorable since the results of the environmental monitoring and mitigation and the site characterization studies can be expected to provide an adequate data base to demonstrate compliance with environmental and safety regulations. The Hanford site should fall between these two groupings, largely because of the concern whether the data collecte from site characterization studies in the underground test facility will be representative of the spatially heterogeneous conditions over the 2,000 acres needed for the repository.

October 30, 1986

TO: Dean Foster/Curt Eschels
FROM: Mike Gillett (Cong. Swift)

I'm sending two sets of documents that will be released today, and which I understand you have discussed with Nancy Smith (on Markey's subcommittee staff):

1. Letter (dated 10/29/86) to Herrington from Swift, Wyden, Markey & Weaver, including two attachments

2. Letter (dated 10/28/86) to Hodel from Markey, including three attachments

Call if you have questions: (202) 225-2605

Congress of the United States
House of Representatives
Washington, D.C. 20515

October 29, 1986

The Honorable John S. Herrington
Secretary
U.S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585

Dear Mr. Secretary:

In the course of our investigation of the high-level radioactive waste program, several internal Department of Energy documents came to our attention which raise questions as to the Department's plans for the first repository program.

The first document contains briefing materials prepared on May 13, 1986, which explore various options for modifying the high-level waste program. Among the options listed is the following:

"Strategy Option - Redesign First Repository:

<u>Pros</u>
- Concentrate on first repository as primary waste disposal facility;
- Enhance systems optimization;
- Accomodate reactor on-site storage problems; and
- Maintain legislated goals and planned receipt rates

<u>Cons</u>
- Increase potential for higher near-term costs;
- Increase pressure for rise in NWF (Nuclear Waste Fund) Fee; and
- Continue to face institutional problems."

The clear and unmistakeable implication of this option is that the Department of Energy was considering the possibility of enlarging the first repository in order to accommodate all of the nation's waste.

In addition, a second document entitled "Considerations Bearing on the Timing for a Second Repository," dated May 16, 1986, explores in detail the potential for expanding the three sites chosen for the first repository. A table in this document projects the total potential capacity of the three sites: Hanford, Washington -- 668,000 metric tons of uranium (MTU); Yucca Mountain, Nevada -- 78,000-136,000 MTU; and Deaf Smith County, Texas -- 107,000 MTU. At one point, this study states that "[I]f adequate capacity is indeed available, considerations of system costs would argue for open[ing] only a single repository site."

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The Honorable John S. Herrington
Page Two
October 29, 1986

The study goes on to compare the costs of a single repository system versus a two repository system.

We request that you provide answers to the following questions by November 10, 1986:

1) Is the Department of Energy considering the possibility of placing all the nation's waste in one repository?

2) Was the potential for expansion of the Hanford site a factor in the Department's decision to select that site?

3) Section 302(d) of the Nuclear Waste Policy Act of 1982 provides that the Secretary may make expenditures from the Waste Fund "only for purposes of radioactive waste disposal activities under titles I and II" of the Act. The studies and options papers, on the other hand, appear to consider options not permitted under the Act. Please cite the specific authorization in title I or II of the Act that permits you to make expenditures from the Waste Fund for these studies.

The waste program has been caught in a web of contradictory statements and political manipulations which have thoroughly entangled the Department's credibility. For instance, on one hand, Secretary Hodel has pronounced the second repository program dead. At the same time, Waste Office Director Ben Rusche says the program continues. It is time to make clear your intentions and policies on these matters, and to tell the same story to audiences in both the East and the West.

Sincerely,

Ed Markey

Edward J. Markey
Member of Congress

Al Swift
Member of Congress

James Weaver
Member of Congress

Ron Wyden
Member of Congress

Project Number

Battelle
Pacific Northwest Laboratories

Internal Distribution

D. F. Newman
M. K. White
File

Date May 16, 1986

To W. W. Ballard - J. L. McElroy

From T. V. Wood

Subject NWSI Discussion Paper: Considerations Bearing on the Timing for a Second Geologic Repository

Attached is a current draft of the subject paper. This paper was requested by Carl Conner, our DOE-HQ sponsor, based on a request to his office by Tom Issacs, Deputy Director of the Office of Geologic Repositories, OCRWM. Our understanding of the basis of this request is to provide technical information relevant to an anticipated debate on currently proposed legislation which would limit DOE's authority to pursue second repository activities.

To achieve this purpose, our guidance was to identify and characterize the technical issues which would bear on the need for a second repository. In light of the potential nature of the legislative proceedings, this treatment needed to be as open and frank as possible. This material will be used by DOE-HQ as input to a staff paper on the second repository.

Due to the potential breadth of interest in this paper, I felt you should be aware of its content and the circumstances surrounding its development. We have, however, been directed to restrict distribution of this paper. It should not be copied or distributed outside your offices.

/ief
Attachment

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CONSIDERATIONS BEARING ON THE TIMING
FOR A SECOND GEOLOGIC REPOSITORY

R.W. MCKEE
T.W. WOOD
R.A. LIBBY

DRAFT

MAY 16, 1986

Prepared for
the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Richland, Washington 99352

CONTENTS

1.0 INTRODUCTION

Since the inception of the DOE/OCRWM geologic repository program, questio[ns] have been raised regarding the need for or timing of a second repository and the basis of 70,000 metric tons of uranium equivalent (MTU) as a nominal capacity for a single repository. The DOE/OCRWM announced in January 1986 the selection of 12 sites (located in seven midwestern and eastern states) for characterization as potential locations for a second geologic repository in crystalline rock formations. Subsequent to this announcement strong objections to these sites and questions concerning the need for a second repository have been voiced by the political leadership from the affected states.

The purpose of this paper is to identify the key factors bearing on the need for and timing of a second repository and to provide a preliminary exploration of the principal issues involved. In general terms these issues involve: (1) projected disposal requirements and the adequacy of repository capacity, (2) the value of flexibility in a two repository system, (3) regional equity, (4) system cost considerations, and (5) strategic and contingency planning considerations. Sections 2.0 - 8.0 discuss these issues and their implications relevant to the need for a second repository. Section 9.0 is a summary. There is also an appendix which discusses projections for nuclear energy and spent fuel.

2.0 RELEVANT NWPA REQUIREMENTS

The Nuclear Waste Policy Act of 1982 (NWPA) includes a 70,000 MTU restriction on the first repository emplacement capacity prior to opening a second repository and sets milestones for certain second repository siting decisions. However, construction of the second repository is not authorized at this time, and it is not yet clear when a second repository will be needed.

The NWPA requires that DOE develop guidelines for the recommendation of sites for repositories. These guidelines for site characterization require consideration of "various geologic media in which sites for repositories may be located and, to the extent practicable, to recommend sites in different geologic media." Five sites are to be nominated as suitable for site characterization for selection of the first repository site.

In addition, the NWPA requires that by July 1989, DOE must nominate five sites suitable for site characterization for a second repository. Up to two of these sites may be from the three sites recommended to the President for first repository site characterization but at least three new sites must be nominated. DOE has focused its site selection activity for the second repository sites on crystalline rock (granite) formations. Crystalline rock is potentially an excellent repository medium and is under consideration by Canada, Sweden, Switzerland, Finland, France, Argentina, Spain, and the United Kingdom.

The NWPA requires DOE/OCRWM to prepare a mission plan considering total repository capacity needed to accommodate all high-level radioactive waste and spent fuel expected to be generated through December 2020 and to begin receiving high-level waste and spent fuel by 1998. The OCRWM 1985 Mission Plan schedule calls for the President to submit a recommendation of one site for the first repository construction authorization by March, 1991 and for the construction authorization of the second repository by March, 1998. After this point it will be up to Congress whether or not and when to authorize construction of the second repository.

Legislation has recently been introduced in both houses of Congress that would amend the NWPA along various lines which would effectively terminate all Federal activities with respect to a second repository and remove the 70,000 MTU limitation on the first repository.

3.0 REPOSITORY CAPACITY REQUIREMENTS

A particularly important factor bearing on the need for a second repositor is the volume of wastes to be disposed. Simply put, total repository capacity (whether located in one or more sites) must be sufficient to accommodate projected waste volumes in a fashion consistent with long-term isolation performance requirements. Determination of the adequacy of repository capacity is subject to considerable uncertainty in both the prospective volume of waste and the potential capacity of various sites. These factors are explored below.

3.1 Civilian Spent Fuel Disposal Requirements

The DOE's Energy Information Administration (EIA) annually prepares a series of energy forecasts including nuclear energy production and resulting spent fuel discharge projections (EIA 1985a and EIA 1985b). Many assumptions regarding future energy production and energy consumption trends are involved in developing these forecasts. The EIA analysis includes the effects of growth in gross national product, energy demand, electrical share of delivered energy, and the share of nuclear-produced electricity through the year 2020 on both currently operating reactors and reactors which are under construction. A more detailed discussion of the EIA forecasts is included in Appendix A.

Due to the wide range of variables and the extended forecast period (out to 2020), EIA has prepared several projections which likely bracket the total spent fuel accumulations. The Middle Case is the current OCRWM planning base. The No New Orders (NNO) Case is used to represent a lower bounding projection of spent fuel disposal requirements for disposal fee analysis studies and for system sensitivity studies.

For the 1985 projections, EIA adopted an assumption of increasing fuel burnup in their standard case set, but these have not as yet been incorporated into the OCRWM planning base. Increased burnup reduces the quantity of spent fuel discharges but the discharged fuel produces more heat. (Essentially the same number of fissions occur to produce the energy, but the fission products are contained in a smaller quantity of fuel.) EIA, however, also provides sensitivity cases with no increased burnup for the NNO Case and the Middle Case. The resulting spent fuel discharge projections are shown in Table 1.

Increasing burnup assumptions are shown to have a substantial effect on the estimated quantities of spent fuel requiring disposal. This will affect transportation, handling and storage requirements, but increased fuel exposure levels will not reduce repository disposal (underground area) requirements. This is because, as is discussed in the next sections, repository capacity in all media is limited by the heat generation rate of the spent fuel or high-level waste. Higher exposure reduces tonnage but total heat is actually somewhat higher, especially in the long term, because of the increasing quantities of long-lived heat generating transuranic nuclides, e.g., americum

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Table 1 - Spent Fuel Projection Cases, Cumulative MTU

Year	NNO Case with No Increased Burnup	NNO Case Increasing Burnup	Middle Case No Increased Burnup	Middle Case Increasing Burnup	High Case
1984	11,442	11,442	11,442	11,442	11,442
1985	12,679	12,474	12,679	12,474	12,474
1990	21,643	20,343	21,792	20,950	21,339
1995	32,538	30,591	33,530	31,441	31,964
2000	44,345	39,861	46,118	41,658	42,159
2005	55,710	48,835	59,729	52,446	53,757
2010	67,678	58,094	77,417	66,381	70,802
2015	80,919	69,280	101,187	86,416	96,913
2020	87,449	74,635	126,642	106,404	126,192

and curium isotopes, that are produced at higher burnups. The 106,000 MTU by 2020 in EIA's 1985 standard Middle Case projection is equivalent to 127,000 MTU in the No Increased Burnup case which is close to the Mission Plan basis of 130,000 MTU which was based on the 1984 EIA projections.

It is evident from Table 1 that projections for cumulative spent fuel projections vary over a considerable range. It is also clear that the projections which indicate the largest fuel accumulations have a majority of accumulation occurring after the year 2005. This is the result of the long period between 1990 and 2000 where very few new reactors start up in any of the cases.

While the 2020 date is mentioned in the NWPA as a planning horizon, it should also be remembered that discharges will not stop in 2020 unless nuclear power has been abandoned as an energy option. A second repository start-up in 2008 or later should be expected to be used for disposal of spent fuel generated after 2010 and should include capacity for fuel discharges to well beyond 2020. Realistic planning will require the planning horizon to be periodically moved further into the future.

3.2 Defense High-Level Waste Disposal Requirements

In addition to the civilian spent fuel disposal, the repository system is to be used for disposal of defense high-level waste (DHLW). There are also substantial uncertainties in projected quantities of these wastes.

DHLW is quite different from civilian power reactor spent fuel, and is low-heat generating waste prepared for disposal by vitrification. These waste are presently stored in both liquid and solid forms at three DOE sites: Savannah River, Hanford, and Idaho. Construction is underway on a DHLW processing facility at Savannah River (SR), but facilities for DHLW processing at the other two sites are still in the planning stages. For the purposes of this paper the SR waste canisters are assumed, on the average, to be typical for all DHLW, but significant variations can be expected.

Each Savannah River Defense Waste Processing Facility (DWPF) canister will be approximately two feet in diameter, 10 feet long and contain 22-25 cu. ft. of vitrified DHLW producing up to 400 watts of heat. Through the year 2019 it is estimated that approximately 7000 of these waste canisters will be produced. There appears to be very little uncertainty on the high side of this estimate but the quantity might be somewhat lower depending on the level of future operations at SR.

The Hanford Waste Vitrification Plant is planned to begin operations in 1995-7 producing canisters of vitrified DHLW similar to the SR canisters. The plan is to process all of the liquid waste currently stored in the existing double-walled tanks, producing about 1500 canisters of waste. Many more canisters could be produced if it is decided to vitrify and dispose in a repository all wastes stored in the single-walled tanks - as much as an additional 22,000 canisters. Future production operations at either Hanford or SR could produce another 1500 canisters.

No final decision has yet been reached with regard to processing DHLW stored at the Idaho Chemical Processing Plant. These wastes are currently stored as calcined solids and contain a large proportion of inert chemicals. The volume of vitrified waste depends on the process selected to reduce the amount of contained inert chemicals. Current state-of-art technology would produce about 22,000 canisters. This could possibly be reduced to about 6,000 canisters with extensive volume reduction processing.

Estimates are summarized for DHLW from all three sites in Table 2.

Table 2 - Projected Range of DHLW Canisters Requiring Repository Disposal through 2020 (a).

	Minimum Planning Base	Possible Upper Bound
Savannah River	7,000	7,000
Hanford	1,500	23,500
Future Hanford or SR	1,500	1,500
Idaho	6,000	22,000
	16,000	54,000

(a) Canisters are 2 ft. dia. x 10 ft. long with an average of around 400 watts/canister.

3.3 Miscellaneous High-Level Wastes

In addition to disposal of spent fuel from civilian nuclear power reactor and disposal of DHLW, some additional repository capacity will be needed for disposal of other high-level waste materials. The only source of other HLW that is clearly committed at present is the commercial HLW to be vitrified in the West Valley Demonstration Project. This project will produce approximatel: 300 canisters by early 1990, similar in size and waste characteristics to the SR DHLW canisters. Some relatively small quantities of other materials such as sealed radiation sources and reactor decommissioning wastes may be classifi as high-level waste and require repository disposal once NRC's pending rulemaking on the definition of high-level waste is promulgated.

4.0 REPOSITORY CAPACITY CAPABILITIES

Repository capacity is commonly referred to in terms of metric tons of uranium (MTU) that were irradiated to produce the spent fuel or HLW. This is a misleading unit of measure. The repository capacity for high heat generating wastes (specificelly commercial spent fuel) is limited in all three media by the total heat generation rate which in turn is determined by the level of spen fuel burnup, and age since reactor discharge. An MTU of spent fuel irradiated (exposed) to 50,000 MWD/MTU will have somewhat more than twice the heat generation rate of an MTU of spent fuel irradiated to only 25,000 MWD/MTU. The fission product activity is directly proportional to the exposure (burnup) level but long-lived heat generating transuranic nuclides increase exponentiall with increased exposure.

Capacity for low heat generating wastes, however, such as the DHLW is primarily limited by just the structural strength of the geologic formation that limits the pitch or spacing of the borehole emplacement sites for these canisters. In general, it has been assumed that two DHLW packages are equivalent to one MT of commercial SNF (DOE 1985c). This implies that the 16,000 DHLW canister planning base is equivalent to 8,000 MTU of SNF.

The following subsections provide information on the disposal capacities of the 3 sites proposed for characterization in the draft environmental assessments of possible first repository sites.

4.1 Salt Repository Capacity

The Deaf Smith site in Texas overlies an extensive bedded salt formation. The area designated as a potential repository site encompasses 9 square miles or approximately 5800 acres. The actual repository area for 70,000 MTU of SNF & DHLW currently defined for the Site Characterization Plan (SCP) design concept encompasses 4280 acres of which a relatively significant portion is allocated for shaft pillar, ventilation entries, and service areas. The portion of the site not allocated in the repository layout is utilized as a buffer zone along the site perimeter.

The current loading limits are 40 kW/acre and 10-foot minimum spacing of canisters. Using these limiting factors, up to 107,000 MTU could be emplaced if the 9-square-mile area underground was totally utilized without the buffer zone between the underground emplacement area and site property boundary and surface facilities and shafts were placed in an area designated as in the maximum probable floodplain. Since the extent of the bedded salt formation is literally hundreds of square miles, it is probable that this site could be expanded to meet the system requirements.

