Sandia National Laboratories
Albuquerque, New Mexico 87185

May 15, 1988

Dr. Daniel Galson
Operations Branch
Division of High-Level Waste Management
Office of Nuclear Materials Safety
and Safeguards
U.S. Nuclear Regulatory Commission
Mail Stop 4D16
Washington, DC 20555

Dear Dr. Galson:

Enclosed is the April 1988 monthly report for FIN A1165. If you have any questions or comments, please feel free to contact me at (FTS) 844-5644, E. J. Bonano at (FTS)844-5303, or P. A. Davis at (FTS)846-5421.

Sincerely,

R. M. Cranwell for NRO

Nestor R. Ortiz, Acting Supervisor
Waste Management Systems
Division 6416

RMC:6416

Enclosure

Copy to:
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A1165

Ltr dtd 5/15/88 A-1165
To: Daniel Galson
Fm: Nestor R. Ortiz

PROGRAM: Licensing-Methodology Assistance FIN A1165 Task I

CONTRACTOR: Sandia National Laboratories BUDGET PERIOD: 10/87 - 9/88

NMSS PROGRAM MANAGER: D. Galson BUDGET AMOUNT: $248K

CONTRACT PROGRAM MANAGER: R. M. Cranwell FTS PHONE: 844-8368

PRINCIPAL INVESTIGATORS: E. J. Bonano FTS PHONE: 844-5303
P. A. Davis FTS PHONE: 846-5421

PROJECT OBJECTIVE

To assist in the overall development and integration of the licensing assessment methodology.

ACTIVITIES DURING APRIL 1988

Sandia staff and management participated in a program review held at SNLA on April 6-7. All deliverables under this FIN were discussed at this meeting. NRC was represented by B. J. Youngblood, S. Coplan, and D. Galson. Two of the letter reports in the original Statement of Work and Form 189 were eliminated because their contents would have been repetitions of sections of other reports to be prepared. Sandia requested a three-month extension across the board in the due dates for all reports (see monthly progress report for March 1988). The preparation of the SCP review guides under Task 5 required more than two and half months longer than originally anticipated at NRC's request. This request for an extension on the due dates will be discussed further at a follow-up program review to be held at NRC on May 24-25.

Subtask 1.1

I. Interim report: compilation of parameters and components of an overall licensing assessment methodology and development of a tracking scheme.

Sandia is waiting for NRC comments in this report.

II. Critical parameters and components for licensing assessment

Following response to the comments on the interim report above, this formal report will be a revised version of the former. Work continued in the compilation of a list of references of work conducted in the past that may be relevant to the evaluation and implementation of the technical components of the overall licensing assessment methodology. Attachement 1 is a preliminary list of the references obtained to

date. Sandia estimates that this report is about 75% complete. It is expected that this report will require approximately $10K to complete.

Subtask 1.2

I. Compilation, comparison, and evaluation of computer codes for licensing assessment

Work has continued in the compilation of computer codes available that could be useful for a licensing assessment methodology. Attachment 2 is a list of the codes that have been compiled to date. The information provided in this list for each code is by no means complete and is only being used by Sandia for fast cross-referencing of the codes. It is expected that from this point until the end of FY88 the actvities in this report will cost about $5K.

Subtask 1.3

I. Modeling efforts needed to support a HLW repository license application

At the April program review it was agreed between Sandia and NRC that this report is a repetition of Chapter 2 in both the interim and formal reports under subtask 1.1. Consequently, this report will not be prepared. NRC has sent Sandia written confirmation of this action.

II. Processes for which validated models will not exist at the time of a HLW repository license application.

No activity this month. The discussion on this report at the April program review led to the conclusion that the objective of this report was not clearly understood. It was agreed that it will be discussed further at the May meeting before proceeding with its preparation. Sandia estimates that completion of this report will require approximately $10K in FY88 funds.

III. Recommended approaches for evaluating the application of HLW disposal system models

No activity this month. This report is estimated to require $10K for completion.

IV. Review of the NRC's modeling strategy document for HLW performance assessment

No activity this month. Since this report is not due until FY89, Sandia has not estimated an approximate cost yet.

