See Pocket 13 for encl.

SEP 15 1986

101/KCC/9/12/86

WM Record File 101

WM Project 10
Docket No.
PDR ✓
LPDR ✓

Distribution:

(Return to WM, 623-SS)

MEMORANDUM FOR: Paul Hildenbrand
Repository Projects Branch

Robert F. Cook
Senior On-site Representative
NRC, Richland, WA

FROM: Kien C. Chang
Materials Engineering Section
Engineering Branch

SUBJECT: DRAFT, TRIP REPORT, APPRENDIX 7 SITE ASSIGNMENT

Enclosed is a draft trip report for the BWIP waste package. Appendix 7 - Site Assignment of August 5 through August 7, 1986. Please provide me your comments or suggested changes in writing by September 25, 1986.

ORIGINAL SIGNED BY

Kien C. Chang
Materials Engineering Section
Engineering Branch

Enclosure:
As stated

8612020027 860915
PDR WASTE
WM-10 PDR

OFC	:WMEG					
NAME	:KCChang:gh					
DATE	:09/15/86					

2164

SEP 15 1986

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DATE	:09/ /86	:	:	:	:	:	:

101

Encl. to memo to Hillenbrand & Cook from Chang - 9/15/86

TRIP REPORT/KCC/8/13/86

TRIP REPORT

Appendix 7 Site Assignment, BWIP Waste Package

A visit by an NRC/NRC contractor team to Richland was made during August 5 through 7, 1986. The team ~~is~~ was made up of three members: K. Chang and E. Wick of NRC and N. Pugh of NBS. A fourth member of the team, Anna C. Fraker of NBS visited Richland on August 14, 1986. The purpose of the visit is to review BWIP project records and draft documents on waste package materials testing and waste package design work.

The BWIP Office at Richland was notified about this visit by F. Cook, NRC's Senior On-Site Licensing Representative (OR) in two letters dated July 18, 1986 and July 28, 1986. The letters stated the purpose of the visit and included a list of suggested documents for review. These documents are:

1. "Waste Packages Preliminary Reliability Analysis Report," SD-BWI-TI-287.

2. "Progress Report on Hydro-Thermal Interaction of Defense Waste Glass with Basalt Groundwater at 150°C," SD-BWI-TI-312.

3. Update to "Barrier Materials Test Plan," SD-BWI-TP-022.

4. Test procedures used for corrosion tests (uniform and localized corrosion).

5. "Waste Package Materials Testing Science Plan."

6. "Performance Assessment Plan," SD-BWI-PAP-003.

7. "Waste Package Advanced Conceptual Design Report," SD-BWI-CDR-005.

On the morning of August 5, 1986, the NRC team and the OR had a discussion on the site assignment with Mr. Joe Kruper of DOE and Mr. Roger Gilchrist of Rockwell. DOE stated that of the documents requested by NRC for the review, items 1, 2, 4 and 7 would be available for NRC's review. Item 1 is preliminary and has not been released. Item 2 has a release date of January 13, 1986. Item 4 was being compiled by BWIP for the team's inspection by August 6, 1986. Item 7 has not been released. DOE may agree to let the team review Item 6 Although DOE indicated that Item 6 may be available for review ~~(in spite of the OR's continuing effort, this document~~ it was ~~never~~ not provided to the team for review during the visit).

Of the items not available for the team's review, Item 3 does not exist since there is no plan to update it and the document will be replaced by Item 5, "The Waste Package Materials Testing Science Plan." Item 5 however, is not ~~completed~~ available ~~and has~~ as it not yet been ~~agreed on~~ reviewed by DOE management.

On the morning of August 5, 1986, one copy each of Items 1, 2 and 7 were provided to the team for review with specific instruction that the team should not make duplicated copies of materials in Item 7. Materials in Items 1 and 2 could be copied.

On the morning of August 6, 1986, the following Item 4 documents were given to the team for review:

a. PNL Test Procedure for BWIP "MD-82-7, Slow-Strain-Rate Studies, Unirradiated," dated August 1, 1984.

b. HEDL-MG-184 Technical Procedures, "Data and Specimen Control for Crack Growth Studies," CGS-1-1, Rev. 1, dated July 18, 1986.

c. HEDL-MG-184 Technical Procedures "Static-Load Crack Growth Testing," CGS-2-1, Rev. 2, dated July 18, 1986.

d. HEDL-MG-184 Technical Procedures "Fatigue Crack Growth Testing," CGS-3-1, Rev. 2, dated July 18, 1986.

e. "Procedure for Operating Autoclaves in Support of BWIP Stress Corrosion Cracking Tests," MD-23-1, dated March 26, 1985.