4.2 Basalt Repository Capacity

The Basalt Waste Isolation Project (BWIP) is sited on the large, 400 plus square mile, DOE Hanford Reservation in Washington State. The reference repository location (RRL) encompasses 18 square miles (about 11,520 acres) within the Hanford Site and is currently being investigated. The current design concept encompasses an underground area of approximately 2000 acres of which a significant portion is reserved for shaft pillar, and service areas.

The basalt repository does not have a far field area thermal limit in the sense that the salt repository has, but it has a near field thermal limit resulting from rock stress considerations that equates to approximately 70 kW/acre. This yields an emplacement area of approximately 1200 acres for a Mission Plan mix of 70,000 MTU of SNF and DHLW.

There are no obvious size limitations based on what is known at this time regarding the Cohasset basalt flow formation selected for the repository. The size of the repository could probably be extensively expanded but waste transport could become a problem if extensive variations in formation dip were found. This would increase the cost of disposal beyond some tonnage limit, but would not technically preclude expansion. Using the entire RRL underground area, over 600,000 MTU capacity potentially is available.

4.3 Tuff Repository Capacity

The tuff repository site at Yucca Mountain in Nevada has an apparently more limited capability for expansion than either the Deaf Smith or Hanford sites. The size of the formation suitable for the repository is estimated at 1650 to 2050 acres.

Thermal calculations have shown that a loading at 57 kW/acre yields temperature profiles well within their established limits for tuff. They have estimated that loading at 80 kW/acre may be feasible. This thermal loading range yields a repository area requirement range of 1050 to 1470 acres for 70,000 MTU of SNF and DHLW.

Based on these results, the area is adequate for the Mission Plan loading of 70,000 MTU or might have capability for a total loading of as much as 136,000 MTU equivalent at the higher thermal loading. Another possibility which could provide additional capacity is expanding the repository site into adjacent areas which are less well defined and would require characterization.

A summary of the results for all three media is shown in Table 3. Note this data is based on current information and could change based on results of detailed site characterization. Also, the capacities are based strictly on technical feasibility and do not reflect practical operational constraints or economics.

Table 3 - Repository Site Underground Area

Site	Repository Underground Area Available (acres)	Capacity Based on Available Area (MTU)	Availability of Additional Area
Salt-Deaf Smith	5,760	107,000	yes
Basalt-Hanford	11,520	668,000	yes
Tuff-Yucca Mtn.	1650-2050	78,000-136,000	possible

5.0 SYSTEM COST CONSIDERATIONS

If adequate capacity is indeed available, considerations of system costs would argue for opening only a single repository site. Development and exploration costs for a second repository would be a major savings - on the order of $2.6 billion. The capital and operating costs of the second repository would be saved but some of the capital and most of the operation cost savings would be added costs for the first repository. Without a second repository in the East, transportation costs would be increased by $400-500 million. Based on a special cost analysis for the middle-case growth rate prepared for the House Science and Technology Committee by Roy F. Weston, Inc., plus subsequent calculations for the NNO case growth rate, cost savings in a single repository system could be several billions of dollars or negligible, depending on the combination of first and second repository sites used for comparison. If the first repository is in a high cost medium like basalt, there is less opportunity for achieving a savings by enlarging this repository in preference to opening up a second repository in a medium that may be less costly to develop. These results are summarized in Table 4 for cases based on the middle-case growth projection and the authorized system (i.e., without an MRS). Similar results for the NNO-case are summarized in Table 5.

The timing requirements for a second repository can be influenced by the capabilities of other components of the waste management system and by efforts designed to minimize system costs. For example, at-reactor storage capabilities could be more fully utilized to delay the timing for opening a second repository while at the same time reducing system costs by delivering older and colder fuel to the repositories. Likewise, a Monitored Retrievable Storage (MRS) facility could be utilized to achieve similar results.

Current studies analyzing waste acceptance schedules indicate the reduced system costs can be realized by either reducing repository spent fuel acceptance rates or by delaying the startup of the second repository. In either case, the age of spent fuel receipts is increased and costs are reduced through disposal of older fuel.

Table 4 - Comparisons of Total System Life Cycle Costs for a Single versus a Two Repository System with the Middle Case Growth Projection (Authorized System)

Single Repository System		Two Repository System	
Repository Medium	Total System Life Cycle Costs, $\$10^9$	Repository Medium (First/Second	Total System Life Cycle Costs, $\$10^9$
Basalt	29.0	Basalt/Cryst. (High)	32.3
		Basalt/Salt	29.9
		Basalt/Tuff	28.8
		Basalt/Cryst. (Low)	29.0
Salt	21.8	Salt/Cryst. (High)	28.5
		Salt/Salt	26.0
		Salt/Cryst. (Low)	25.3
Tuff	18.5	Tuff/Cryst. (High)	26.9
		Tuff/Salt	24.3
		Tuff/Cryst. (Low)	23.6

Table 5 - Comparison of Total system Life Cycle Costs for a Single versus a Two Repository System with the NWD Case Growth Projection (Authorized System)

Single Repository System		Two Repository System	
Repository Medium	Total System Life Cycle Costs, $\$10^9$	Repository Medium (First/Second	Total System Life Cycle Costs, $\$10^9$
Basalt	23.1	Basalt/Cryst. (High)	28.4
Salt	17.6		
Tuff	15.3	Tuff/Cryst. (Low)	21.3

6.0 REGIONAL EQUITY CONSIDERATIONS

Section 112 of the NWPA requires the Secretary of Energy to consider the advantages of regional distribution in siting geologic repositories for disposal of HLW and SNF, as well as to take into account the proximity of potential repository sites to sites where HLW and SNF are generated and the transportation and safety factors associated with moving the waste to a repository (See Section

112(a)). The majority of the commercial nuclear power reactors in the United States are found in the eastern half of the United States. Of all the Eastern states, only in Mississippi are potential locations of a first repository under active consideration. The other six potential first repository sites are in the West, where only about 10% of the SNF is projected to be generated.

A broad consideration of regional distribution and equity over the entire continental United States is most fully consistent with NWPA requirements. This will ensure consideration of potential sites in proximity to HLW or SNF generation or storage locations and the transportation and safety factors related to movement to the place of permanent disposal. The lack of an active second repository site selection and characterization program could jeopardize the site approvals required for the first repository, by creating a situation in which people in the first repository state feel that they are inequitably treated. This may cause a state to adopt a "notice of disapproval" and cause delay in the construction and operation of the first repository, unless Congres overrides the state objection as provided for in the NWPA.

7.0 THE VALUE OF FLEXIBILITY

A two repository system has the advantage of increased flexibility relativ to a single repository system. This increased flexibility will be manifest in increased system availability in both the short term and the long run. In the short term, the presence of two independent facilities for the receipt and disposal of waste would make the waste management system operation much less sensitive to minor disruptions and capable of continuous operation with greater certainty. The value of this greater confidence of continuous operation will be reflected in a greater confidence level in allowing scheduled waste acceptance from generators in the authorized system or outprocessing at the MRS in the improved performance system. This increased system availability also has economic benefits. First, it permits more efficient capital utilization (less idle time) for other elements of the system (transportation, MRS). Second, it would allow operation with a smaller transportation cask flee: (even after accounting for distance effects discussed in section 5.0) since there would tend to be less reliance on transport fleet as de facto lag storage.

In addition to the value of redundancy for the expected, frequent, short duration limitations on capacity, there is also a value in terms of insuring against the effects of major disruptive events at a single repository. Althougl such events are not foreseen, they are clearly possible. An example might be the discovery of unanticipated geologic features in some part of the rock body with a subsequent need to limit the extent of operations.

A single repository system is particularly vulnerable to this sort of event. Without any backup emplacement capacity, this type of event could effectively shut down the disposal function of the waste management system.

8.0 STRATEGIC AND CONTINGENCY PLANNING CONSIDERATIONS

In light of the uncertainty surrounding the adequacy of first repository capacity to accommodate projected waste volumes, it is clear that any sort of "final" OCRWM decision on the need for a second repository cannot be made at this time. Rather, the current options appear to be (1) continuation of the current siting program for the second repository, or (2) slowdown of the current siting plan. Either of these choices is subject to some risk. In the first case, the risk is a financial one - that the costs incurred in continuation of second repository activities may ultimately prove to have been unwarranted. In the second case, the risk seems to be both financial and schedule-related. The financial risk in this case is due to the potential for inefficiencies in reducing and later gearing up again. Although the magnitude of this risk is unknown, it could be a substantial fraction of any prospective financial savings. The schedule-related risk associated with delay of the second repository program would be in the possibility of not being able to meet requirements. If the waste volumes, costs, and regional equity and other considerations discussed above do turn out to require a second repository, then a considerable slippage might have occurred by the time this is known with certainty.

In weighing the relative attractiveness of these two risks, two facts seem relevant. First, the "speculative" nature of expenditures on a second repository program before need is known with certainty is by no means unique - the same might be said of unsuccessful first repository sites. The nature of the OCRWM mission and the levels of uncertainty require this sort of insurance to meet NWPA mandates. Second, given that the choice posed above seems to be one largely hinging on the trade-off between potential financial and schedule losses, the relative abundance of funds and time within the program are relevant. Based on the program's overall posture at present, it seems clear that time is the scarce resource.

Still another consideration is a concern to minimize the obviously substantial discomfort of states that have been identified as possible second repository sites. It would appear that the best course for minimizing this discomfort, that has been manifested for example by reduced property values, would be to proceed expeditiously to narrow down the site selection for a second repository to a single site. Actual construction might then be delayed depending on the need perceived at that time.

9.0 SUMMARY

There is no clear answer, either pro or con, on the need and best timing for a second repository based on repository capacity limitations and projections of disposal requirements. In any case, it must be recognized that waste generation will continue after 2020, which may eventually require a second repository at a later date.

It is clear that the resolution of uncertainty about both the waste volumes and site capacities will occur in the early 1990s, when the projected new nuclear reactor orders are forecasted and data from the three first repository site characterization programs begin to be available. This is also the time at which the second repository program would transition from a relatively inexpensive siting phase to the more costly site characterization phase. This coincidence suggests that efforts to make a "final" determination on the need and timing for a second repository might be focused on this time period.

The data indicate that initiation of detailed site characterization for the second repository could be delayed for several years beyond the current planning schedule date of 1994 if required, with a concomitant delay in the startup date, without affecting the waste management emplacement rates for fuel which is relatively certain to exist.

REFERENCES

Energy Information Administration, 1985a. Commercial Nuclear Power: Prospects for the United States and the World. DOE/EIA-0438 (85), U.S. Department of Energy, Washington, DC 20585.

Energy Information Administration, 1985b. World Nuclear Fuel Cycle Requirements 1985. DOE/EIA-0436 (85), U.S. Department of Energy, Washington, DC 20585.

U.S. Department of Energy, 1985c. An Evaluation of Commercial Repository Capacity for the Disposal of Defense High-Level Waste. DOE/DP/0020/1, U.S. Department of Energy, Washington, DC 20585.

U.S. Department of Energy, Office of Civilian Radioactive Waste Management. Mission Plan for the Civilian Radioactive Waste Management Program, DOE/RW-0005/1, U.S. Department of Energy, Washington, D.C. 20585.

APPENDIX

NUCLEAR ENERGY AND SPENT FUEL DISCHARGE PROJECTIONS

This appendix provides a brief description of the assumptions and methodology used in developing EIA's energy forecasts and spent-fuel discharge projections.

The EIA analysis is divided into two time frames - the intermediate term through 1995 and the long term through 2020. Projections in terms of four separate cases are developed for a range of assumptions regarding growth in demand and actions taken to meet the demand. Projections include low, middle, and high cases and a no new orders case (NNOC) in which no new orders for nuclear plants beyond those already in place are assumed. Table A.1, from EIA 1985a, shows projected nuclear capacity and energy generation through 2020 for each of the four EIA cases.

The intermediate-term nuclear capacity projections through 1995 are based on a reactor "pipeline" analysis, which entails a reactor-by-reactor review of units that are under construction or in the licensing process. The middle- and high-case nuclear supply scenarios assume that the amount of installed nuclear capacity in 1995 will be determined by the completion of all units currently in the licensing and construction pipeline (i.e., that potential cancellations will be offset by, for example, the reactivation of mothballed units and that any new units ordered during the projection period will not be operable until after the year 2000). The low-case nuclear supply scenario assumes that a number of units currently in the construction pipeline will be canceled and will not be balanced by any new unit orders.

Projections of installed nuclear capacity for the period from 1995 through 2000 are based on a continuation of the reactor pipeline analysis, since it is assumed that no newly ordered plants are likely to become operable through 2000. In the middle and low cases, no additional units remain in the construction pipeline while three units comprising 1.1 GWe are retired by 2000. In the high case, three additional reactors (2.5 GWe) are assumed to be completed by the year 2000.

Recognizing the large uncertainty during the period from 2000 through 2020, the EIA's long-term projections for the low-, middle-, and high-case scenarios assume that U.S. Utilities will maintain a diversified baseload electricity supply by continuing to rely on coal and nuclear fuels in order to reduce consumption of relatively high-cost oil and gas supplies, and to meet demand growth until new generating technologies become available. The high case assumes much lower energy prices and a significantly increasing electrical share, whereas the low case assumes higher energy prices and only a modest increase in the electrical share. The nuclear energy share is assumed to increase in the high case and to remain essentially constant in the low case.

The middle-case projection of 248 GWe in 2020 is based on modest average annual growth rates for the gross national product (GNP) and for energy demand of 2.1 and 1.3 percent, respectively, from 2000 through 2020. The electricity share of delivered energy is projected to increase from nearly 17 percent in 1984 to about 28 percent by 2020. The nuclear share of electricity supply for the middle case is projected to increase from nearly 14 percent to 22 percent in 2020, compared with the intermediate-term projection of 19 percent in 1995. It is assumed that ordering of new nuclear plants will resume in

Table A.1 - Projections of U.S. Operable Nuclear Capacity and Generation at End of Year, 1985-2020 (a,b)

sufficient time for the resulting capacity to become operable between the years 2000 and 2005.

The middle-case growth scenario is the base case for OCRWM planning purposes and the no new orders case is used as a lower bound on expected nuclear growth.

In developing the spent-fuel discharge projections from the capacity and energy generation estimates, the 1985 EIA projections include consideration of utility trends towards increasing fuel burnups (or fuel exposure). Increases in the burnup level are achieved by increasing the concentration of U-235 in the enriched uranium fuel and modifying the design of the fuel rods. As a result, a smaller fraction of the core is replaced during refueling, or the length of the operating cycle is increased. Increased burnup reduces the requirements for enriched uranium, the fabrication of fuel for use in the reactors, and reduces the discharges of spent fuel and its storage requirements. The total costs of a fuel cycle are expected to decrease as burnup increases. The burnup level to achieve minimum cost is a function of design parameters and cost components of the fuel cycle. Burnup levels are now in the range of 30,000 to 35,000 MWD/MTU and tests have been successfully conducted at a burnup of 45,000 MWD/MTU.

In the EIA standard cases it is assumed that utilities will move to higher burnup levels. The reactors are assumed to achieve a 30 percent increase in burnup over current levels by 1993. The burnup level is then assumed to remain constant through the end of the analysis period. This assumption, in effect, presumes that the utilities will gradually increase their levels of burnup to the levels near those at which tests have been conducted successfully. The resulting cumulative spent fuel discharge projections are shown in Table A.2.

The EIA analysis also includes sensitivity cases to illustrate the impact of burnup-level assumptions. In a sensitivity case of no increased burnup, the burnup level is held constant through 2020 at the average historical level for 1979 through 1983. In a high burnup case, the burnup level rises at the same rate as the middle case through 2000 but is allowed to continue to rise until 2020, when the burnup rate is 50 percent above current levels. Results of these sensitivity cases are shown in Table A.3.

Table A.2 - 1985 EIA Projections of Cumulative Spent Fuel Discharges Since 1957 from U.S. Nuclear Power Plants, MTU of 1985 (Metric Tons of Initial Heavy Metal)

Table A.3 - Sensitivity Spent Fuel Projection Cases
Cumulative MTU

This may be of interest to you. TR. Bill S.