V. A technical basis for NRC review of HLW repository modeling programs

No activity this month. This report is not due until FY89, therefore, a cost estimate is not available at this time.

Subtask 1.4

I. Performance assessment program reviews

No activity this month.

Management Issues

The $5K correction needed on staff charges to this task was not reflected in the budget report for April. We are investigating the reason.

PROGRAM: Identification and Analysis of Uncertainties — FIN A1165 Task II

CONTRACTOR: Sandia National Laboratories — BUDGET PERIOD: 10/87 - 9/88

NMSS PROGRAM MANAGER: D. Galson — BUDGET AMOUNT: $495K

CONTRACT PROGRAM MANAGER: R. M. Cranwell — FTS PHONE: 844-8368

PRINCIPAL INVESTIGATORS: E. J. Bonano — FTS PHONE: 844-5303
P. A. Davis — FTS PHONE: 846-5421

PROJECT OBJECTIVE

To identify, analyze, and recommend generic methodologies for treating uncertainties associated with performance assessments of HLW repositories.

ACTIVITIES DURING APRIL 1988

Subtask 2.1

I. Recommended techniques for assessing compliance with the EPA's HLW repository containment requirement (40CFR191.13)

No activity this month. It is estimated that this report will require approximately $20K for completion.

Subtask 2.2

I. Identification, evaluation, quantification, and reduction of uncertainty in HLW repository performance assessments: a preliminary report.

Sandia is waiting for NRC written comments on this report. Completion of this report should require approximately $10K of FY88 funds.

Subtask 2.3

I. Elicitation and use of expert judgement in dealing with uncertainty in HLW repository performance assessments.

No activity this month. It was agreed at the April program review that this report will include the elicitation and use of expert opinion for addressing data and parameter uncertainty. Estimated cost for this report is $75K.

Subtask 2.4

I. Methods for analyzing uncertainty in HLW repository performance assessment models.

No activity this month. The estimated cost for this report is $62K.

II. Approaches to building confidence in HLW repository performance assessment models.

No activity this month. Estimated cost for this report is $30K.

Subtask 2.5

I. Methodology for scenario development and screening.

Some changes were made to this report. The major ones were: (1) deletion of all references to health effects and risk; (2) deletion of all references to features; and (3) final revisions to several figures in the report. These figures were sent to drafting. The GTP on Anticipated Events and Processes and Unanticipated Events and Processes was examined to insure that the report reflects the definitions and terminology in the GTP. It is anticipated that completion of this report will require about $20K.

Subtask 2.6

I. Recommended methodologies for the analysis of data and parameter uncertainty in HLW repository performance assessment.

Several documents were reviewed for this report. These documents include NUREG/CR-3904 by R. Iman and J. Helton on uncertainty and sensitivity analysis techniques and ORNL/TM-8339 by E. Oblow on the GRESS Software System. In addition several papers on the Fourier Amplitute Sensistivity Test (FAST) have been studied. Completion of this reprot will require about $65K.

II. The use of expert judgement to estimate data and parameter uncertainty.

This report has been deleted because this subject will be covered in the report under subtask 2.3. This was agreed by Sandia and NRC at the April program review and confirmed in writing by NRC.

III. Identification, analysis, quantification, and reduction of data and parameter uncertainty in HLW repository performance assessment.

No activity this month. Completion of this report has been estimate to cost $65K.

IV. Uncertainty and sensitivity analysis in ground-water flow modelling.

This is a new report proposed by Sandia in which a suite of uncertainty and sensitivity analysis techniques will be compared using data from the Avra Valley in southeastern Arizona. E. Bonano and P. Davis travelled to Tucson, AZ on April 11-12 and met with USGS staff who will be collaborating with Sandia in this work. The USGS will provide the data base for the analysis and will apply some of the

techniques. An outiline for this report will be presented at the May program review. Estimated cost for this report is $50K.

V. Recommended procedures for obtaining data and parameter uncertainty from site characterization data.

This report was inadvertently omitted from earlier versions of the Statement of Work (SOW) and Form 189. However, it is included in the latest SOW. Initially the report was due March 31, 1988, but because of the omission there has been no activity. Sandia will request that a new due date is negotiated at the May program review. An outline will be presented then. A preliminary estimated cost for this report is $20K.