f. "Gamma Irradiation Procedures for Pitting Kinetics Studies," Rockwell International, Procedure No. ESG-204, Rev. 2, dated January 23, 1986.

g. Procedures for Westinghouse Hanford Company (WHC) Testing in Support of BWIP: "Data and Sample Control for Container Materials Corrosion Studies," CMC-1-1, Rev. 0, dated June 26, 1984.

h. Procedures for WHC Testing in Support of BWIP: "Autoclave Operations and Testing," CMC-2-1, Rev. 0, dated June 25, 1984.

i. Procedures for WHC Testing in Support of BWIP: "Static Pressure Vessel Testing," CMC-3-1, Rev. 0, dated June 26, 1984.

j. Procedures for WHC Testing in Support of BWIP: "Air/Steam Corrosion Testing," CMC-4-1, Rev. 0, dated June 26, 1984.

k. Procedures for WHC Testing in Support of BWIP: "Preparation of Basalt and Packing Materials," CMC-5-1, Rev. 0, dated June 26, 1984.

l. Procedures for WHC Testing and Control of Groundwater," CMC-5-2, Rev. 0, dated June 13, 1984.

m. Procedures for WHC Testing in Support of BWIP: "Corrosion Specimen Preparation and Analysis," CMC-6-1, Rev. 0, dated June 25, 1984.

The team's comments on the visit and the documents provided are included in Enclosures 1 and 2.

Just 2 Sentences Dr. Pugh's Trip Rpt No Summary Rpt if attached

Throughout the period of this visit, Dr. Pugh attempted to meet the BWIP workers who perform corrosion experiments on container materials. The personnel he attempted to meet include S.G. Pitman, R.E. Westerman and G. McVay of PNL and L.A. James of Westinghouse Hanford Company. His first telephone conversations to set up meetings were typically greeted with welcome remarks. However, when Dr. Pugh called a second time to firm up meeting time and place, he was told that BWIP management did not want such contacts. Apparently, BWIP's order not to have contacts with NRC had been passed along after Dr. Pugh completed his first calls. Dr. Pugh did manage to meet and talk to some PNL and Westinghouse Hanford workers but was not allowed to see any test set-ups. (See the attached NBS Trip Report).

App 7?

In the morning of August 7, 1986, the team visited the low-level waste site at Hanford. The site is managed by U.S. Ecology for the State of Washington. The U.S. Ecology staff consists of a facility manager (Steve Carpenter), an assistant manager (John Deold), and 25 or so technicians, crane operators and workers. Mr. John Deold escorted us on a short inspection of the waste site. The site appears to be simple but neatly operated.

In the afternoon of August 7, 1986, Dr. Mick Apted of PNL briefed the team on the progress of the Performance Assessment Scientific Support Program (PASS). The PASS program is funded directly by DOE Headquarters to assess compliance of DOE's nuclear waste disposal with regulatory requirements on radionuclide release. Present emphasis on the program is on spent fuel as a waste form and on radionuclide release from the waste package. Both deterministic and probabilistic approaches are used with generic parametric input parameters (rather than repository specific). A copy of the viewgraphs of the briefing is included in this report as Enclosure 3. The first draft report of the PASS program will be ready for release in a few months.

Since the work being done in PASS is very similar to the work being done at Aerospace Corporation (FIN 4165) for NMSS, a copy of the draft Demonstration of Methodology for Waste Package Performance Assessment, dated July 1986, was given to Dr. Apted (one copy was also given to the O.R.).

An exit meeting was held in the afternoon of August 7, 1986. Enclosure 4 is a list of attendees. Comments on the documents reviewed were discussed in the meeting (see Enclosure 1).

It is the team's opinion that the amount of material provided for the team's review is very limited. The team's NRC members were not allowed to meet with BWIP's experimenters for any discussion or to inspect the experimental set-up to gain a better understanding of the tests performed. We consider that very little insight about BWIP's waste package program was gained from this Appendix 7 Assignment.

ENCLOSURE 1

Comments on "Progress Report on the Hydro-Thermal Interaction of Defense Waste Glass with Basalt and Groundwater at 150°C," BWI-TI-312, dated December 26, 1985

This report documents progress made in developing baseline data on glass behavior under hydro-thermal conditions. Specifically, experimental results are to be collected to investigate the radionuclide release characteristics of the waste form as a function of time, temperature, and waste package components. However, two of the components, i.e., container material and packing were not included in the experiments. The effects of these components must be accounted for, to project the realistic release characteristics of the waste form. We suggested that BWIP address this in future experiments and in updates of this report.