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EIA's Reduced Projections of Spent Fuel Discharges: Implications for OCRWM's Repository Program

DRAFT

- EIA Produces Four Basic Projection Series
  - No New Orders Case
  - Low Case
  - Middle Case
  - High Case
- All Projections Assume "Extended Bu
- However, each Projection Assumes Differing Prospects for the Commercia Nuclear Power Industry

- EIA Has Lowered Its Projections o
  Cumulative SNF Discharges Becau
  - Increasing construction costs and extended licensing times f reactors, coupled with declining energy demand, have eroded nuclear energy's competitive posit
  - Industry is gradually adopting "extended burnup" operating prac
- No reversal of these trends in sigh

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- EIA's Current Projections Through The Year 2020 Are:
  - No New Orders Case - 74,600 MT
  - Low Case - 87,400 MT
  - Middle Case - 106,400 MT
  - High Case - 126,200

- OCRWM's Current Reference Case ... EIA's Middle Case ("Constant Burnup"
  - Equal to 126,600 MTU

Oct 30,86 10:12

Implications of Reduced Projections For Repository Program - Strategy Optio

- Stretch Out Second Repository Progr
- Propose Cancellation of Second Reposi
- Maintain Current Program For Th Two Planned Repositories
- Redesign First Repository
- Postpone Second Repository

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Strategy Option - Stretch Out Program:

<u>Pros</u>

- Conserve near-term financial resource
- Concentrate on first repository / accumul SNF
- Avoid near-term increase in NWF

<u>Cons</u>

- Increase TSLCC by as much as 10 (or about $ 3.5 billion)
- Worsen relationships with second repository States by extending uncerta

Strategy Option - Propose Cancellation:

Pros

- Moderate political problems with second repository States
- Reduce TSLCC by significant margin
- Avoid NWF fee increase for many y

Cons

- Worsen relations with first repository
- Eliminate program flexibility
- Endanger achievement of legislative goals
- Require revision of NWPA

Strategy Option - Maintain Current Program

Pros

- Show unwavering determination to meet legislated goals
- Avoid possible schedule delays and other disruptions

Cons

- Strengthen appearance of inflexibili
- Increase potential for significant cost overruns
- Increase pressure for NWF fee increase

Strategy Option - Redesign First Reposit

Pros

- Concentrate on first repository as prima waste disposal facility
- Enhance systems optimization
- Accomodate reactor on-site storage pro
- Maintain legislated goals and planned receipt rates

Cons

- Increase potential for higher near-term cos
- Increase pressure for rise in NWF Fee
- Continue to face institutional problems

Option - Postpone Second Repository

Pros

- Responds to political opposition registered by "Second Repository" States
- Concentrates on first repository
- Maintains program momentum

Cons

- Raises questions about ability to reduce SNF inventory
- Reduces program flexibility
- Elevates MRS beyond original intent; increases its vulnerability
- Arouses nuclear industry concerns
- Intensifies "First Repository" State opposition

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[illegible]

U.S. HOUSE OF REPRESENTATIVES
SUBCOMMITTEE ON ENERGY CONSERVATION
AND POWER
OF THE
COMMITTEE ON ENERGY AND COMMERCE
WASHINGTON, DC 20515

October 30, 1986

The Honorable Donald Paul Hodel
Secretary
U.S. Department of the Interior
18th and C Streets, N.W.
Washington, D.C. 20240

Dear Secretary Hodel:

I was disturbed to read a news article describing your misleading statements concerning the status of the second repository program. According to the wire service report, you stated during a campaign swing in North Carolina that the second repository is "a dead issue" and is being used "to scare people" by the Democratic nominee for Congress, James McClure Clark.

Mr. Secretary, you must know that your remarks are false. The Nuclear Waste Policy Act of 1982, which you administered when you were Secretary of Energy, calls for a second repository to be selected by a specified time. It limits the amount of waste that can be put in the first repository. Both the Department of Energy's own General Counsel and the General Accounting Office agree that the only way that requirement can be changed is through legislation.

However, no such legislation has been passed. To the contrary, the Administration opposes such legislation.

Nonetheless, the Department of Energy could have taken another step to assure the people of North Carolina. It could have read the thousands of comments, which it required the public to file under a tightened schedule because of the "deadlines in the Act", and determined whether the North Carolina sites were poor selections. They did not do so. According to a letter of July 8, 1986, from Secretary Herrington to my Subcommittee, the comments are not being reviewed for technical merit. Although there is no current site-specific activity with respect to the second repository, no site has been disqualified based upon the comments. The letter also explains that the 70,000 metric ton cap on the first repository should not be removed because the cap is "consistent with the decision to postpone indefinitely, but not terminate, the second repository program." (emphasis added).

The Honorable Donald Paul Hodel
Page Two
October 28, 1986

Perhaps more to the point is a speech given by Ben Rusche, the Director of the Office of Civilian Radioactive Waste Management of the Department of Energy, on October 20, 1986. He is responsible for administering the waste program. He said:

> "We have not abandoned a second repository. The Nuclear Waste Policy Act requires that a second repository be considered under a certain set of conditions and that we proceed to the definition of a site. The Secretary and I have reiterated on several occasions our view that the Act, as it stands, ought to remain."

Frankly, Mr. Secretary, you should be personally wary of your own attempts to inject nuclear waste politics into the campaign. In 1984, during a campaign stop in Texas for the Republican nominee for the Senate, Phil Gramm, you told people there that because of public pressure and the influence of Phil Gramm, there would not be a repository in Texas. You reiterated that point in a letter to the former Chairman of this Subcommittee, Richard Ottinger. Of course, despite your assurances back then, presumably to aid the Republican candidate who was an author of the bill, Texas is still one of the three contenders for the first repository. I am enclosing news articles from that campaign to refresh your memory.

The people of North Carolina consider the use of their State as a nuclear waste repository as one of the most important issues that faces their State. Don't lull them into a false sense of security as you tried to do to the people of Texas. Tell it like it is. Tell them the law still requires a second repository, and that the program has not been terminated. Tell them that the same Department of Energy, which selected them as one of seven States for the second repository, will be making the choice again. The people deserve to know the facts.

Sincerely,

Ed Markey

Edward J. Markey
Chairman

Enclosures (As Stated)

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Dallas Morning News 9/1/84

2 Texas N-waste sites won't open, energy chief predicts

DMN 9/1/84

[illegible]

"One of the safest activities ever undertaken by man will be the handling of nuclear wastes."

— Donald Hodel, energy secretary

[illegible]

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P.25

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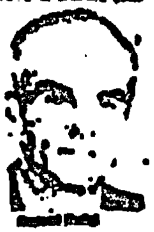
Hodel response on N-waste sites angers 2 House Democrats

By Jim [illegible]

WASHINGTON — Energy Secretary Donald Hodel, in a letter [illegible]



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107 AP 10-27-86 08:37 AET 62 LINES
BC-Repeating:
PM-Waste Dump, N.C. Bjt,570:
Interior Secretary Says Nuke Dump 'Dead Issue'
ASHEVILLE (AP) _ A high-level nuclear waste site could still be placed in North Carolina, despite statements to the contrary by the U.S. Interior Secretary, said James McClure Clarke, the 11th District Democratic congressional candidate.

''The Nuclear Waste Policy Act of 1982 is still the law,'' Clarke said. ''It still requires the president to pick a second dump site in 1990. Only Congress can change it, and when I get back to Washington I will introduce an amendment to (the law) to eliminate the second site altogether.''

But U.S. Interior Secretary Donald Hodel, who was in Asheville to defend Clarke's Republican opponent, incumbent U.S. Rep. Bill Hendon, said the waste site has been kept alive by Clarke as a scare tactic to win votes.

''We've got a desperate candidate desperately looking for an issue to scare people,'' Hodel said Saturday. ''But after the election it's going to be gone, finished, dead. It will be seen for what it is _ a dead issue.''

Hendon, who was in office when the dump issue arose earlier this year, has said repeatedly that the threat of a repository in Western North Carolina or in any other Eastern state has been removed by Energy Secretary John Herrington and by Congress, and that the country's first and only dump will be located in a Western state.

Clarke maintains that the law calling for a second site remains in effect and the search could be reactivated at any time.

''Not only is Western North Carolina not on any list for a waste dump, there is no list,'' said Hodel, who served as Energy Secretary for two years before moving to Interior in January 1985.

Hodel said a television advertisement for Clarke saying North Carolina has not been taken off the site study list is ''totally untrue.''

''If somebody's willing to make that kind o it down, and that's really Congressman Hendon has found himself up against here in this campaign,'' Hodel said.

Hendon and Hodel said the Department of Energy doesn't want the second site, nor does the Reagan Administration or Congress _ except members from the Western states who do not want their areas to house the country's entire arsenal of nuclear waste.

''I don't think when we passed the (Nuclear Waste Policy Act of 1982 calling for the second site) we realized that a second repository would engender so much opposition _ and Congress has been traumatized by this,'' Hodel said.

Clarke, responding to the two Republicans' comments, said Western North Carolina is still a potential waste site.

''Secretary Hodel obviously supports our present congressman's disinformation policy on the proposed high-level nuclear waste dump,'' he said. ''However, we who live here must face the truth.

''On Sept. 5, the general counsel of the DOE stated that the department's decision to postpone site specific work on a second repository would require congressional approval. It has not received

Clarke quoted Rep. Tom Bevill of Alabama, chairman of the House
ey Development, as
saying that his subcommittee's decision to delete funding was ''for
budgetary reasons'' and ''did not intend to affirm the secretary's
decision to suspend work on a second repository.''

''As a matter of fact, when the second repository is scheduled,
then of course the funding will be made available,'' Clarke quoted
Bevill as saying.

J. Summer -

STATE OF WASHINGTON
OFFICE OF THE GOVERNOR

OLYMPIA
98504 0413

October 31, 1986

Mr. John Herrington
Secretary of Energy
Washington, D.C. 20585

Dear Secretary Herrington:

Over the past several months informal efforts have been made by the Washington State Nuclear Waste Board to obtain information concerning ongoing and planned activities relating to the candidate repository site at Hanford. These efforts have been unsuccessful. Although Department of Energy officials have on several occasions promised to provide answers to our inquiries, they have not been forthcoming.

If any site characterization activities are ongoing, our position is such activities are in violation of the Nuclear Waste Policy Act. We understand the Nuclear Waste Policy Act to require submission of a site characterization plan and the conduct of public hearings on such plan before site characterization activities may be undertaken. Section 113(a) of the Act requires you to consider fully the comments received in public hearings on a site characterization plan. Further, that section requires consultation with the Governor of the affected state in conducting site characterization activities.

Despite these requirements, it appears the Department of Energy and its contractors are proceeding with site characterization activities without consulting the State of Washington and prior to the conduct of public hearings. The serious nature of such noncompliance is illustrated by the attached correspondence between Terry Husseman, Director of our Office of Nuclear Waste Management, and the Richland Operations Office. Your contractor was apparently planning to use radioactive tracers in a flowrate survey until the state's Office of Nuclear Waste Management learned of the plan and intervened. Not only would such activity have violated the consultation and public hearing requirements of the NWPA, but it would also have been in direct contravention of restrictions on the use of radioactive materials contained in section 113(c).

The State of Washington insists upon compliance with the provisions of section 113(a) of the NWPA which require submission of a site characterization plan and the conduct of public hearings before site characterization activities are undertaken. In addition, we formally request response to the following questions pursuant to the State of Washington's right under section 117(a) of the NWPA to receive "timely and complete information regarding determination or plans made with respect to the site characterization... of such repository."

1. Does the Department of Energy intend to conduct any site characterization activities prior to public hearings on a site characterization plan? If yes, how do you intend to comply with the provisions of section 113 of the Act which require you to consider fully comments received in public hearings and to consult with the Governor in conducting site characterization?

2. Have any laboratory or field activities relating to characterization of the Hanford site been conducted from May 28, 1986 to the present? If such activities have been or are being conducted, detail the nature and rationale of the activities, the names and positions of the persons overseeing such activities, and the documents which relate to or were generated as a result of such activities.

3. Please detail the activities included in each project work package referenced on the attached "Table of Project Activities by Work Package" and indicate which activities are exempt from the stop work order issued in May 1986 pertaining to inadequate quality assurance procedures.

4. What laboratory or field activities relating to characterization of the Hanford site are planned to be conducted in the three months following your response to these questions? Please detail the nature of the activities, the purpose of the activities, the dates when such activities will be conducted, the names and positions of the persons who will oversee such activities, and all documents which describe such activities.

5. Please furnish any documents, described in questions 2 and 4, above, developed by your agency or its contractors.

Consistent with the state's right to timely information, we request immediate response to questions 1 through 3 regarding activities which are ongoing or will be undertaken within the next 30 days. Question 4 must be answered within 30 days pursuant to section 117(a)(2) of the Act. Timely and complete answers to the very important requests we make will avoid the necessity for resorting to statutory remedies.

Thank you for your consideration in this pressing matter.

Sincerely,

Booth Gardner
Governor

BG:216p

Enclosures

STATE OF WASHINGTON

DEPARTMENT OF ECOLOGY

Mail Stop PV-11 • Olympia, Washington 98504-8711 • (206) 459-6000

August 27, 1986

Mr. Lee Olson, Project Manager
Basalt Waste Isolation Project
U.S. Department of Energy
P.O. Box 550
Richland, WA 99352

Dear ~~Mr. Olson~~ Lee:

It has come to my attention that USDOE and Rockwell may soon initiate radioactive tracer and pump tests at well DC 23. If this is true it concerns me because you did not notify us of this activity, and you did not provide the state of Washington timely and complete information regarding this testing as required in Section 117 of the Nuclear Waste Policy Act.

We have not received specific details about your planned testing, but it appears the proposed tracer and pump tests are in conflict with the following:

- Section 113(c) of the Nuclear Waste Policy Act which places specific restrictions on the use of radioactive material during site characterization.

- The agreement made at the May 7 USDOE/States/Tribes meeting and confirmed at the August 13 USDOE/States/Tribes meeting. At both meetings, USDOE agreed not to start new work at federal sites until the states had an opportunity to review the 15-20 page document which describes ongoing work. In addition, USDOE agreed to consult with the states prior to beginning new work.

- The general stop work order issued to Rockwell Operations on May 13, 1986.

- The Hydrologic Test Strategy agreement with NRC and the state of Washington which calls for a consensus on the hydrologic baseline before pump tests are initiated.

- State of Washington water quality and water rights laws and regulations which preclude contamination of groundwaters.

In addition, the need to monitor and differentiate the source of environmental contamination from a repository or from defense wastes was a major comment on the Defense Waste DEIS and the EMMP annotated outline. We are concerned that your use of radioactive tracers, rather than the conventional tracers, may destroy the baseline for radioactive iodine.

Even if these legal and procedural obstacles can be resolved, the state will have continuing strong objections to the use of <u>any</u> radioactive tracer in the basalt aquifers. On many occasions, and most recently in our response to the Defense Waste DEIS, we have expressed concern over the ability to perform postclosure monitoring of releases from a deep repository. Such monitoring would logically be performed at depth and in the aquifers now involved in hydraulic testing. Iodine-131/129, in fact, would be one of the most objectionable radionuclide tracers, since it would occur in the leading edge of a release plume from the repository. It would be essential to postclosure monitoring to have an iodine baseline in each of several aquifers above the repository, and the deliberate introduction of radioiodine today could destroy that baseline. Since there are adequate synthetic organic tracers available, they should be seriously considered for use in any proposed tracer tests. We are available and willing to work with you in the future planning of such tests.

Please provide us with the rationale for and the description of these tests. Thank you for your anticipated cooperation.

Sincerely,

Terry Husseman

Terry Husseman, Director
Office of Nuclear Waste Management

TH:kc

cc: Warren Bishop

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

86-GTB-58

OCT 24 1986

Mr. Terry Husseman, Program Director
Office of Nuclear Waste Management
Washington State Department of
Ecology, MS PV-11
Olympia, WA 98504

Dear Mr. Husseman:

VELOCITY SHOT TRACER INJECTION SURVEY DC-23GR (IODINE-131 LOGGING)

Thank you for your letter of August 27, 1986, concerning potential radioactive tracer logging at borehole DC-23GR.

Our contractor (Rockwell) is still investigating the advantages of performing a velocity shot tracer survey using radioactive I-131 as the tracer and developing the appropriate support documentation.

The purpose of the proposed survey is to determine vertical flowrates within the borehole. The interval proposed to be logged is from 2,385 feet to 3,532 feet. Conventional logging techniques in our opinion will not yield usable results, as the formation does not appear to yield adequate flow. The tracer, I-131, is being considered because of its approximate eight day half-life.

The current borehole status is that a bridge-plug has been set in the McCoy Canyon flow to isolate the Umtanum. The need for additional bridge-plugs is being evaluated. Further testing, logging and piezometer installation will occur when the Stop Work Order is lifted for these specific activities. If radioactive tracer logging is to be pursued it would be considered at that time. Radioactive tracer logging will not proceed, however, until we are certain the activity is consistent with the Nuclear Waste Policy Act and applicable NRC and Washington State applicable statutes and regulations and the appropriate documentation is in place. Assurances will be made, if I-131 is used as a radioisotope tracer, that other long-lived radioisotopes, including I-129, will not be injected into the subsurface.

Although the decision has not been made to proceed with the radioactive tracer logging, the NRC and State of Washington will be kept apprised of the progress of the study and provided with all relevant documentation which will include a full rationale and description of the tests prior to initiating the activity.