PROGRAM: Probability Techniques — FIN A1165 Task III

CONTRACTOR: Sandia National Laboratories — BUDGET PERIOD: 10/87 - 9/88

NMSS PROGRAM MANAGER: D. Galson — BUDGET AMOUNT: $240K

CONTRACT PROGRAM MANAGER: R. M. Cranwell — FTS PHONE: 844-8368

PRINCIPAL INVESTIGATORS: E. J. Bonano — FTS PHONE: 844-5303
P. A. Davis — FTS PHONE: 846-5421

PROJECT OBJECTIVE

To identify techniques for assigning probabilities to geologic processes and events.

ACTIVITIES DURING APRIL 1988

Subtask 3.1

I. Techniques for estimating probabilities of events and processes affecting the performance of geologic repositories: a literature review.

Pursuant to a letter from NRC requesting that four chapters in the initial version of this report be removed, Sandia has proceeded to make the appropriate revisions. It is expected that these will be completed by the end of June. Completion of this report is expected to require less than $5K.

Subtask 3.2

I. Recommended techniques for estimating probabilities of events and processes affecting the performance of geologic repositories: assessing compliance with the EPA's containment requirements (40CFR191.13).

Sandia is currently in the process of assembling the team of staff and contractors that will be working in the preparation of this report. It is estimated that the cost of the report is about $150K.

Management Issues

In his response to the March monthly progress report, the NMSS PM expressed concern regarding charges to this task when no activity was reported. These were subcontractor charges incurred for work performed earlier. Typically subcontractor charges are reflected 30 to 60 days after the work has been performed. In the future Sandia will insure that these occurrences are explicitly noted in the budget reports.

PROGRAM:	Maintenance and Management of PA Codes		FIN A1165 Task IV
CONTRACTOR:	Sandia National Laboratories	BUDGET PERIOD:	10/87 - 9/88
NMSS PROGRAM MANAGER:	D. Galson	BUDGET AMOUNT:	$5K
CONTRACT PROGRAM MANAGER:	R. M. Cranwell	FTS PHONE:	844-8368
PRINCIPAL INVESTIGATORS:	E. J. Bonano P. A. Davis	FTS PHONE: FTS PJONE:	844-5303 846-5421

PROJECT OBJECTIVE

To provide for a program of computer code maintenance and configuration management for codes developed for the NRC's HLW performance assessment program.

ACTIVITIES DURING APRIL 1988

Subtask 4.5

No activity this month.

Management Issues

In the monthly progress report for March expenditures were reported in the amount of $7K. In NRC's response to that monthly report, the NMSS PM expressed a concern that it appears that work only for the amount of $5K was performed. Of the $7K spent, $5K were transferred from FIN A1158 for expenses incurred during February. The remainder $2K covered the attendance by C. Harlan and G. Wilkinson to the Waste Management 88 Conference as well as consulting on the SWIFT II code provided by P. Davis and C. Harlan (see March monthly progress report).

The NMSS PM has requested that a cost estimate be prepared for (1) the installation and quality assurance of the Dosimetry and Health Effects code, (2) the corrections of errors in SWIFT II, and (3) the generalization of the Code Coupler programs. Sandia had advised NRC that these activites could not be carried out due to reappropriation of funds from this task to Task 5. These estimates will be presented to NRC at the May program review.

PROGRAM: Technical Assistance for SCP Review — FIN A1165 Task V

CONTRACTOR: Sandia National Laboratories — BUDGET PERIOD: 10/87 - 9/88

NMSS PROGRAM MANAGER: D. Galson — BUDGET AMOUNT: $45K

CONTRACT PROGRAM MANAGER: R. M. Cranwell — FTS PHONE: 844-8368

PRINCIPAL INVESTIGATORS: E. J. Bonano — FTS PHONE: 844-5303
P. A. Davis — FTS PHONE: 846-5421

PROJECT OBJECTIVE

To develop internal staff guidance for review of the draft consultation SCP's and final SCP's in the area of performance assessment, to review selected parts of the draft and final SCP's, and to review NRC staff comments on selected parts of the draft and final SCP's.