If you have any additional questions on this issue please contact Mr. M. L. Powell (509-376-5267) of my office and he will arrange for proper interface on the technical issues as may be required.

Sincerely,

John H. Anttonen, Assistant Manager
for Commercial Nuclear Waste

BWI:MKT

cc: Mr. Russell Jim, Program Manager
Yakima Tribal Council
Mr. Ron Halfmoon, Program Manager
Nez Perce Tribal Executive Comm.
Mr. Bill Burke, Program Chairman
Umatilla Confederated Tribes
Mr. David Stewart-Smith
Department of Energy, OR
Mr. Max S. Power
Institute for Public Policy, WA
Mr. Glen Lane
Council of Energy Resource Tribes
Mr. Donald Provost
St. of Wash, Dept. of Ecology

TABLE OF PROJECT ACTIVITIES
BY WORK PACKAGE

SUMMARY TABLE

Work Packages to be Stopped		329
Work Packages Excepted from SWO by Justification*:		
1. Data Gathering Activities	20	
2. Project Management Program Support Activities	44	
3. Personnel Safety and Maintenance Activities	61	
4. Administrative Activities	118	
5. SCP Preparation Activities	46	
6. Essential Activities/Imprudent to Stop	61	
7. Categories Require Clarification	141	
Total Work Packages Excepted from SWO		501
Total Project Work Packages		830

*Complete definitions of the six justifications for excluding work from the general Stop Work Order are given on Pages 1 and 2 of a letter dated May 1, 1986, from R. D. Larson to General Manager, Rockwell Hanford Operations titled, "Basalt Waste Isolation Project Work Evaluation."

Browning / Henehan

OFFICE OF THE ATTORNEY GENERAL

November 17, 1986

Honorable Ronald Reagan
President
The White House
Washington, D.C. 20500

Dear Mr. President:

I was pleased and encouraged by your comment (when recently visiting Spokane, Washington) that you would personally see to it that the letter of the law is followed by the United States Department of Energy in choosing a nuclear waste repository.

Regretfully, I must say your comment made clear to me that you have not been informed about the gross disregard of the Nuclear Waste Policy Act already committed by the Energy Department. By way of immediate example, I invite your attention to the actions of the Department in bulldozing past the lawful requirement of a second repository. I am firmly convinced the Department's actions are in clear violation of the Act and I expect to eventually prevail in the Courts.

The Nuclear Waste Policy Act requires the Secretary of the Department to recommend sites for two regionally distributed repositories with the second candidate sites to be nominated and recommended no later than July 1, 1989. This is the clear language and mandate of this federal law. The following points will demonstrate the flagrant disregard of this mandate by the Department.

1. On May 28, 1986, the Secretary of the Department announced the decision to suspend all site-specific work leading to the site for the second repository. In the words of the Secretary, "site specific work for a second repository has been postponed indefinitely."

2. On June 16, 1986, before Congress, the Secretary testified that "when and whether" the second repository process would be resumed would not be decided until the mid-1990's.

Ken Eikenberry Attorney General
Temple of Justice, Olympia, Washington 98504-0521

3. In a May 28, 1986 news release, the Department declared the eastern and midwestern states were "no longer under active consideration."

4. In a letter dated June 12, 1986 to Representative Broyhill, the Secretary stated, "Our search for a second repository site has been discontinued."

5. In its Mission Plan dated June, 1985, the Department stated that it would require <u>five years</u> of work to recommend candidate sites.

6. General Counsel for the Department, on September 5, 1986, advised that the requirement to make a recommendation regarding the second repository in 1989 "remain(s) intact until repealed, amended or supplanted by new legislation."

The foregoing clearly demonstrates the Department's determined violation of the Nuclear Waste Policy Act. I believe it is also important for you to personally know the criteria used by the USDOE in taking this action. This is best represented in notes of a meeting of May 21, 1986 (one week before the announcement) between high-ranking officials in the Department. In deciding whether to terminate the search for the second repository, a list of the pros and cons was created. First on the list of the pros was "immediate political relief from CRP states", and first on the list of the cons was "obvious political ploy." It is this kind of information which has lead to a total lack of confidence in the process by the citizens of the State of Washington. In the recent election they voiced this concern by passing an initiative with an 85 percent majority objecting to the process used in the selection of a site.

The foregoing serves to demonstrate not only violations of law by the United States Department of Energy but highlights the politically motivated reasons for the violations. I ask for your assistance and action in addressing this issue of far-reaching implications for the citizens of the entire country and the State of Washington, in particular.

Very truly yours,

Ken Eikenberry

KEN EIKENBERRY
Attorney General

jf
cc: John Herrington

Benting

FOR RELEASE NOVEMBER 20, 1986

MELVIN R. SAMPSON, Chairman of the Tribal Council of the Yakima Indian Nation, today announced that the Yakima Indian Nation had filed a petition in U.S. Court of Appeals for the Ninth Circut to review the actions of President Ronald Reagan, Energy Secretary John Herrington and the Department of Energy concerning failure to fulfill their legal responsibilities under the Nuclear Waste Policy Act and the trust responsibility due the Yakima Indian Nation in the following decisions:

(1) The nomination by the Secretary of five sites, including a site on the Hanford Nuclear Reservation and upon the treaty ceded lands of the the Yakima Indian Nation, as suitable for site characterization as a high-level nuclear waste repository;

(2) The reommendation by the Secretary to the President of three of the nominated sites, including the Hanford site, for characterization as candidate sites for a high-level nuclear waste repository;

(3) The issuance by the Secretary of environmental assessments relating to these nominations;

(4) The preliminary determination by the Secretary that the recommended sites are suitable for development as repositories;

(5) The approval by the President of the three recommended sites in Nevada, Texas and Washington; and,

(6) The decision by the Department and Secretary to indefinitely postpone all site-specific work leading to the nomination and recommendation of sites for selection of second round repository.

Further, the Yakima Indian Nation asked for a determination of whether the Department of Energy was correct in limiting funds for legal review of these actions as is contemplated in the Nuclear Waste Policy Act.

Sampson said distortion of DOE's technical scientific analysis in order to support selection of the Hanford site necessitated bringing these actions for review even though limited tribal funds must be used for this purpose. "We are fulfilling our responsibility as an affected tribe under the Nuclear Waste Policy Act and consider this effort necessary to see that Secretary Herrington and the Department of Energy fulfill theirs" Sampson said.

For any clarification, contact Russell Jim, Program Manager, Yakima Indian Nation Nuclear Waste Program (509) 865 5121, James B. Hovis, Tribal Attorney, (509) 575 1500 or Phillip Bing Olney, Yakima Indian Nation General Council Chairman, (509) 865-5121, Ext. 302.

Justus

STATE OF WASHINGTON
OFFICE OF THE GOVERNOR

OLYMPIA
98504-0413

BOOTH GARDNER
GOVERNOR

October 20, 1986

Mr. William N. Schlax
508 Buena Vista Drive
Santa Rosa, California 95404

Dear Mr. Schlax:

Thank you for sending Governor Gardner your paper on the basalt in the Hanford area. He forwarded it to me as his nuclear waste advisor and a member of the Nuclear Waste Board.

The Board consists of directors of various state health, resource, and energy agencies. I have distributed your paper to them and to the professional staff of the Board.

In addition we have a Nuclear Waste Advisory Council, which is conducting informational meetings on the referendum measure. I have forwarded your paper to its members also, for their use during these meetings.

I appreciate your sending your paper. I hope you will be able to continue contributing to the body of knowledge on Hanford's geology.

Sincerely,

Curtis Eschels

Curtis Eschels
Special Assistant for Policy

cc: Nuclear Waste Board
Nuclear Waste Advisory Council
Office of Nuclear Waste Management

26761

WILLIAM N. SCHLAX
GEOLOGIST
508 BUENA VISTA DRIVE
SANTA ROSA, CALIFORNIA 95404

October 9, 1986

Governor Booth Gardner
State Capitol
Olympia, WA 98504

Dear Governor Gardner:

On April 2, 1985, I sent you a copy of my testimony opposing the proposed nuclear waste repository at Hanford (given at Richland March 5, 1985).

Enclosed are copies of a Nuclear Regulatory Commission letter dated May 30, 1986, an Association of Engineering Geologists letter dated July 31, 1986, and my paper titled "Unsuitability of Hanford, Washington Site for a Nuclear Waste Repository". On October 7, 1986, I read this paper before the Annual Meeting of the Association of Engineering Geologists in San Francisco.

I hope you feel this paper merits the attention of the people of Washington before they vote on the issue of the repository in November. I request that you have this paper released to involved agencies of the State of Washington and to the media of the State.

Sincerely yours,

William N. Schlax

William N. Schlax
Engineering Geologist
CEG #28

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION V
1450 MARIA LANE, SUITE 210
WALNUT CREEK, CALIFORNIA 94596

May 30, 1986

MEMORANDUM FOR: Robert E. Browning, Director
Division of Waste Management

THROUGH: Ross A. Scarano, Director
Division of Radiation Safety and Safeguards

FROM: Dean M. Kunihiro
Regional State Liaison Officer

SUBJECT: CONCERNS REGARDING THE SUITABILITY OF HANFORD AS A HIGH-LEVEL WASTE REPOSITORY

On May 16, 1986, Mr. William Schlax visited the Region V office to express his concerns over the Department of Energy's (DOE) continuing high-level waste repository investigations of the Hanford site. According to Mr. Schlax, there are compelling technical bases to reject Hanford from further consideration. He noted that he has presented testimony to that effect at a public hearing on the DOE Draft Environmental Assessment in Richland, Washington on March 5, 1985 (Enclosure A), and sought assurances that the NRC be aware of and evaluate the issues set forth in his testimony. While briefly reviewing his technical rationale, he reiterated grave concern over the continued expenditure of "millions of dollars" studying a site which, according to him, has obviously little, if any, technical merit based on already known geologic information about the site.

One of his purposes in visiting the Regional office was to voice his concerns with appropriate NRC officials. I advised him that the NRC high-level waste program was managed by the Office of Nuclear Materials Safety and Safeguards, and assured him that his concerns would be forwarded to that office.

Also enclosed is an abstract from the paper entitled, "Unsuitability of Hanford, WA site for a nuclear waste repository," which Mr. Schlax has submitted for presentation at the annual meeting of the Association of Engineering Geologist.

Dean M. Kunihiro

Dean M. Kunihiro
Regional State Liaison Officer

Enclosures:
As stated

cc w/o enclosures:
W. N. Schlax

Association of Engineering Geologists

1986

ANNUAL MEETING

SAN FRANCISCO · EVERYBODY'S FAVORITE CITY ·

July 31st, 1986

Mr. William Schlax
508 Buena Vista Dr.
Santa Rosa, CA
95404

Dear Mr. Schlax

The technical program committee is pleased to inform you that you have been accepted to present an abstract at the 1986 Annual Meeting. Your abstract is entitled:

Unsuitability of Hanford, Washington site for a nuclear waste repository

Your paper has been scheduled for the following session:

1a Tue/AM

We encourage you to write your paper for publication in the AEG Bulletin. We have enclosed guidelines for the short paper format.

Sincerely,

1986 AEG ANNUAL MEETING COMMITTEE

Rex

R. Rexford Upp
Program Chairman
(408) 984-1336

Enclosures: Annual Meeting Short Papers

Received Aug. 11, 86 MRL

Unsuitability of Hanford, Washington site for a Nuclear Waste Repository

William N. Schlax, Engineering Geologist
508 Buena Vista Drive, Santa Rosa, CA 95404

This paper is based on the author's review of the Department of Energy's draft and final Environmental Assessments of the Hanford site, and on the author's knowledge of the region, acquired in part, as a co-author of the U. S. Geological Survey report on the Geology and Groundwater Resources of the Wenas Creek Valley (forty miles west of Hanford) which is referenced in the Environmental Assessments.

In the Pacific Northwest, the 260,000 square mile drainage basin of the Columbia River encompasses Idaho, parts of western Montana and Wyoming, large parts of Oregon and Washington, and the southeast part of British Columbia. In the central part of this drainage basin is the Columbia Lava Plateau where there are thick accumulations of Tertiary lava flows and related continental sedimentary strata. Major accumulations of usable groundwater occur in parts of these volcanic and sedimentary strata and are available for use from many prolific aquifers. There are other areas in the Columbia drainage basin where relatively impermeable pre-Tertiary rocks crop out which contain only minor accumulations of usable groundwater.

At Hanford, Washington, five miles from the Columbia River, it is proposed to construct a nuclear waste repository inside the flat lying Cohassett basalt lava flow which is one of many Tertiary lava flows underlying the area to a possible depth of 16,000 feet (DOE, 1984). The jointed and fractured Cohassett flow ranges in thickness from 240 to 266 feet and is at a depth of about 3000 feet below ground surface at the site. The water table is about 165 feet below ground surface (DOE, 1986). The groundwater below constitutes one of the largest bodies of usable groundwater in the Pacific Northwest.

The waste site would resemble a large underground mine with a horizontal tunnel complex extending over an area of about 2000 acres (1.2 X 2.7 miles). Construction would be done by blind drilling a vertical shaft with a rotary drill rig, using drilling mud, and then cementing a steel casing against the bedrock strata from the ground surface down through the Cohassett flow. Drilling mud would then be pumped out of the shaft and be replaced by air at atmospheric pressure of about 16 pounds per square inch. Tunnels would be extended horizontally from the shaft into the Cohassett flow by the usual mining methods of drilling and blasting. Such blasting would cause substantial additional fracturing of the hard, brittle basalt lava. Construction and operation of the site is expected to last 37 years followed by a 50 year period in which the nuclear waste must be recoverable.

Prolific groundwater aquifers above and below the jointed and fractured Cohassett flow contain enormous volumes of groundwater at a pressure of about 1,380 pounds per square inch (DOE, 1986) or 100 tons per square foot, as compared to the tunnels to be constructed, which must be kept filled with air at 16 pounds per square inch for 87 years, Should there ever be any abrupt, large inflow of groundwater anywhere in the site, in the 37 years of construction and operation, the entire complex might be quickly flooded and rendered useless, with probable loss of life of underground personnel.

To seal off expected large inflows of groundwater by grouting open, fractured basalt tunnels over a 2000 acre site, at a depth of 3000 feet, against water pressures of 1,380 pounds per square inch or 100 tons per square foot, is probably not possible or feasible. Certainly, it is highly undesirable when sites without such a problem can be found.

To pump out expected large inflows of groundwater would require shafts and pumping installations around the perimeter of the 2000 acre site with continuous pumping for 87 years. With the vertical lift of 3000 feet, the costs for equipment and power would be astronomical. Water, more mineralized than from shallower aquifers, would be discharged at the surface. Should any nuclear waste containers be breached, as by rock bursts or tunnel collapses, poisonous radioactive material might be pumped with the water and be discharged at the surface and into the Columbia River.

When continuous pumping ceased after 87 years, the nuclear waste material in the tunnel complex would be enclosed within and no longer isolated from the regional groundwater system. There would be almost certain contamination of the groundwater and eventually of the Columbia River.

Hazards to underground personnel would clearly exceed a reasonable risk because of : the jointed and fractured nature of the rock, additional fracturing from blasting, the potential for rock bursts and tunnel collapses, and the 1,380 pounds per square inch or 100 tons per square foot pressure of enormous volumes of groundwater surrounding the entire air filled tunnel complex.

In the drainage basin of the Columbia River, far less hazardous, difficult, and expensive sites could be found in areas of outcrop of relatively impermeable pre-Tertiary rocks which contain only minor accumulations of groundwater. Such sites could also be found in other parts of the United States. The Hanford site is unsuitable for a nuclear waste repository. Use of the site for such a purpose would be a major financial and ecological disaster for future generations.

REFERENCES

DOE (U. S. Department of Energy), December, 1984
Draft Environmental Assessment, Reference Repository Location, Hanford Site, Washington, DOE/RW-0017

DOE (U. S. Department of Energy), May 1986,
Environmental Assessment, Reference Repository Location, Hanford Site, Washington, DOE/RW-0070, 3 volumes

The Secretary of Energy
Washington, DC 20585

J. Linehan / B. Lilley

November 13, 1986

Honorable Booth Gardner
Governor of Washington
Olympia, Washington 98504-0413

Dear Governor Gardner:

Thank you for your September 18, 1986, letter regarding the nuclear waste repository program.

I appreciate your concerns and share your views regarding the importance of a selection process that results in a scientifically sound decision in which affected parties can have confidence. One of the primary reasons we asked the National Academy of Sciences' Board on Radioactive Waste Management (the Board) to undertake an independent, scientific review of the ranking methodology and its application was to achieve this confidence. The Board concluded that the methodology used was appropriate and provided a sound analytical basis for aiding the site characterization decision (see enclosure). The Board's recommendations were of significant value to the program and, I believe, exemplify the value to the public of continued independent involvement by the Board in our site characterization activities.

As I indicated to you in my July 3, 1986, letter, I considered additional independent review of the application of the methodology. Although it is conceivable that such a review might have enhanced the perceived credibility of the selection process, it would not have significantly changed the insights obtained from the application of the methodology or the recommendation decision. This is because the methodology employed an extensive set of sensitivity analyses. The Board recognized the value of this analysis and found no indication of bias in the Department of Energy's implementation of the methodology.

With regard to Professor Detlof von Winterfeldt's comments on the sites selected, he is a recognized expert in the field of decision analysis, and it was in that capacity only that he served as a consultant to the Board in their review of the methodology. That Board repeatedly stressed that the methodology is only a decision-aiding tool and that additional factors and judgments are required to make site selection decisions. Consideration of such additional factors, together with the insights provided by the methodology, formed the basis of the recommendation I sent to the President on May 27 of this year. The values attached to the methodology and the additional factors that were considered are clearly indicated in the recommendation report. That Professor von Winterfeldt reached different value judgments and perceived the decision-aiding methodology in a different role in no way invalidates the site recommendation decision.

I appreciate the opportunity to respond to your concerns.

Yours truly,

John S. Herrington

John S. Herrington

Enclosure

J. Linehan

STATE OF WASHINGTON
OFFICE OF THE GOVERNOR

OLYMPIA
98504-0413

October 31, 1986

Mr. John Herrington
Secretary of Energy
Washington, D.C. 20585

Dear Secretary Herrington:

Over the past several months informal efforts have been made by the Washington State Nuclear Waste Board to obtain information concerning ongoing and planned activities relating to the candidate repository site at Hanford. These efforts have been unsuccessful. Although Department of Energy officials have on several occasions promised to provide answers to our inquiries, they have not been forthcoming.

If any site characterization activities are ongoing, our position is such activities are in violation of the Nuclear Waste Policy Act. We understand the Nuclear Waste Policy Act to require submission of a site characterization plan and the conduct of public hearings on such plan before site characterization activities may be undertaken. Section 113(a) of the Act requires you to consider fully the comments received in public hearings on a site characterization plan. Further, that section requires consultation with the Governor of the affected state in conducting site characterization activities.

Despite these requirements, it appears the Department of Energy and its contractors are proceeding with site characterization activities without consulting the State of Washington and prior to the conduct of public hearings. The serious nature of such noncompliance is illustrated by the attached correspondence between Terry Husseman, Director of our Office of Nuclear Waste Management, and the Richland Operations Office. Your contractor was apparently planning to use radioactive tracers in a flowrate survey until the state's Office of Nuclear Waste Management learned of the plan and intervened. Not only would such activity have violated the consultation and public hearing requirements of the NWPA, but it would also have been in direct contravention of restrictions on the use of radioactive materials contained in section 113(c).

The State of Washington insists upon compliance with the provisions of section 113(a) of the NWPA which require submission of a site characterization plan and the conduct of public hearings before site characterization activities are undertaken. In addition, we formally request response to the following questions pursuant to the State of Washington's right under section 117(a) of the NWPA to receive "timely and complete information regarding determination or plans made with respect to the site characterization... of such repository."

1. Does the Department of Energy intend to conduct any site characterization activities prior to public hearings on a site characterization plan? If yes, how do you intend to comply with the provisions of section 113 of the Act which require you to consider fully comments received in public hearings and to consult with the Governor in conducting site characterization?

2. Have any laboratory or field activities relating to characterization of the Hanford site been conducted from May 28, 1986 to the present? If such activities have been or are being conducted, detail the nature and rationale of the activities, the names and positions of the persons overseeing such activities, and the documents which relate to or were generated as a result of such activities.

3. Please detail the activities included in each project work package referenced on the attached "Table of Project Activities by Work Package" and indicate which activities are exempt from the stop work order issued in May 1986 pertaining to inadequate quality assurance procedures.

4. What laboratory or field activities relating to characterization of the Hanford site are planned to be conducted in the three months following your response to these questions? Please detail the nature of the activities, the purpose of the activities, the dates when such activities will be conducted, the names and positions of the persons who will oversee such activities, and all documents which describe such activities.

5. Please furnish any documents, described in questions 2 and 4, above, developed by your agency or its contractors.

Consistent with the state's right to timely information, we request immediate response to questions 1 through 3 regarding activities which are ongoing or will be undertaken within the next 30 days. Question 4 must be answered within 30 days pursuant to section 117(a)(2) of the Act. Timely and complete answers to the very important requests we make will avoid the necessity for resorting to statutory remedies.

Thank you for your consideration in this pressing matter.

Sincerely,

Booth Gardner
Governor

BG:216p

Enclosures

ANDREA BEATTY RINIKER
Director

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY

Mail Stop PV-11 • Olympia, Washington 98504-8711 • (206) 459-6000

August 27, 1986

Mr. Lee Olson, Project Manager
Basalt Waste Isolation Project
U.S. Department of Energy
P.O. Box 550
Richland, WA 99352

Dear ~~Mr. Olson~~ Lee:

It has come to my attention that USDOE and Rockwell may soon initiate radioactive tracer and pump tests at well DC 23. If this is true it concerns me because you did not notify us of this activity, and you did not provide the state of Washington timely and complete information regarding this testing as required in Section 117 of the Nuclear Waste Policy Act.

We have not received specific details about your planned testing, but it appears the proposed tracer and pump tests are in conflict with the following:

- Section 113(c) of the Nuclear Waste Policy Act which places specific restrictions on the use of radioactive material during site characterization.
- The agreement made at the May 7 USDOE/States/Tribes meeting and confirmed at the August 13 USDOE/States/Tribes meeting. At both meetings, USDOE agreed not to start new work at federal sites until the states had an opportunity to review the 15-20 page document which describes ongoing work. In addition, USDOE agreed to consult with the states prior to beginning new work.
- The general stop work order issued to Rockwell Operations on May 13, 1986.
- The Hydrologic Test Strategy agreement with NRC and the state of Washington which calls for a consensus on the hydrologic baseline before pump tests are initiated.
- State of Washington water quality and water rights laws and regulations which preclude contamination of groundwaters.

In addition, the need to monitor and differentiate the source of environmental contamination from a repository or from defense wastes was a major comment on the Defense Waste DEIS and the EMMP annotated outline. We are concerned that your use of radioactive tracers, rather than the conventional tracers, may destroy the baseline for radioactive iodine.

Even if these legal and procedural obstacles can be resolved, the state will have continuing strong objections to the use of <u>any</u> radioactive tracer in the basalt aquifers. On many occasions, and most recently in our response to the Defense Waste DEIS, we have expressed concern over the ability to perform postclosure monitoring of releases from a deep repository. Such monitoring would logically be performed at depth and in the aquifers now involved in hydraulic testing. Iodine-131/129, in fact, would be one of the most objectionable radionuclide tracers, since it would occur in the leading edge of a release plume from the repository. It would be essential to postclosure monitoring to have an iodine baseline in each of several aquifers above the repository, and the deliberate introduction of radioiodine today could destroy that baseline. Since there are adequate synthetic organic tracers available, they should be seriously considered for use in any proposed tracer tests. We are available and willing to work with you in the future planning of such tests.

Please provide us with the rationale for and the description of these tests. Thank you for your anticipated cooperation.

Sincerely,

Terry Husseman

Terry Husseman, Director
Office of Nuclear Waste Management

TH:kc

cc: Warren Bishop

Department of Energy
Richland Operations Office
P.O. Box 550
Richland, Washington 99352

86-GTB-58

OCT 24 1986

Mr. Terry Husseman, Program Director
Office of Nuclear Waste Management
Washington State Department of
Ecology, MS PV-11
Olympia, WA 98504

Dear Mr. Husseman:

VELOCITY SHOT TRACER INJECTION SURVEY DC-23GR (IODINE-131 LOGGING)

Thank you for your letter of August 27, 1986, concerning potential radioactive tracer logging at borehole DC-23GR.

Our contractor (Rockwell) is still investigating the advantages of performing a velocity shot tracer survey using radioactive I-131 as the tracer and developing the appropriate support documentation.

The purpose of the proposed survey is to determine vertical flowrates within the borehole. The interval proposed to be logged is from 2,385 feet to 3,532 feet. Conventional logging techniques in our opinion will not yield usable results, as the formation does not appear to yield adequate flow. The tracer, I-131, is being considered because of its approximate eight day half-life.

The current borehole status is that a bridge-plug has been set in the McCoy Canyon flow to isolate the Umtanum. The need for additional bridge-plugs is being evaluated. Further testing, logging and piezometer installation will occur when the Stop Work Order is lifted for these specific activities. If radioactive tracer logging is to be pursued it would be considered at that time. Radioactive tracer logging will not proceed, however, until we are certain the activity is consistent with the Nuclear Waste Policy Act and applicable NRC and Washington State applicable statutes and regulations and the appropriate documentation is in place. Assurances will be made, if I-131 is used as a radioisotope tracer, that other long-lived radioisotopes, including I-129, will not be injected into the subsurface.

Although the decision has not been made to proceed with the radioactive tracer logging, the NRC and State of Washington will be kept apprised of the progress of the study and provided with all relevant documentation which will include a full rationale and description of the tests prior to initiating the activity.

If you have any additional questions on this issue please contact Mr. R. L. Powell (509-376-5267) of my office and he will arrange for proper interface on the technical issues as may be required.

Sincerely,

John H. Anttonen, Assistant Manager
for Commercial Nuclear Waste

BWI:MXT

cc: Mr. Russell Jim, Program Manager
Yakima Tribal Council
Mr. Ron Halfmoon, Program Manager
Nez Perce Tribal Executive Comm.
Mr. Bill Burke, Program Chairman
Umatilla Confederated Tribes
Mr. David Stewart-Smith
Department of Energy, OR
Mr. Max S. Power
Institute for Public Policy, WA
Mr. Glen Lame
Council of Energy Resource Tribes
Mr. Donald Provost
St. of Wash, Dept. of Ecology

Enclosure 3

TABLE OF PROJECT ACTIVITIES BY WORK PACKAGE

SUMMARY TABLE

Work Packages to be Stopped		329
Work Packages Excepted from SWO by Justification*:		
1. Data Gathering Activities	20	
2. Project Management Program Support Activities	44	
3. Personnel Safety and Maintenance Activities	61	
4. Administrative Activities	118	
5. SCP Preparation Activities	46	
6. Essential Activities/Imprudent to Stop	61	
7. Categories Require Clarification	141	
Total Work Packages Excepted from SWO		501
Total Project Work Packages		830

*Complete definitions of the six justifications for excluding work from the general Stop Work Order are given on Pages 1 and 2 of a letter dated May 1, 1986, from R. D. Larson to General Manager, Rockwell Hanford Operations titled, "Basalt Waste Isolation Project Work Evaluation."

~~Booth~~
Curt
FYI

Department of Energy
Washington, DC 20585

OCT 10 1986

Honorable Booth Gardner
Governor of Washington
Olympia, Washington 98504-0413

Dear Governor Gardner:

Thank you for your letter of September 18, 1986, to Secretary Herrington, regarding the first repository site selection process.

The Department of Energy is working on a response to your concerns. A reply will be sent to you within 3 weeks.

Sincerely,

Ben C. Rusche

Ben C. Rusche, Director
Office of Civilian Radioactive
Waste Management

STATE OF WASHINGTON
OFFICE OF THE GOVERNOR

OLYMPIA
98504-0413

BOOTH GARDNER
GOVERNOR

September 18, 1986

John Herrington, Secretary
U.S. Department of Energy
1000 Independence Avenue
Washington, D.C. 20585

Dear Secretary Herrington:

I understand that USDOE recently requested the National Academy of Sciences to participate in an undefined capacity in the first-round repository site characterization process. I submit that before USDOE takes any steps toward site characterization it must [redacted] and begin to establish [redacted] in the process by which it decides which sites it will characterize. As you know, in response to the USDOE and Presidential decisions of May 28th, I have urged a temporary halt and a restructuring of the site selection process. [redacted] we are [redacted] find a safe and [redacted] to permanently dispose of the nation's high-level nuclear waste, we must establish and follow a process which all affected parties are confident will result in a scientifically sound decision.

The attached letters from Professor von Winterfeldt to Mr. Rusche have [redacted] ous doubts about the convoluted reasoning on which USDOE based its decision to recommend Hanford for further study even though it is the least safe and most costly of all the sites under consideration. In his letter dated July 22, 1986, Professor von Winterfeldt concludes:

> *"The logical implications of the judgments and estimates made by DOE experts and managers themselves as reported in the Methodology Report [redacted] the Hanford site and for choosing the [redacted] site [redacted] ...*
>
> *"Unfortunately, it appears that DOE [redacted] and of its own experts' [redacted] and instead simply repeated the choice that was made one and a half years ago."*

Professor von Winterfeldt is known and respected as one of the nation's foremost experts on decision analysis. He has no stake in the outcome of the site selection process other than his professional concern that the crucial decisions in this complex and controversial process are defendable on a logical and scientific basis. He could have returned to his position at the University of Southern California and passively observed the process, but instead Professor von Winterfeldt voluntarily chose to communicate his serious concerns to USDOE and as a result involve himself directly in this national controversy. I commend him for his commitment to fulfill his professional and public responsibilities and, Mr. Secretary, I encourage USDOE to take appropriate actions to respond to his and to our concerns.

As I have done on several previous occasions, I once again ask that USDOE agree to submit its entire site selection process to a thorough, independent review by credible scientific experts. Such review must include examination of the basis upon which value judgments were made and examination of the implementation of the ranking methodology. I am convinced that if USDOE fails to respond positively to our concerns the site selection process is headed for total collapse.

Thank you for your consideration.

Sincerely,

Booth Gardner
Governor

cc: Frank Press, Ph.D.
Professor Detlof von Winterfeldt

DICK NELSON
Thirty-Second District
122 N.W. 80th
Seattle, WA 98107
307 House Office Building
Olympia, WA 98504
RES. TEL. (206) 782-1239
LEG. TEL. (206) 786-7114
HOTLINE 1-800 562-6000

State of Washington House of Representatives

RECEIVED
OCT 17 1986
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Forty-Ninth Legislature
1985-86

Committees
Energy and Utilities, Chair
Higher Education
Natural Resources

October 14, 1986

Mr. Terry Lash
Illinois Department of Nuclear Safety
1035 Outer Park Drive
Springfield, Illinois 62704

Dear Mr. Lash:

The Energy Committee of the House, which I chair, has been actively involved in radioactive waste matters for the past three years. This involvement has intensified with the recent site designation of Hanford for the first (and perhaps only) high-level repository.

The Committee has been examining emergency response planning and environmental monitoring systems among other issues. We are interested in your experience and thoughts in these areas. Specifically, what considerations led to the establishment of your office? How does it relate to federal and other state agencies? How is it funded? What role has your state had in emergency response planning? Has this role, or your efforts, changed at all since the events at Chernobyl? What techniques and system does your agency use to conduct environmental monitoring?

I have called a special meeting of the Committee on November 18th in Seattle to address these (and other) emergency response and environmental monitoring issues. I am hoping you would be available to attend to assist us in addressing these matters. We will contact you shortly to determine your availability.

If you have any questions regarding this, please contact me at (206) 782-1239 or Ted Hunter of my staff at (206) 786-7114.

We look forward to working with you.

Sincerely,

Dick Nelson

Representative Dick Nelson, Chairman
House Energy & Utilities Committee

DN:cas

101486.2
E&U4

STATE OF ILLINOIS
DEPARTMENT OF NUCLEAR SAFETY
1035 OUTER PARK DRIVE
SPRINGFIELD 62704
(217) 546-8100

TERRY R. LASH
DIRECTOR

October 14, 1986

Mr. Ted Hunter
House Energy Committee Staff
AL-1
Olympia, Washington 98504

Dear Mr. Hunter:

In response to your call today, enclosed are the following materials about the Illinois Department of Nuclear Safety and its monitoring program for commercial nuclear power plants in Illinois:

1. "Remote Monitoring of Nuclear Power Reactors"
2. "Isotopic Effluent Monitoring for Nuclear Power Plants"
3. Fact Sheets: "The Illinois Plan for Radiological Accidents;" "Radiological Emergency Assessment Center;" "Reactor Parameter Data Link;" "The Radioactive Gaseous Effluent Monitoring System;" and "Environmental Radiation Monitoring System"
4. IDNS Annual Report
5. IDNS informational brochure
6. "Radioactive Gaseous Effluent Monitoring System" brochure.

If you have any questions or guidance for my presentation on November 18, please feel free to contact me.