ACTIVITIES DURING APRIL 1988

No activity this month.

PROGRAM: Short-Term Technical Assistance FIN A1165 Task VI

CONTRACTOR: Sandia National Laboratories BUDGET PERIOD: 10/87 - 9/88

NMSS PROGRAM MANAGER: D. Galson BUDGET AMOUNT: $64K

CONTRACT PROGRAM MANAGER: R. M. Cranwell FTS PHONE: 844-8368

PRINCIPAL INVESTIGATORS: E. J. Bonano FTS PHONE: 844-5303
P. A. Davis FTS PHONE: 846-5421

PROGRAM OBJECTIVE

To provide, on short notice, general technical assistance on HLW matters related to Tasks 1 through 5 that would not be provided in the normal course of the work in these tasks.

ACTIVITIES DURING APRIL 1988

No activity this month.

FIN A1165
Total for Case 1183.000
April 1988

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year-to-Date
I. Direct Manpower (man-months of charged effort)	4.3	21.0
II. Direct Loaded Labor Costs	38	209
Materials and Services	0	3
ADP Support (computer)	0	0
Subcontracts	2	133
Travel	1	14
G&A	4	37
Other (computer roundoff)	1	0
TOTAL COSTS	46*	396

III. Funding Status

Prior FY Carryover	FY 88 Projected Funding Level	FY 88 Funds Received to Date	FY 88 Funding Balance Needed
$267K	$1067K	$800K	None

*Includes $5K of staff-time charges that need to be corrected.

FIN A1165, Task I - Licensing Methodology Assistance
Subcase 1183.010
April 1988

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year-to-Date
I. Direct Manpower (man-months of charged effort)	3.6	14.4
II. Direct Loaded Labor Costs	31	131
Materials and Services	0	2
ADP Support (computer)	0	0
Subcontracts	2	54
Travel	0	4
G&A	3	20
Other (computer roundoff)	0	0
TOTAL COSTS	36*	211

III. Funding Status

Prior FY Carryover	FY 88 Projected Funding Level	FY 88 Funds Received to Date	FY 88 Funding Balance Needed
$68K	$248K	$180K	None

*Includes $5K of staff-time charges that need to be corrected.

FIN A1165, Task II - Identification and Analysis of Uncertainties
Subcase 1183.020
April 1988

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

		Current Month	Year-to-Date
I.	Direct Manpower (man-months of charged effort)	.5	2.8
II.	Direct Loaded Labor Costs	5	33
	Materials and Services	0	1
	ADP Support (computer)	0	0
	Subcontracts	0	19
	Travel	1	8
	G&A	1	6
	Other (computer roundoff)	0	1
	TOTAL COSTS	7	68

III. Funding Status

Prior FY Carryover	FY 88 Projected Funding Level	FY 88 Funds Received to Date	FY 88 Funding Balance Needed
$60K	$495K	$435K	None

FIN A1165, Task III - Probability Techniques
Subcase 1183.030
April 1988

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year-to-Date
I. Direct Manpower (man-months of charged effort)	.2	0.9
II. Direct Loaded Labor Costs	2	10
Materials and Services	0	0
ADP Support (computer)	0	0
Subcontracts	0	24
Travel	0	0
G&A	0	4
Other (computer roundoff)	1	0
TOTAL COSTS	3*	38

III. Funding Status

Prior FY Carryover	FY 88 Projected Funding Level	FY 88 Funds Received to Date	FY 88 Funding Balance Needed
$120K	$190K	$70K	None

* Administrative charges

FIN A1165, Task IV - Maintenance and Management of PA Codes
Subcase 1183.040
April 1988

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year-to-Date
I. Direct Manpower (man-months of charged effort)	.0	.3
II. Direct Loaded Labor Costs	0	2
Materials and Services	0	0
ADP Support (computer)	0	0
Subcontracts	0	5
Travel	0	0
G&A	0	0
Other (computer roundoff)	0	0
TOTAL COSTS	0	7

III. Funding Status

Prior FY Carryover	FY 88 Projected Funding Level	FY 88 Funds Received to Date	FY 88 Funding Balance Needed
None	$5K	$5K	None

FIN A1165, Task V - Technical Assistance for SCP Review
Subcase 1183.050
April 1988

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year -to- Date
I. Direct Manpower (man-months of charged effort)	0.0	3.6
II. Direct Loaded Labor Costs	0	33
Materials and Services	0	0
ADP Support (computer)	0	0
Subcontracts	0	30
Travel	0	2
G&A	0	8
Other (computer roundoff)	0	-1
TOTAL COSTS	0	72

III. Funding Status

Prior FY Carryover	FY 88 Projected Funding Level	FY 88 Funds Received to Date	FY 88 Funding Balance Needed
None	$90K	$90K	$None

FIN A1165, Task VI - Short Term Technical Assistance
Subcase 1183.060
April 1988

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC B SANDIA'S ACCOUNTING DEPARTMENT.

	Current Month	Year -to- Date
I. Direct Manpower (man-months of charged effort)	0.0	0.0
II. Direct Loaded Labor Costs	0	0
Materials and Services	0	0
ADP Support (computer)	0	0
Subcontracts	0	0
Travel	0	0
G&A	0	0
Other (computer roundoff)	0	0
TOTAL COSTS	0	0

III. Funding Status

Prior FY Carryover	FY 88 Projected Funding Level	FY 88 Funds Received to Date	FY 88 Funding Balance Needed
$19K	$39K	$20K	None

FIN A1165
Total for Case 1183.000
April 1988

THIS IS AN ESTIMATE ONLY AND MAY NOT MATCH THE INVOICES SENT TO NRC BY SANDIA'S ACCOUNTING DEPARTMENT.

		Current Month	Year-to-Date
I.	Direct Manpower (man-months of charged effort)	4.3	21.0
II.	Direct Loaded Labor Costs	38	209
	Materials and Services	0	3
	ADP Support (computer)	0	0
	Subcontracts	2	133
	Travel	1	14
	G&A	4	37
	Other (computer roundoff)	1	0
	TOTAL COSTS	46*	396

III. Funding Status

Prior FY Carryover	FY 88 Projected Funding Level	FY 88 Funds Received to Date	FY 88 Funding Balance Needed
$267K	$1067K	$800K	None

*Includes $5K of staff-time charges that need to be corrected.

Attachment #1

A1165 / 1183.000
Summary of References

1.0 NRC Rules (10CFR60.113)

10 CFR Part 60 (Code of Federal Regulations), 1986, Title 10, Energy, Part 60, Disposal of High-Level Radioactive Wastes in Geologic Repositories: U.S. Government Printing Office, Washington, D.C.

1.1 Waste Package Performance and Reliability

Abraham, T., Jain, H., Soo, P., 1986, Stress Corrosion Cracking Tests on High-Level-Waste Container Materials in Simulated Tuff Repository Environments: NUREG/CR-4619 (BNL-NUREG-51996), Brookhaven National Laboratory, Upton, NY.

Beavers, J. A., Thompson, N. G., Parkins, R. N., 1987, Stress-Corrosion Cracking of Low-Strength Carbon Steels in Candidate High-Level Waste Repository Environments: NUREG/CR-3861, (BMI-2147), Battelle's Columbus Division, Columbus, OH.

Burns, P.J., 1982, TACO2D: A Finite Element Heat Transfer Code: Lawrence Livermore National Lab, UCID-17980-Rev. 2, 119 p.

Claiborne, H. C., Croff, A. G., Griess, J. C., Smith, F. J., 1985, Repository Environmental Parameters Relevant to Assessing the Performance of High-Level Waste Packages: NUREG/CR-4134, (ORNL/TM-9522), Oak Ridge National Laboratory, Oak Ridge, TN.

Glass, R.S., 1981, Effects of Radiation on the Chemical Environment Surrounding Waste Canisters to Proposed Repository Sites and Possible Effects on the Corrosion Process: SAND81-1677, Sandia National Lab., 97 p.