Sincerely,

Terry R. Lash
Director

TRL:dk

bcc: Terry Husseman w/o enclosures

RICHARD H. BRYAN
Governor

STATE OF NEVADA

ROBERT R. LOUX
Executive Director

AGENCY FOR NUCLEAR PROJECTS
NUCLEAR WASTE PROJECT OFFICE

Capitol Complex
Carson City, Nevada 89710
(702) 885-3744

October 20, 1986

Dr. Raphael G. Kasper
National Research Council
CPSMR
2101 Constitution Avenue, N.W.,
Room NAS285
Washington, D.C. 20418

Dear Dr. Kasper:

On behalf of the representatives of the affected states and Indian tribes, I would like to express our appreciation for your recent presentation to us describing and discussing the role of the National Academy in the Department of Energy's high-level radioactive waste program. Your discussion of the relationship between the Academy and the Department of Energy was particularly informative.

As you heard from the state-tribal representatives, there is general consensus that the siting process by which the Department of Energy nominated and recommended candidate repository sites for characterization is flawed and illegal. We were quite interested to hear your description of the Academy's very limited role in reviewing the decision-aiding methodology used by the Department as a part of this decision-making process. As we explained to you, there are numerous examples of the Department of Energy's utilizing your limited review and its favorable conclusions to support the implication that the Academy has fully reviewed the entire decision-making process, found it sound and that the Academy completely agrees with and supports the Department's selection of the sites in Nevada, Texas and Washington.

Although you clearly stated to us that the Academy was given a very limited review role and you have not endorsed the actual selection of the aforementioned sites, we believe that the Academy should, in a very public way, announce the scope of your limited review of the methodology and the extent to which the Academy has endorsed the sites selected for characterization, and the method by which they were selected.

After having some discussion with the Department regarding the future role of the Academy in the Department of Energy's repository selection program, we were pleased and surprised to learn of your willingness to support the Academy's conducting its activities in an open and public forum, something that Department of Energy officials have told us you would be unable to accommodate and, in fact was not the case in recent Academy reviews of DOE decision-aiding documents. More surprising, however, was your statement that in another recent endeavor the Secretary of Energy has specifically required the Academy to conduct its review in a manner which includes full public participation, and the Academy has agreed to that requirement. It is interesting that the Department of Energy would not impose a similar requirement on the Academy in the radioactive waste program, even though the Nuclear Waste Policy Act specifically requires full public participation in the DOE program. The DOE has informed us that the procedures of the Academy's review are at the discretion of the Academy.

We were also pleased to learn that you support the state-tribal interest in working with the Department of Energy to develop the scope and extent of the Academy's future activities in the program under the Department's contract with you.

And in a related matter, I believe, consistent with your invitation, the state and tribal representatives likely will be suggesting individuals for consideration by the Academy for inclusion on the Board on Radioactive Waste Management panel or panels that will review the Department of Energy's program.

The state-tribal representatives have grave concerns regarding the way in which the Academy's participation has been used and perhaps exploited by the Department of Energy in the past, and we believe that any future review by the Academy must be approached in a very well defined and clearly stated manner. Full public access to the Academy's deliberations while they are in progress, in our opinion, is an absolute prerequisite for future activities by the Academy in this program. Additionally, the issues of reviewers' potential conflicts of interest, the scope and extent of the Academy's review, and actual role of the affected states and tribes, and public, in the review process are critical issues that must be resolved prior to the initiation of any activity by the Academy in the DOE high-level nuclear waste repository program.

I want to thank you again for your presentation and for your clarification of the position of the Academy on issues such as public participation.

Sincerely,

Robert R. Loux
Executive Director

RRL/gjb

cc: Mr. Ben Rusche
Mr. Grant Sawyer
Mr. Frank Press
Senator Paul Laxalt
Senator Chic Hecht
Representative Barbara Vucanovich
Representative Harry Reid
Representative Morris Udall
Senator Pete Domenici
Mr. Terry Husseman
Mr. Steve Frishman
Mr. Ron Halfmoon
Mr. Russell Jim
Mr. William Burke

CONGRESSIONAL COMMITTEES AND SUBCOMMITTEES INVOLVED IN NUCLEAR WASTE ISSUES

A Listing of Chairpersons, Ranking Majority and Minority Members, and Members from States of Washington, Oregon and Idaho

U.S. HOUSE

October 1986

Committees are listed below in alphabetical order. Subcommittees are listed alphabetically under each committee. Democrats (D) are the majority party; Republicans (R) are the minority party. Asterisks (*) indicate that chairmen and/or ranking minority members are also *ex officio* members of all subcommittees of which they are not regular members.

APPROPRIATIONS

H218 Capitol Building (202) 225-2771

Jamie L. Whitten, D-Miss., Chairman*

Edward P. Boland, D-Mass.
Norman D. Dicks, D-Wash.
Les AuCoin, D-Ore.

Silvio O. Conte, R-Mass.*

Subcommittee on Energy and Water Development
2362 Rayburn House Office Building
Washington, D.C. 20515
(202) 225-3421

Tom Bevill, D-Ala., Chairman
Lindy (Mrs. Hale) Boggs, D-La.
John T. Myers, R-Ind.

Subcommittee on Interior and Related Agencies
B308 Rayburn House Office Building
Washington, D.C. 20515
(202) 225-3081

Sidney R. Yates, D-Ill., Chairman
John P. Murtha, D-Pa.
Norman D. Dicks, D-Wash.
Les AuCoin, D-Ore.
Ralph Regula, R-Ohio

ENERGY AND COMMERCE

2125 Rayburn House Office Building (202) 225-2927

John D. Dingell, D-Mich., Chairman*

James H. Scheuer, D-N.Y.
Al Swift, D-Wash.
Ron Wyden, D-Ore.

Norman F. Lent, R-N.Y*

Subcommittee on Energy Conservation and Power

316 House Office Building, Annex #2
Washington, D.C. 20515
(202) 226-2424

Edward J. Markey, D-Mass., Chairman
Al Swift, D-Wash.
Ron Wyden, D-Ore.
Carlos J. Moorhead, R-Calif.

Subcommittee on Health and the Environment

2415 Rayburn House Office Building
Washington, D.C. 20515
(202) 225-4952

Henry A. Waxman, D-Calif., Chairman
James H. Scheuer, D-N.Y.
Ron Wyden, D-Ore.
Edward R. Madigan, R-Ill.

Subcommittee on Oversight and Investigations

2323 Rayburn House Office Building
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(202) 225-4441

John D. Dingell, D-Mich., Chairman
Ron Wyden, D-Ore.
Bob Whittaker, R-Kan.

Subcommittee on Telecommunications, Consumer Protection, and Finance

B331 Rayburn House Office Building
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(202) 225-9304

Timothy E. Wirth, D-Colo., Chairman
Al Swift, D-Wash.
Matthew J. Rinaldo, R-N.J.

INTERIOR AND INSULAR AFFAIRS

1324 Longworth House Office Building (202) 225-2761

Morris K. Udall, D-Ariz., Chairman*

John F. Seiberling, D-Ohio
Don Young, R-Alaska*
Larry E. Craig, R-Idaho
Denny Smith, R-Ore.

Subcommittee on Energy and the Environment

1327 Longworth House Office Bldg.
Washington, D.C. 20515
(202) 225-8331

Morris K. Udall, D-Ariz., Chairman
John F. Seiberling, D-Ohio
Manuel Lujan, Jr., R-N.M.

Subcommittee on General Oversight, Northwest Power, and Forest Management

1626 Longworth House Office Building
Washington, D.C. 20515
(202) 225-1661

James Weaver, D-Ore., Chairman
Morris K. Udall, D-Ariz.
Charles Pashayan, Jr., R-Calif.

Subcommittee on Public Lands

812 House Office Building, Annex #1
Washington, D.C. 20515
(202) 226-7734

John F. Sieberling, D-Ohio, Chairman
James Weaver, D-Ore.
Ron Marlenee, R-Mont.

Subcommittee on <u>Water and Power Resources</u>

1522 Longworth House Office Building
Washington, D.C. 20515
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Morris K. Udall, D-Ariz.
Dick Cheney, R-Wyo.

SCIENCE AND TECHNOLOGY

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Richard H. Stallings, D-Idaho
Manuel Lujan, Jr., R-N.M.*
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Subcommittee on <u>Energy, Development and Applications</u>

B374 Rayburn House Office Building
Washington, D.C. 20515
(202) 225-4494

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Robert A. Roe, D-N.J.
F. James Sensenbrenner, Jr., R-Wis.

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Subcommittee on <u>Investigations and Oversight</u>

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Michael A. Andrews, D-Texas
Ron Packard, R-Calif.
Sid Morrison, R-Wash.

<u>Task Force on Science Policy</u>

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Richard H. Stallings, D-Idaho
Manuel Lujan, Jr., R-N.M.
Sid Morrison, R-Wash.

CONGRESSIONAL COMMITTEES AND SUBCOMMITTEES INVOLVED IN NUCLEAR WASTE ISSUES

A Listing of Chairpersons, Ranking Majority and Minority Members, and Members from States of Washington, Oregon and Idaho

U.S. SENATE

October 1986

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APPROPRIATIONS
118 Dirksen Senate Office Building (202) 224-3471

Mark O. Hatfield, R-Ore., Chairman*

Ted Stevens, R-Alaska
James A. McClure, R-Idaho

John C. Stennis, D-Miss.*

Subcommittee on Energy and Water Development

142 Dirksen Senate Office Bldg.
Washington, D.C. 20510
(202) 224-7260

Mark O. Hatfield, R-Ore., Chairman
James A. McClure, R-Idaho
J. Bennett Johnston, D-La.

Subcommittee on Interior and Related Agencies

114 Dirksen Senate Office Bldg.
Washington, D.C. 20510
(202) 224-7233

James A. McClure, R-Idaho, Chairman
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Robert C. Byrd, D-W. Va.

COMMERCE, SCIENCE AND TRANSPORTATION
508 Dirksen Senate Office Building (202) 224-5115

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Slade Gorton, R-Wash.

Ernest F. Hollings, D-S.C.*

Subcommittee on Communications

227 Hart Senate Office Building
Washington, D.C. 20510
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Slade Gorton, R-Wash.
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Subcommittee on Science, Technology, and Space

427 Hart Senate Office Bldg.
Washington, D.C. 20510
(202) 224-8172

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Barry Goldwater, R-Ariz.
Donald W. Riegle, Jr., D-Mich.

Subcommittee on Surface Transportation

428 Hart Senate Office Building
Washington, D.C. 20510
(202) 224-4852

Bob Packwood, R-Idaho, Chairman
Larry Pressler, R-S.D.
Russel B. Long, D-La.*

ENERGY AND NATURAL RESOURCES

358 Dirksen Senate Office Building (202) 224-4971

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Daniel J. Evans, R-Wash.

J. Bennett Johnston, D-La.*

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212 Hart Senate Office Bldg.
Washington, D.C. 20510
(202) 224-2366

Don Nickles, R-Okla., Chairman
Mark O. Hatfield, R-Ore.
Daniel J. Evans, R-Wash.
Howard M. Metzenbaum, D-Ohio

Subcommittee on Energy Research and Development

317 Dirksen Senate Office Bldg.
Washington, D.C. 20510
(202) 224-4431

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John W. Warner, R-Va.
Daniel J. Evans, R-Wash.
Wendell H. Ford, D-Ky.

Subcommittee on Water and Power

212 Dirksen Senate Office Building
Washington, D.C. 20510
(202) 224-2366

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Mark O. Hatfield, R-Ore.
Daniel J. Evans, R-Wash.
Bill Bradley, D-N.J.

ENVIRONMENT AND PUBLIC WORKS
410 Dirksen Senate Office Building (202) 224-6176

Robert T. Stafford, R-Vt., Chairman

John H. Chafee, R-R.I.
Steven D. Symms, R-Idaho

Lloyd Bentsen, D-Texas

Subcommittee on Environmental Pollution

408 Hart Senate Office Building
Washington, D.C. 20510
(202) 224-6691

John H. Chafee, R-R.I., Chairman
Alan K. Simpson, R-Wyo.
Steven D. Symms, R-Idaho
George J. Mitchell, D-Maine

Subcommittee on Nuclear Regulation

415 Hart Senate Office Building
Washington, D.C. 20510
(202) 224-2991

Alan K. Simpson, R-Wyo., Chairman
Pete V. Domenici, R-N.M.
Steven D. Symms, R-Idaho
Gary Hart, D-Colo.

Subcommittee on Toxic Substances and Environmental Oversight

410 Dirksen Senate Office Bldg.
Washington, D.C. 20510
(202) 224-6031

Dave Durenberger, R-Minn., Chairman
Alan K. Simpson, R-Wyo.
Max Baucus, D-Mont.

Subcommittee on Transportation

415 Dirksen Senate Office Building
Washington, D.C. 20510
(202) 224-7863

Steven D. Symms, R-Idaho, Chairman
John H. Chafee, R-R.I.
Quentin N. Burdick, D-N.D.

STATE OF WASHINGTON
OFFICE OF THE GOVERNOR

OLYMPIA
98504-0413

BOOTH GARDNER
GOVERNOR

October 20, 1986

Mr. William N. Schlax
508 Buena Vista Drive
Santa Rosa, California 95404

Dear Mr. Schlax:

Thank you for sending Governor Gardner your paper on the basalt in the Hanford area. He forwarded it to me as his nuclear waste advisor and a member of the Nuclear Waste Board.

The Board consists of directors of various state health, resource, and energy agencies. I have distributed your paper to them and to the professional staff of the Board.

In addition we have a Nuclear Waste Advisory Council, which is conducting informational meetings on the referendum measure. I have forwarded your paper to its members also, for their use during these meetings.

I appreciate your sending your paper. I hope you will be able to continue contributing to the body of knowledge on Hanford's geology.

Sincerely,

Curtis Eschels

Curtis Eschels
Special Assistant for Policy

cc: Nuclear Waste Board
Nuclear Waste Advisory Council
Office of Nuclear Waste Management

2676

WILLIAM N. SCHLAX
GEOLOGIST
508 BUENA VISTA DRIVE
SANTA ROSA, CALIFORNIA 95404

October 9, 1986

Governor Booth Gardner
State Capitol
Olympia, WA 98504

Dear Governor Gardner:

On April 2, 1985, I sent you a copy of my testimony opposing the proposed nuclear waste repository at Hanford (given at Richland March 5, 1985).

Enclosed are copies of a Nuclear Regulatory Commission letter dated May 30, 1986, an Association of Engineering Geologists letter dated July 31, 1986, and my paper titled "Unsuitability of Hanford, Washington Site for a Nuclear Waste Repository". On October 7, 1986, I read this paper before the Annual Meeting of the Association of Engineering Geologists in San Francisco.

I hope you feel this paper merits the attention of the people of Washington before they vote on the issue of the repository in November. I request that you have this paper released to involved agencies of the State of Washington and to the media of the State.

Sincerely yours,

William N. Schlax

William N. Schlax
Engineering Geologist
CEG #28

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION V
1450 MARIA LANE, SUITE 210
WALNUT CREEK, CALIFORNIA 94596

May 30, 1986

MEMORANDUM FOR: Robert E. Browning, Director
Division of Waste Management

THROUGH: Ross A. Scarano, Director
Division of Radiation Safety and Safeguards

FROM: Dean M. Kunihiro
Regional State Liaison Officer

SUBJECT: CONCERNS REGARDING THE SUITABILITY OF HANFORD AS A HIGH-LEVEL WASTE REPOSITORY

On May 16, 1986, Mr. William Schlax visited the Region V office to express his concerns over the Department of Energy's (DOE) continuing high-level waste repository investigations of the Hanford site. According to Mr. Schlax, there are compelling technical bases to reject Hanford from further consideration. He noted that he has presented testimony to that effect at a public hearing on the DOE Draft Environmental Assessment in Richland, Washington on March 5, 1985 (Enclosure A), and sought assurances that the NRC be aware of and evaluate the issues set forth in his testimony. While briefly reviewing his technical rationale, he reiterated grave concern over the continued expenditure of "millions of dollars" studying a site which, according to him, has obviously little, if any, technical merit based on already known geologic information about the site.

One of his purposes in visiting the Regional office was to voice his concerns with appropriate NRC officials. I advised him that the NRC high-level waste program was managed by the Office of Nuclear Materials Safety and Safeguards, and assured him that his concerns would be forwarded to that office.

Also enclosed is an abstract from the paper entitled, "Unsuitability of Hanford, WA site for a nuclear waste repository," which Mr. Schlax has submitted for presentation at the annual meeting of the Association of Engineering Geologist.

Dean M. Kunihiro
Regional State Liaison Officer

Enclosures:
As stated

cc w/o enclosures:
W. N. Schlax

ASSOCIATION ENGINEERING GEOLOGISTS AEG

Association of Engineering Geologists

SAN FRANCISCO EVERYBODY'S FAVORITE CITY

1986

ANNUAL MEETING

July 31st, 1986

Mr. William Schlax
508 Buena Vista Dr.
Santa Rosa, CA
95404

Dear Mr. Schlax

The technical program committee is pleased to inform you that you have been accepted to present an abstract at the 1986 Annual Meeting. Your abstract is entitled:

Unsuitability of Hanford, Washington site for a nuclear waste repository

Your paper has been scheduled for the following session:

1a Tue/AM

We encourage you to write your paper for publication in the AEG Bulletin. We have enclosed guidelines for the short paper format.