Gopal, S., Ballinger, R., Cunnane, J., Kuhn, W., Lee, B., Moran, P., Westerman, R., 1987, Multifactor Test Design to Investigate Uniform Corrosion of Low-Carbon Steel in a Nuclear Waste Salt Repository Environment: BMI/ONWI-642, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

Interrante, C., Escalante, E., Fraker, A., Kaufman, M., Liggett, W., Shull, R., 1987, Evaluation and Compilation of DOE Waste Package Test Data: NUREG/CR-4735, Volume 1, U.S. Department of Commerce, National Bureau of Standards, Gaithersburg, MD.

Moak, D.P., Perrin, J.S., 1986, ERG Review of Waste Package Container Materials Selection and Corrosion: BMI/ONWI-611, Office of Nuclear Waste Isolation, Battelle Memorial Institute, Columbus, OH.

NRC, 1985, Generic Technical Position: Waste Package Reliability Analysis for High-Level Nuclear Waste Repositories: Engineering Branch,

Division of Waste Management.

Oversby, V. M., Wilson, C. N., 1985, Derivation of a Waste Package Source Term for NNWSI from the Results of Laboratory Experiments: UCRL-92096, Lawrence Livermore National Lab., CA.

Rockwell Hanford Operations, 1987, Site Characterization Plan Conceptual Design Report for BWIP High-Level Nuclear Waste Packages, SD-BWI-CDR-005, prepared by Gilbert/Commonwealth, Inc.

Russell, E. L., Jansen, G., Harper, W. V., 1988, Sensitivity Study of the Waste Package Near Field Subsystem: Waste Management '88, Roy Post, editor.

Sastre, C., Pescatore, C., Sullivan, T., 1986, Waste Package Reliability: NUREG/CR-4509, (BNL-NUREG-51953), Brookhaven National Laboratory, Upton, NY.

Stahl, D., Miller, N. E., 1986, Long-Term Performance of Materials Used for High-Level Waste Packaging: NUREG/CR-4379, (BMI-2128), Battelle's Columbus Division, Columbus, OH.

Stephens, K., Boesch, B., Crane, R., Johnson, R., Moler, R., Smith, S., Zaremba, L., 1986, Methodologies for Assessing Long-Term Performance of High-Level Radioactive Waste Packages: NUREG/CR-4477, (ATR-85(5810-01)1ND), The Aerospace Corporation, Washington, D.C.

Van Konyenburg, R.A., 1986, Radiation Chemical Effects in Experiments to Study the Reaction of Glass in an Environment of Gamma-Irradiated Air: Lawrence Livermore National Lab, UCRL-53719, 57 p.

Walton, J. C., Sagar, B., 1988, Mathematical Modeling of Copper Container Corrosion: The Transport Limited Approach: Waste Management '88, Roy Post, editor.

1.2 Engineered Barrier System (EBS)

Ellison, R.D., Shukla, D.K., and Kelsall, P.C., 1981, Design of Repository Sealing Systems-1981: The Technology of High-Level Nuclear Waste Disposal, Volume 1, U.S. Department of Energy, DOE/TIC-4621(vol. 2), pp. 207-227.

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

1.3 Ground-Water Travel Time

NRC, 1988a, DHLWM, Regulatory Guide on Groundwater Travel Time: U.S. Nuclear Regulatory Commission, Washington, D.C.

2.0 EPA Standards (40CFR191 and 10CFR60.112)

40 CFR Part 191 (Code of Federal Regulations), 1985, Title 40, Protection of Environment, Part 191, Environmental Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level, and Transuranic Radioactive Wastes: U.S. Government Printing Office, Washington, D.C.

2.1 Containment Requirements

2.1.1 Radionuclide and Contaminant Transport

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Bonano, E.J., Shipers, L.R., and Gutjahr, A.J., 1987, Stochastic Analysis of Contaminant Transport in Porous Media. Analysis of a Two-Member Radionuclide Chain: Water Resources Research, 23, pp. 1063-1078.

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Tang, D.H., Frind, E.O., and Sudicky, E.A., 1981, Contaminant Transport in Fractured Porous Media: Analytical Solution for a Single Fracture: Water Resources Research, 17(3), pp. 555-564.

van Genutchen, M.Th., and Wierenga, P.J., 1976, Mass Transfer Studies in Sorbing Porous Media, I. Analytical Solutions: Solid Science Society of

America Journal, 40, pp. 473-480.

2.1.2 Geochemistry

Apps, J.A., Carnahan, C.L., and others, 1983, Status of Geochemical Problems Relating to the Burial of High-Level Radioactive Waste, NUREG/CR-3062, LBL-15103, Lawrence Berkeley Laboratory, Berkeley, CA.

Bonano, E.J., and Beyeler, W.E., 1985, Transport and Capture of Colloidal Particles in Single Fractures: Scientific Basis for Waste Management, vol. 8, Jantzen, C.M., and others ed.: Materials Research Society, PN, pp. 385-394.

Bonano, E.J., Nuttall, H.E., and Siegel, M.D., 1984, Review of the Physical Phenomena and Population Balance for Radioactive Colloid Transport: SAND84-0540, Sandia National Laboratories, Albuquerque, NM.

Brookins, D.G., 1984, Geochemical Aspects of Radioactive Waste Disposal: Springer-Verlag, New York.

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Attachment #2

Computer Codes Currently Available for HLW Performance Assessment

I. Waste Package

A. Source Term

ORIGEN - radionuclide inventory

ORIGEN2 - initial waste inventory, heat generation rate, gamma photon spectrum (Russell, et. al.)

B. Transport

ANISEN-W - radionuclide transport

CHAINT - multicomponent radionuclide transport in fractured, porous rock

MAGNUM 2D - transient ground water flow/heat transfer in fractured, porous rock

MAKSIMA-CHEMIST - mass action kinetics

PORFLO - porous media flow

TRANSL - linear transport through packing

TRANSO - cylindrical transport through packing

C. Corrosion

BROOKHAVEN - canister corrosion

BWIP - canister corrosion

PANDORA - physical and chemical degradation of barriers, radionuclide flux

PC - statistical model of pitting corrosion

D. Geochemistry

EQ3/EQ6 - equil. models of aqueous geochemical systems

EQ3NR - calculates speciation and solubility of various solutes in aqueous solution

MINEQL/MICROQL - speciation

PHR81 - geochemical speciation and mass transfer

PHREEQE - chemical reactions

TRANQL - coupled chemical speciation and transport, equilibrium geochemical transport, uses MINEQL and ISOQUAD (transport)

E. Temperature and Thermomechanical / Thermochemical Response

ADINA - general structural and rock mechanics stress analysis

ADINAT - thermal analysis w/ ADINA

ARRAYF - 3D thermal conduction and radiation

BRINETEMP - transient repository temperature and thermally driven brine migration (Russell, et al)

HEATING5 - heat conduction

NIKE - static and dynamic response of 2D solids to deformation

SAGUARO COYOTE -

TACO2D - finite-element heat transfer code

TEMP - finite line heat transfer code

TEMP3D - develops response surface for WP temperature

history

F. Radiolysis

RADIOL - amounts of radiation-produced species in brine solution

MORSE-L - atomic displacements, attenuation and absorbed dose rate from gamma rays

G. Combined

BARIER - waste package containment time

TRANQL - see above

WAPPA - waste package degradation, leaching, radionuclide decay (Russell, et al)

WAPPAG - same as WAPPA, but also has capability to calculate the first derivative of any variable with respect to any other variable in the code.

II. EBS (see WP)

A. Transport

FEMTRAN - convective, dispersive, and diffusive transport of dissolved constituents in unsaturated porous media

NUTRAN - estimated peak, integrated and cumulative releases at points in engineered and geologic systems

B. Geochemistry

BALANCE - calculates mass transfer for geochemical reactions in ground water

EQ3/EQ6 - see above

EQ3NR - see above

MINEQL/MICROQL - see above

PHREEQE - see above

SOLMNEQ - equilibrium thermodynamic modeling

TRANQL - see above

WATEQ2 - makes prediction of sorption behavior

C. Temperature and Thermomechanical / Thermochemical Response

JAC2D - linear and nonlinear static stress analysis of 2D solids

SPECTROM31 - thermoplastic and plastic analyses of stresses, displacement, plasticity zones and failure zones

SPECTROM41 - see SPECTROM31

D. Combined

III. Geologic Media (Far Field)

A. Transport and Flow

i. Saturated Zone

DNET - simulates salt dissolution, models fluid flow, heat transfer in rock, brine transport, salt creep, dissolution, thermal expansion and subsidence.