Sincerely,

1986 AEG ANNUAL MEETING COMMITTEE

Rex

R. Rexford Upp
Program Chairman
(408) 984-1336

Enclosures: Annual Meeting Short Papers

Received Aug. 11, 86 [illegible]

Unsuitability of Hanford, Washington site
for a Nuclear Waste Repository

William N. Schlax, Engineering Geologist
508 Buena Vista Drive, Santa Rosa, CA 95404

This paper is based on the author's review of the Department of Energy's draft and final Environmental Assessments of the Hanford site, and on the author's knowledge of the region, acquired in part, as a co-author of the U. S. Geological Survey report on the Geology and Groundwater Resources of the Wenas Creek Valley (forty miles west of Hanford) which is referenced in the Environmental Assessments.

In the Pacific Northwest, the 260,000 square mile drainage basin of the Columbia River encompasses Idaho, parts of western Montana and Wyoming, large parts of Oregon and Washington, and the southeast part of British Columbia. In the central part of this drainage basin is the Columbia Lava Plateau where there are thick accumulations of Tertiary lava flows and related continental sedimentary strata. Major accumulations of usable groundwater occur in parts of these volcanic and sedimentary strata and are available for use from many prolific aquifers. There are other areas in the Columbia drainage basin where relatively impermeable pre-Tertiary rocks crop out which contain only minor accumulations of usable groundwater.

At Hanford, Washington, five miles from the Columbia River, it is proposed to construct a nuclear waste repository inside the flat lying Cohassett basalt lava flow which is one of many Tertiary lava flows underlying the area to a possible depth of 16,000 feet (DOE, 1984). The jointed and fractured Cohassett flow ranges in thickness from 240 to 266 feet and is at a depth of about 3000 feet below ground surface at the site. The water table is about 165 feet below ground surface (DOE, 1986). The groundwater below constitutes one of the largest bodies of usable groundwater in the Pacific Northwest.

The waste site would resemble a large underground mine with a horizontal tunnel complex extending over an area of about 2000 acres (1.2 X 2.7 miles). Construction would be done by blind drilling a vertical shaft with a rotary drill rig, using drilling mud, and then cementing a steel casing against the bedrock strata from the ground surface down through the Cohassett flow. Drilling mud would then be pumped out of the shaft and be replaced by air at atmospheric pressure of about 16 pounds per square inch. Tunnels would be extended horizontally from the shaft into the Cohassett flow by the usual mining methods of drilling and blasting. Such blasting would cause substantial additional fracturing of the hard, brittle basalt lava. Construction and operation of the site is expected to last 37 years followed by a 50 year period in which the nuclear waste must be recoverable.

Prolific groundwater aquifers above and below the jointed and fractured Cohassett flow contain enormous volumes of groundwater at a pressure of about 1,380 pounds per square inch (DOE, 1986) or 100 tons per square foot, as compared to the tunnels to be constructed, which must be kept filled with air at 16 pounds per square inch for 87 years, Should there ever be any abrupt, large inflow of groundwater anywhere in the site, in the 37 years of construction and operation, the entire complex might be quickly flooded and rendered useless, with probable loss of life of underground personnel.

To seal off expected large inflows of groundwater by grouting open, fractured basalt tunnels over a 2000 acre site, at a depth of 3000 feet, against water pressures of 1,380 pounds per square inch or 100 tons per square foot, is probably not possible or feasible. Certainly, it is highly undesirable when sites without such a problem can be found.

To pump out expected large inflows of groundwater would require shafts and pumping installations around the perimeter of the 2000 acre site with continuous pumping for 87 years. With the vertical lift of 3000 feet, the costs for equipment and power would be astronomical. Water, more mineralized than from shallower aquifers, would be discharged at the surface. Should any nuclear waste containers be breached, as by rock bursts or tunnel collapses, poisonous radioactive material might be pumped with the water and be discharged at the surface and into the Columbia River.

When continuous pumping ceased after 87 years, the nuclear waste material in the tunnel complex would be enclosed within and no longer isolated from the regional groundwater system. There would be almost certain contamination of the groundwater and eventually of the Columbia River.

Hazards to underground personnel would clearly exceed a reasonable risk because of : the jointed and fractured nature of the rock, additional fracturing from blasting, the potential for rock bursts and tunnel collapses, and the 1,380 pounds per square inch or 100 tons per square foot pressure of enormous volumes of groundwater surrounding the entire air filled tunnel complex.

In the drainage basin of the Columbia River, far less hazardous, difficult, and expensive sites could be found in areas of outcrop of relatively impermeable pre-Tertiary rocks which contain only minor accumulations of groundwater. Such sites could also be found in other parts of the United States. The Hanford site is unsuitable for a nuclear waste repository. Use of the site for such a purpose would be a major financial and ecological disaster for future generations.

REFERENCES

DOE (U. S. Department of Energy), December, 1984
Draft Environmental Assessment, Reference Repository Location, Hanford Site, Washington, DOE/RW-0017

DOE (U. S. Department of Energy), May 1986,
Environmental Assessment, Reference Repository Location, Hanford Site, Washington, DOE/RW-0070, 3 volumes

Justus

STATE OF WASHINGTON
OFFICE OF THE GOVERNOR

OLYMPIA
98504-0413

BOOTH GARDNER
GOVERNOR

October 20, 1986

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508 Buena Vista Drive
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Sincerely,

Curtis Eschels

Curtis Eschels
Special Assistant for Policy

cc: Nuclear Waste Board
Nuclear Waste Advisory Council
Office of Nuclear Waste Management

2676

WILLIAM N. SCHLAX
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508 BUENA VISTA DRIVE
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Sincerely yours,

William N. Schlax

William N. Schlax
Engineering Geologist
CEG #28

UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION V
1450 MARIA LANE, SUITE 210
WALNUT CREEK, CALIFORNIA 94596

May 30, 1986

MEMORANDUM FOR: Robert E. Browning, Director
Division of Waste Management

THROUGH: Ross A. Scarano, Director
Division of Radiation Safety and Safeguards

FROM: Dean M. Kunihiro
Regional State Liaison Officer

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On May 16, 1986, Mr. William Schlax visited the Region V office to express his concerns over the Department of Energy's (DOE) continuing high-level waste repository investigations of the Hanford site. According to Mr. Schlax, there are compelling technical bases to reject Hanford from further consideration. He noted that he has presented testimony to that effect at a public hearing on the DOE Draft Environmental Assessment in Richland, Washington on March 5, 1985 (Enclosure A), and sought assurances that the NRC be aware of and evaluate the issues set forth in his testimony. While briefly reviewing his technical rationale, he reiterated grave concern over the continued expenditure of "millions of dollars" studying a site which, according to him, has obviously little, if any, technical merit based on already known geologic information about the site.

One of his purposes in visiting the Regional office was to voice his concerns with appropriate NRC officials. I advised him that the NRC high-level waste program was managed by the Office of Nuclear Materials Safety and Safeguards, and assured him that his concerns would be forwarded to that office.

Also enclosed is an abstract from the paper entitled, "Unsuitability of Hanford, WA site for a nuclear waste repository," which Mr. Schlax has submitted for presentation at the annual meeting of the Association of Engineering Geologist.

Dean M. Kunihiro
Regional State Liaison Officer

Enclosures:
As stated

cc w/o enclosures:
W. N. Schlax

Association of Engineering Geologists

SAN FRANCISCO · EVERYBODY'S FAVORITE CITY

1986

ANNUAL MEETING

ANNUAL MEETING COMMITTEE

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July 31st, 1986

Mr. William Schlax
508 Buena Vista Dr.
Santa Rosa, CA
95404

Dear Mr. Schlax

The technical program committee is pleased to inform you that you have been accepted to present an abstract at the 1986 Annual Meeting. Your abstract is entitled:

Unsuitability of Hanford, Washington site for a nuclear waste repository

Your paper has been scheduled for the following session:

1a Tue/AM

We encourage you to write your paper for publication in the AEG Bulletin. We have enclosed guidelines for the short paper format.

Sincerely,

1986 AEG ANNUAL MEETING COMMITTEE

Rex

R. Rexford Upp
Program Chairman
(408) 984-1336

Enclosures: Annual Meeting Short Papers

Received Aug. 11, 86 MA

Unsuitability of Hanford, Washington site for a Nuclear Waste Repository

William N. Schlax, Engineering Geologist
508 Buena Vista Drive, Santa Rosa, CA 95404

This paper is based on the author's review of the Department of Energy's draft and final Environmental Assessments of the Hanford site, and on the author's knowledge of the region, acquired in part, as a co-author of the U. S. Geological Survey report on the Geology and Groundwater Resources of the Wenas Creek Valley (forty miles west of Hanford) which is referenced in the Environmental Assessments.

In the Pacific Northwest, the 260,000 square mile drainage basin of the Columbia River encompasses Idaho, parts of western Montana and Wyoming, large parts of Oregon and Washington, and the southeast part of British Columbia. In the central part of this drainage basin is the Columbia Lava Plateau where there are thick accumulations of Tertiary lava flows and related continental sedimentary strata. Major accumulations of usable groundwater occur in parts of these volcanic and sedimentary strata and are available for use from many prolific aquifers. There are other areas in the Columbia drainage basin where relatively impermeable pre-Tertiary rocks crop out which contain only minor accumulations of usable groundwater.

At Hanford, Washington, five miles from the Columbia River, it is proposed to construct a nuclear waste repository inside the flat lying Cohassett basalt lava flow which is one of many Tertiary lava flows underlying the area to a possible depth of 16,000 feet (DOE, 1984). The jointed and fractured Cohassett flow ranges in thickness from 240 to 266 feet and is at a depth of about 3000 feet below ground surface at the site. The water table is about 165 feet below ground surface (DOE, 1986). The groundwater below constitutes one of the largest bodies of usable groundwater in the Pacific Northwest.

The waste site would resemble a large underground mine with a horizontal tunnel complex extending over an area of about 2000 acres (1.2 X 2.7 miles). Construction would be done by blind drilling a vertical shaft with a rotary drill rig, using drilling mud, and then cementing a steel casing against the bedrock strata from the ground surface down through the Cohassett flow. Drilling mud would then be pumped out of the shaft and be replaced by air at atmospheric pressure of about 16 pounds per square inch. Tunnels would be extended horizontally from the shaft into the Cohassett flow by the usual mining methods of drilling and blasting. Such blasting would cause substantial additional fracturing of the hard, brittle basalt lava. Construction and operation of the site is expected to last 37 years followed by a 50 year period in which the nuclear waste must be recoverable.

Prolific groundwater aquifers above and below the jointed and fractured Cohassett flow contain enormous volumes of groundwater at a pressure of about 1,380 pounds per square inch (DOE, 1986) or 100 tons per square foot, as compared to the tunnels to be constructed, which must be kept filled with air at 16 pounds per square inch for 87 years, Should there ever be any abrupt, large inflow of groundwater anywhere in the site, in the 37 years of construction and operation, the entire complex might be quickly flooded and rendered useless, with probable loss of life of underground personnel.

To seal off expected large inflows of groundwater by grouting open, fractured basalt tunnels over a 2000 acre site, at a depth of 3000 feet, against water pressures of 1,380 pounds per square inch or 100 tons per square foot, is probably not possible or feasible. Certainly, it is highly undesirable when sites without such a problem can be found.

To pump out expected large inflows of groundwater would require shafts and pumping installations around the perimeter of the 2000 acre site with continuous pumping for 87 years. With the vertical lift of 3000 feet, the costs for equipment and power would be astronomical. Water, more mineralized than from shallower aquifers, would be discharged at the surface. Should any nuclear waste containers be breached, as by rock bursts or tunnel collapses, poisonous radioactive material might be pumped with the water and be discharged at the surface and into the Columbia River.

When continuous pumping ceased after 87 years, the nuclear waste material in the tunnel complex would be enclosed within and no longer isolated from the regional groundwater system. There would be almost certain contamination of the groundwater and eventually of the Columbia River.

Hazards to underground personnel would clearly exceed a reasonable risk because of : the jointed and fractured nature of the rock, additional fracturing from blasting, the potential for rock bursts and tunnel collapses, and the 1,380 pounds per square inch or 100 tons per square foot pressure of enormous volumes of groundwater surrounding the entire air filled tunnel complex.

In the drainage basin of the Columbia River, far less hazardous, difficult, and expensive sites could be found in areas of outcrop of relatively impermeable pre-Tertiary rocks which contain only minor accumulations of groundwater. Such sites could also be found in other parts of the United States. The Hanford site is unsuitable for a nuclear waste repository. Use of the site for such a purpose would be a major financial and ecological disaster for future generations.

REFERENCES

DOE (U. S. Department of Energy), December, 1984
Draft Environmental Assessment, Reference Repository Location, Hanford Site, Washington, DOE/RW-0017

DOE (U. S. Department of Energy), May 1986,
Environmental Assessment, Reference Repository Location, Hanford Site, Washington, DOE/RW-0070, 3 volumes

NUCLEAR WASTE BOARD AND NUCLEAR WASTE ADVISORY COUNCIL
REFERENDUM 40 INFORMATION MEETING
VANCOUVER, KENNEWICK, SEATTLE

SUMMARY OF ALL COMMENT FORMS

	POOR 1	2	3	4	EXCELLENT 5
1. How do you rate today's meeting?	8	1	5	7	7
2. The presentation of major issues was	9	4	2	4	9
3. Responses to audience questions were	10	2	3	6	7
4. How do you rate the information materials provided?	10	2	2	5	7
5. How do you rate the meeting facilities?	0	0	2	7	18
6. How well did this meeting help you understand the issues presented?	11	2	1	9	4

7. Where did you hear about this meeting?

Newspaper Article	12
Radio News	1
Television News	2
Public Service Announcement	3
Advertisement	2
Newsletter	4
Flyer	4
Friend	4
Other	8

NUCLEAR WASTE BOARD AND NUCLEAR WASTE ADVISORY COUNCIL
REFERENDUM 40 INFORMATION MEETING
Seattle
October 28, 1986

SUMMARY OF COMMENT FORM

	POOR 1	2	3	4	EXCELLENT 5
1. How do you rate today's meeting?	0	0	1	1	2
2. The presentation of major issues was	0	0	1	1	2
3. Responses to audience questions were	0	0	0	1	3
4. How do you rate the information materials provided?	0	0	0	0	3
5. How do you rate the meeting facilities?	0	0	0	0	4
6. How well did this meeting help you understand the issues presented?	1	0	0	1	2

7. Where did you hear about this meeting?

Newspaper Article	2
Radio News	0
Television News	0
Public Service Announcement	0
Advertisement	1
Newsletter	0
Flyer	0
Friend	0
Other	3

NUCLEAR WASTE BOARD AND NUCLEAR WASTE ADVISORY COUNCIL
REFERENDUM 40 INFORMATION MEETING
KENNEWICK
October 23, 1986

SUMMARY OF COMMENT FORM

	POOR 1	2	3	4	EXCELLENT 5
1. How do you rate today's meeting?	8	1	4	2	0
2. The presentation of major issues was	9	4	1	0	1
3. Responses to audience questions were	10	2	2	1	0
4. How do you rate the information materials provided?	10	2	1	2	0
5. How do you rate the meeting facilities?	0	0	1	4	10
6. How well did this meeting help you understand the issues presented?	10	2	1	2	0

7. Where did you hear about this meeting?

Newspaper Article	6
Radio News	1
Television News	2
Public Service Announcement	2
Advertisement	1
Newsletter	2
Flyer	4
Friend	3
Other	4

8. Please use the space below to comment on other issues and concerns you have regarding today's meeting.

*Our position as ordinary citizens is very disturbing! Why have consultants at tremendous defense to ignore their findings. More information is needed about transfer of wastes. More information is needed about storage before sealing. More time needed for questions and solutions.

*As a resident of the Tri-Cities for 3 years (1982-85), and now a resident in the Puget Sound area, I can really appreciate the great difference between the populations in these two areas in regards to "nuclear" issues. Tri-Citians, in my opinion, don't really see the "threat" from nuclear energy and nuclear waste since they and the area grew up with the "stuff". I experienced an "isolation attitude among people there, meaning we are here - you are over there, so why are you worried about the Hanford site and nuclear waste. This attitude by the Tri-City people won't be changed easily and thus there will be opposition to any ideas to change "there way of life".

8. Please use the space below to comment on other issues and concerns you have regarding today's meeting.

*Von Winterfeldt quote is only one view of DOE action. I am certain quotes portraying the DOE decision in a more favorable light were also available. Suggest you either "balance" viewpoints or delete the Winterfeldt quote.

Speakers were methodical to the point of boredom. Sounded like they were reading from prepared scripts which I can understand. But they need to work at avoiding a monotone.