GENMIX - GENNET with mixing cell source model

GENNET - NWFTDVM with generalized flow network

HDOC - two-phase nonlinear mass and heat transport in porous media; advection and diffusion with decay and retardation

NEFTRAN - GENMIX with matrix diffusion (fractured

media, leg transfer capability, and
multiple chain feature

NWFTDVM - 1D network, GW flow and radionuclide transport in porous media

SWIFT - 2D and 3D GW flow in porous media, heat transfer, brine transport, radionuclide transport

SWIFT II - SWIFT modified to include fractured media

TRUMP - diffusive-advective transport of sorbing radionuclides

UCBNE10.2 - radionuclide transport and discharge to accessible environment (Russell, et al)

USGS 3D - 3D GW flow, porous media

VSFAST - saturated and unsaturated water flow in porous media, radionuclide migration

ii. Unsaturated Zone

FECTRA - 2D, solute transport

FECWASTE - 2D, solute transport

FECWATER - 2D, liquid flow

FLUMP - 2D, liquid flow

MLTRAN - 2D, solute transport
heat transfer in porous, fractured media

NORIAH - 1D and 2D, liquid/gas flow, heat transfer

PETROS - 1D, liquid/gas flow, heat transfer

SAGUARO - 2D, liquid flow, heat transfer

SEGOL - 3D, liquid flow, solute transport

SHAFT 79 - 3D, liquid flow, water vapor, heat transfer

SUPERMOCK - 2D, liquid flow

TOUGH - 1D, 2D and 3D, water, vapor and air flow,

TRACR3D - 3D, liquid and air flow, solute transpor

TRANSTWO - 2D, liquid flow, solute transport

TRUST - 3D, liquid flow

UNFLOW - 2D, liquid flow

UNSAT2 - 2D, liquid flow

VERGE - 3D, liquid flow

VS2D - 2D, liquid flow

WAFE - 2D, liquid/gas flow

WHC - 3D, liquid flow, heat transfer, solute transport

B. Geochemistry

EQ3/EQ6 - see above

MINEQL/MICROQL - see above

PHREEQE - see above

TRANQL - see above

C. Temperature and Thermomechanical / Thermochemical Response

BOYLEM - stress, PC code

DNET - see above

HEFF - "

NTPLT - "

NTRAN - "

SANCHO, COYOTE, MERLIN, QMESH (family of codes)

STEALTH -

SWIFT -

SWIFT II -

THCYLB1 - "

THERST - stress due to cavity, PC code

VSRC3D - thermal composite, PC code

D. Combined

DNET - see above

SPARTAN - water flow and radionuclide transport through dual porosity media; Darcy's law and convective transport of sorbing radionuclides

SYVAC - total system model

TOSPAC - infiltration through unsaturated porous media, radionuclide decay and leaching, saturated and unsaturated flow and transport of decaying radionuclides in porous media

E. Geosphere

GARD - geosphere model

IV. Ground Water and Individual Protection

AIRODS-EPA - predictions of radionuclide concentrations in air; rates of deposition, intake rates, and doses

DACRIN - organ dose to man from acute or chronic inhalation of radioactive aerosols

DHE - converts curie intakes and external exposure levels to dose commitments

FOOD II - calculates dose to man

GWTT - probability distributions of ground-water travel times along distribution of flow paths; simplified Darcy's law in both matrix and fractures.

ISOQUOD - regional saturated hydrologic analysis of aquifer systems in multilayered media.

NEPTUN - calculates dose to man

PABLM - internal doses and dose commitments to man for acute or chronic ingestion of radionuclides

PATH1 - environmental movement and human uptake of radionuclides

V. Other

A. Data Sampling

AKRIP - kriging

LHS - generates either Latin Hypercube or random multivariate samples

B. Correlations/Estimations

STEPWISE - forward stepwise or backward elimination solution to multiple regression problems