In general presentation of issues were balanced and thorough and I sensed an honest attempt to be fair. Availability of materials was good. Lobby display was clear and helpful.

Use of Sebero and Valoria was good. Sebero did good job of moderating.

*The presentations were biased and do not provide the information required to make informed decisions. Why did you not comment on the statement in opposition to the referendum? The arguments against are equally as valid as the proponents statements (attitudes), perhaps more so!

*I rated the meeting high not because of any answers provided by the Nuclear Waste Board panel but because of the excellent issues (in the form of questions) raised by the audience. I attended this meeting hoping to be enlightened by the supposed "information" to be presented to the audience. Instead, I believe the "information meeting" presented slanted versions, solved incorrect data challenged by some in the audience, and a very weak panel.

*I would oppose continual state challenges to the federal selection process for a repository to store high-level nuclear waste. DOE's selection process is statutory. The states solution to this problem of what to dispose of the nations nuclear waste is flawed. The so-called findings delineatel in section 1 of House Bill 2130 are conclusions with little or no factual support. I object to the one sided views expressed at this meeting. I heard nothing to support a no vote on Referendum 40. Please send me a copy of the state's legal brief fined in support of its position.

*Too much valuable time wasted in beginning of meeting on various introductions - over ½ hour. A very biased and subjective presentation for Referendum 40! Cop-outs on answers! Incomplete numerical evidence - too little information that totally leads to a biases opinion!

*The presentation was all one sided. This is a railroad Referendum 40 information meeting all in favor of the Referendum 40 to support the Governor. Too much time wasted saying nothing, especially the introductions was a waste of time.

*The presentation took up too much time and wasn't very enlightening. More information came out during the question and answer period. I am more convinced than ever that all this is an exercise in futility!

*Highly biased in favor of Ref 40. No information about what DOE wants to do at Hanford (What is site Characterization?) No discussion of costs that Ref 40 (if passed) would inflict on Washington taxpayers.

*There is no correct way to vote on Ref 40.

*Meeting purports not to take a stand but panelists seemed to be negative. Major issues involved in repository selection were not addressed general level of knowledge regarding geology of the various sites and the physical process involved was not very high. Pro's and con's of Ref 40 were not really addressed. Panelists generally did not give direct answers.

*How can I believe the Board on other issues when this one was so biased? I should think that the state's Advisory Board should be objective and present all sides of an issue. I am ashamed that one gentleman, Bill Brewer, portrayed himself as an Engineer/Scientist. If scientific endeavors were done this way we would still be in the stone age.

*The panel said they were not going to tell us how to vote but give us information on Referendum Bill 40. The information they presented was completely one sided and the only message they gave was to vote for Referendum Bill 40. I don't like the idea of our state money being spent for such an unfair presentation.

*Good presentation by Max Power. Please send me copies of the Attorney General's briefs for all 5 suits filed by the State of Washington against the USDOE.

*Far too biased in favor of Ref. 40.

NUCLEAR WASTE BOARD AND NUCLEAR WASTE ADVISORY COUNCIL
REFERENDUM 40 INFORMATION MEETING
VANCOUVER
October 21, 1986

SUMMARY OF COMMENT FORM

	POOR 1	2	3	4	EXCELLENT 5
1. How do you rate today's meeting?	0	0	0	4	5
2. The presentation of major issues was	0	0	0	3	6
3. Responses to audience questions were	0	0	1	4	4
4. How do you rate the information materials provided?	0	0	1	3	4
5. How do you rate the meeting facilities?	0	0	1	3	4
6. How well did this meeting help you understand the issues presented?	0	0	0	6	2

7. Where did you hear about this meeting?

Newspaper Article	4
Radio News	0
Television News	0
Public Service Announcement	1
Advertisement	0
Newsletter	2
Flyer	0
Friend	1
Other	1

8. Please use the space below to comment on other issues and concerns you have regarding today's meeting.

*Thank you for providing this opportunity to learn substantial information about the potential impact of the Referendum. I think that these meetings are helping the local citizens to feel less depressed about this issue on the repository. For a while there, most people I spoke to about this issue felt it was hopeless to even try to stop the selection of Hanford. My deepest thanks to every person who aided in the organization of these meetings.

*We have needed meetings like this for a long time and need more such as this. Too bad they were not started sooner.

I learned very little I did not already know. This meeting has merit for someone just learning about Hanford.

*Do not like the "wording" in Ref. 40.

*Excellent opening overview. Questions become repetitious and dragged on to long. A good clue is when over half the people have left.

J. Sumner

CONGRESSIONAL COMMITTEES AND SUBCOMMITTEES INVOLVED IN NUCLEAR WASTE ISSUES

A Listing of Chairpersons, Ranking Majority and Minority Members, and Members from States of Washington, Oregon and Idaho

U.S. HOUSE

October 1986

Committees are listed below in alphabetical order. Subcommittees are listed alphabetically under each committee. Democrats (D) are the majority party; Republicans (R) are the minority party. Asterisks (*) indicate that chairmen and/or ranking minority members are also *ex officio* members of all subcommittees of which they are not regular members.

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(202) 226-2424

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CONGRESSIONAL COMMITTEES AND SUBCOMMITTEES INVOLVED IN NUCLEAR WASTE ISSUES

A Listing of Chairpersons, Ranking Majority and Minority Members, and Members from States of Washington, Oregon and Idaho

U.S. SENATE

October 1986

Committees are listed below in alphabetical order. Subcommittees are listed alphabetically under each committee. Republicans (R) are the majority party; Democrats (D) are the minority party. Asterisks (*) indicate that chairmen and/or ranking minority members are also *ex officio* members of all subcommittees of which they are not regular members.

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(202) 224-8172

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Subcommittee on Nuclear Regulation

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STATE OF NEVADA

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Executive Director

AGENCY FOR NUCLEAR PROJECTS
NUCLEAR WASTE PROJECT OFFICE

Capitol Complex
Carson City, Nevada 89710
(702) 885-3744

October 20, 1986

Dr. Raphael G. Kasper
National Research Council
CPSMR
2101 Constitution Avenue, N.W.,
Room NAS285
Washington, D.C. 20418

Dear Dr. Kasper:

On behalf of the representatives of the affected states and Indian tribes, I would like to express our appreciation for your recent presentation to us describing and discussing the role of the National Academy in the Department of Energy's high-level radioactive waste program. Your discussion of the relationship between the Academy and the Department of Energy was particularly informative.

As you heard from the state-tribal representatives, there is general consensus that the siting process by which the Department of Energy nominated and recommended candidate repository sites for characterization is flawed and illegal. We were quite interested to hear your description of the Academy's very limited role in reviewing the decision-aiding methodology used by the Department as a part of this decision-making process. As we explained to you, there are numerous examples of the Department of Energy's utilizing your limited review and its favorable conclusions to support the implication that the Academy has fully reviewed the entire decision-making process, found it sound and that the Academy completely agrees with and supports the Department's selection of the sites in Nevada, Texas and Washington.

Although you clearly stated to us that the Academy was given a very limited review role and you have not endorsed the actual selection of the aforementioned sites, we believe that the Academy should, in a very public way, announce the scope of your limited review of the methodology and the extent to which the Academy has endorsed the sites selected for characterization, and the method by which they were selected.

After having some discussion with the Department regarding the future role of the Academy in the Department of Energy's repository selection program, we were pleased and surprised to learn of your willingness to support the Academy's conducting its activities in an open and public forum, something that Department of Energy officials have told us you would be unable to accommodate and, in fact was not the case in recent Academy reviews of DOE decision-aiding documents. More surprising, however, was your statement that in another recent endeavor the Secretary of Energy has specifically required the Academy to conduct its review in a manner which includes full public participation, and the Academy has agreed to that requirement. It is interesting that the Department of Energy would not impose a similar requirement on the Academy in the radioactive waste program, even though the Nuclear Waste Policy Act specifically requires full public participation in the DOE program. The DOE has informed us that the procedures of the Academy's review are at the discretion of the Academy.

We were also pleased to learn that you support the state-tribal interest in working with the Department of Energy to develop the scope and extent of the Academy's future activities in the program under the Department's contract with you.

And in a related matter, I believe, consistent with your invitation, the state and tribal representatives likely will be suggesting individuals for consideration by the Academy for inclusion on the Board on Radioactive Waste Management panel or panels that will review the Department of Energy's program.

The state-tribal representatives have grave concerns regarding the way in which the Academy's participation has been used and perhaps exploited by the Department of Energy in the past, and we believe that any future review by the Academy must be approached in a very well defined and clearly stated manner. Full public access to the Academy's deliberations while they are in progress, in our opinion, is an absolute prerequisite for future activities by the Academy in this program. Additionally, the issues of reviewers' potential conflicts of interest, the scope and extent of the Academy's review, and actual role of the affected states and tribes, and public, in the review process are critical issues that must be resolved prior to the initiation of any activity by the Academy in the DOE high-level nuclear waste repository program.

I want to thank you again for your presentation and for your clarification of the position of the Academy on issues such as public participation.

Sincerely,

Robert R. Loux
Executive Director

RRL/gjb

cc: Mr. Ben Rusche
Mr. Grant Sawyer
Mr. Frank Press
Senator Paul Laxalt
Senator Chic Hecht
Representative Barbara Vucanovich
Representative Harry Reid
Representative Morris Udall
Senator Pete Domenici
Mr. Terry Husseman
Mr. Steve Frishman
Mr. Ron Halfmoon
Mr. Russell Jim
Mr. William Burke

J. Bunting

STATE OF ILLINOIS
DEPARTMENT OF NUCLEAR SAFETY
1035 OUTER PARK DRIVE
SPRINGFIELD 62704
(217) 546-8100

TERRY R. LASH
DIRECTOR

October 14, 1986

Mr. Ted Hunter
House Energy Committee Staff
AL-1
Olympia, Washington 98504

Dear Mr. Hunter:

In response to your call today, enclosed are the following materials about the Illinois Department of Nuclear Safety and its monitoring program for commercial nuclear power plants in Illinois:

1. "Remote Monitoring of Nuclear Power Reactors"
2. "Isotopic Effluent Monitoring for Nuclear Power Plants"
3. Fact Sheets: "The Illinois Plan for Radiological Accidents;" "Radiological Emergency Assessment Center;" "Reactor Parameter Data Link;" "The Radioactive Gaseous Effluent Monitoring System;" and "Environmental Radiation Monitoring System"
4. IDNS Annual Report
5. IDNS informational brochure
6. "Radioactive Gaseous Effluent Monitoring System" brochure.

If you have any questions or guidance for my presentation on November 18, please feel free to contact me.

Sincerely,

Terry R. Lash
Director

TRL:dk

bcc: Terry Husseman w/o enclosures

J. Bunting

DICK NELSON
Thirty Second District
133 N.W. 80th
Seattle, WA 98107
307 House Office Building
Olympia, WA 98504
RES. TEL. (206) 782-1239
LEG. TEL. (206) 786-7826
HOTLINE 1-800-562-6000

State of Washington House of Representatives

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Forty-Ninth Legislature
1985-86

Committees
Energy and Utilities, Chair
Higher Education
Natural Resources

October 14, 1986

Mr. Terry Lash
Illinois Department of Nuclear Safety
1035 Outer Park Drive
Springfield, Illinois 62704

Dear Mr. Lash:

The Energy Committee of the House, which I chair, has been actively involved in radioactive waste matters for the past three years. This involvement has intensified with the recent site designation of Hanford for the first (and perhaps only) high-level repository.

The Committee has been examining emergency response planning and environmental monitoring systems among other issues. We are interested in your experience and thoughts in these areas. Specifically, what considerations led to the establishment of your office? How does it relate to federal and other state agencies? How is it funded? What role has your state had in emergency response planning? Has this role, or your efforts, changed at all since the events at Chernobyl? What techniques and system does your agency use to conduct environmental monitoring?

I have called a special meeting of the Committee on November 18th in Seattle to address these (and other) emergency response and environmental monitoring issues. I am hoping you would be available to attend to assist us in addressing these matters. We will contact you shortly to determine your availability.

If you have any questions regarding this, please contact me at (206) 782-1239 or Ted Hunter of my staff at (206) 786-7114.

We look forward to working with you.

Sincerely,

Dick Nelson

Representative Dick Nelson, Chairman
House Energy & Utilities Committee

DN:cas

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J. Bunting

STATE OF WASHINGTON

OFFICE OF THE GOVERNOR

OLYMPIA

98504-0413

BOOTH GARDNER
GOVERNOR

September 18, 1986

John Herrington, Secretary
U.S. Department of Energy
1000 Independence Avenue
Washington, D.C. 20585

Dear Secretary Herrington:

I understand that USDOE recently requested the National Academy of Sciences to participate in an undefined capacity in the first-round repository site characterization process. I submit that before USDOE takes any steps toward site characterization it must [illegible] and begin to establish public confidence in the process by which it decides which sites it will characterize. As you know, in response to the USDOE and Presidential decisions of May 28th, I have urged a temporary halt and a restructuring of the site selection process. [illegible] we are [illegible] find a safe and acceptable means to permanently dispose of the nation's high-level nuclear waste, we must establish and follow a process which all affected parties are confident will result in a scientifically sound decision.

The attached letters from Professor von Winterfeldt to Mr. Rusche have heightened my serious doubts about the convoluted reasoning on which USDOE based its decision to recommend Hanford for further study even though it is the least safe and most costly of all the sites under consideration. In his letter dated July 22, 1986, Professor von Winterfeldt concludes:

> *"The logical implications of the judgments and estimates made by DOE experts and managers themselves as reported in the Methodology Report [illegible] the Hanford site and for choosing the [illegible] site [illegible] . . .*
>
> *"Unfortunately, it appears that DOE [illegible] and of its own experts' [illegible] and instead simply repeated the choice that was made one and a half years ago."*

Professor von Winterfeldt is known and respected as one of the nation's foremost experts on decision analysis. He has no stake in the outcome of the site selection process other than his professional concern that the crucial decisions in this complex and controversial process are defendable on a logical and scientific basis. He could have returned to his position at the University of Southern California and passively observed the process, but instead Professor von Winterfeldt voluntarily chose to communicate his serious concerns to USDOE and as a result involve himself directly in this national controversy. I commend him for his commitment to fulfill his professional and public responsibilities and, Mr. Secretary, I encourage USDOE to take appropriate actions to respond to his and to our concerns.

As I have done on several previous occasions, I once again ask that USDOE agree to submit its entire site selection process to a thorough, independent review by credible scientific experts. Such review must include examination of the basis upon which value judgments were made and examination of the implementation of the ranking methodology. I am convinced that if USDOE fails to respond positively to our concerns the site selection process is headed for total collapse.

Thank you for your consideration.

Sincerely,

Booth Gardner
Governor

cc: Frank Press, Ph.D.
Professor Detlof von Winterfeldt

Bell
apparently the person
is refining ceramics to
extract
uranium
to concentrate it. He may need a
license
etc.

James L. Acord, Sculptor-507 Third Avenue
#914,Seattle,Wa.98104-TELEX:292982SCLP UR

The universal language of art spans 250 centuries to unite us with our earliest ancestors. Our oldest artifacts are eloquent testimony to the human desire to create art, to use art to consciously record in permanent form the ideas most important to us. This strongly forged and common bond of art speaks vividly across time to us of our ancestors' hopes and dreams, aspirations and accomplishments. Our oldest art remains clear and vital today; its spirit is timeless.

From the old stone age, through the bronze and iron ages, until very recently, the art of sculpture contributed to innovation in manufacturing techniques and raw material applications. The technical requirements of sculpture, along with those of tool and weapon production were the foundation of metal alloying and casting processes and with them a host of other manufacturing advancements and discoveries without which our present industrial society would not exist. If modern sculpture seems to have lost its vitality, it is because this connection with the processes and materials of mundane production has been severed. Sculptors no longer work at the leading edge of technology enriching society's understanding of materials usage and application.

Today, society's most advanced manufacturing technology is monopolized by the defense industry and its handmaiden, the nuclear industry. I have chosen to incorporate the materials and processes of the nuclear industry into the sculptures I am currently producing for reasons that may be construed as highly traditional. I seek to recapture the art of sculpture's traditional place at the cutting-edge of technology and to record, in as permanent a form as that technology allows, symbols and metaphors of the issues of the age.

Nuclear waste, an issue of universal concern and, for all practical purposes, permanence, is arguably our greatest technological challenge. It is also itself a symbol and metaphor of the civilization that produces it. All manufacturing activity, from the making of spears to the building of cathedrals, produces waste. Nuclear waste is analogous to the stone chips produced since the neolithic age, with one difference: all nuclear waste is, in the broadest sense, weapons-production waste and none of it is, in any sense, art waste. Until now.

In bringing together sculpture and nuclear technology, I hope not only that this art will benefit from a return to the use of innovative materials and processes but also and more important that society will benefit, in ways now difficult to define or foresee, from the return of artists to the decision-making process of modern materials usage.