Not release Preliminary should not be included

ENCLOSURE 1

Comments on "Waste Package Preliminary Reliability Analysis,"
BWI-TI-287 Preliminary,
Unpublished Report, dated November 1985

1. This is a well organized report on waste package performance analysis. It is our opinion that the overall methodology used is consistent with NRC's General Technical Position on Waste Package Reliability Analysis, dated December 1985. We would like to have the opportunity to spend more time (than the two days here) to review the content of this report.

2. Potential localized corrosion (pitting, crevice corrosion, intergranular corrosion, stress corrosion cracking and hydrogen embrittlement) is dismissed with inadequate justification. The data quoted in this report (p. 126) to support the claim of no pitting, crevice corrosion, or intergranular corrosion is only short-term data for up to 5 months exposure. Appendix B (corrosion data base, p. 282) of the report states that the corrosion data collected "are not representative of the anticipated waste package environment," because these conditions include "no packing material, high groundwater flow rate, and oxic groundwater."

   Appendix B also states that recent short-term pit growth studies at Westinghouse Hanford Company (WHC) indicated "that pits developed under oxic conditions may not grow when the prepitted specimens are subsequently exposed to anoxic conditions." If, indeed, long-term results (beyond those presently accumulated by WHC) indicate the same trend and if the anoxic conditions (unspecified in the report) used are realistic repository conditions after closure, this could substantiate BWIP's claim

that no pitting corrosion would occur after the repository returns to anoxic conditions. It would then be necessary for BWIP to estimate the length of time after repository closure it takes (the repository) to return to the anoxic environment. NRC has not seen the WHC test results quoted. The comments by Dr. Neville Pugh on corrosion studies performed by BWIP would apply to this report also since these are the studies which generated the data used in this report.

3. The report stated that reprocessed HLW (West Valley High-Level Waste) will account for less than one percent of total repository inventory-thus, the analysis is limited to spent fuel waste form. NRC questioned the one percent figure if defense high-level waste is considered.

4. The report stated that low inventory and short half-life radionuclides plus those shown by analysis to be inconsequential were screened out. Thus, only 12 long-lived radionuclides were considered. NRC questioned why strontium -90 and cesium -137 were not included. Massive quantities of these radionuclides are present during the first few hundred years after permanent closure. These radionuclides, therefore, must be considered in analyzing releases that result from early containment failures.

5. The report pointed out in a later section that each container at the time of its failure was assumed to contain the full initial radionuclide inventory at the time of failure. The report stated that this approach yields conservative results for those radionuclides with short half-lives because no credit is taken for decay to small inventories prior to container failure. NRC commented that this statement conflicts with item 4, which said that short-lived radionuclides were screened out of the analysis.

6. The report states that the 18 cm annular gap between the waste package and the outer shell contains a 15.2 cm thick donut of packing. The analysis assumes that the packing will swell during resaturation to fill the entire gap.

   NRC questioned whether the packing would expand sufficiently to fill more than a 20 percent void volume. Dr. Salter replied that the project has data to support this design expansion.

7. The report estimates 99 percentile lifetimes in excess of 6000 years for spent fuel containers and 1700 years for containers of West Valley HLW. The maximum temperature of the spent fuel containers was estimated to be 250°C, whereas the temperature of the West Valley HLW container was estimated to be less than 100°C. The estimate was based on results of corrosion tests which showed lower corrosion rates at higher temperatures. The lower rates are attributed to a layer of iron-rich clay that forms on the container due to the presence of the bentonite component in the packing material.

   NRC noted that this estimate of higher rates of corrosion at much lower temperatures seemed unusual. One of the BWIP staff commented that one strategy under consideration is to place WVDP waste packages among spent fuel waste packages to achieve higher container temperatures and thus reduce the corrosion rate (by forming the iron-rich protective clay coating).

ENCLOSURE 2

Trip Report - E. N. Pugh

Visited Richland and Hanford site, WA, on August 5-7, 1986, with E. Wick and K. Chang, primarily to review progress in the Basalt Waste Isolation Project. Part of the time was spent reviewing documents in Bob Cook's (NRC Site Representative) office. In particular, eight documents describing the Basalt Operating Procedures used by Rockwell International Science Center in their corrosion studies were made available. These provided useful new information on an existing report by this group (SD-BWI-TS-014), but did not satisfy our earlier questions (Draft Waste Package Review Form by A. Fraker 2/86) concerning the technique used by Lumsden and his colleagues to determine the pitting potentials. I believe it is important to conduct cyclic polarization tests to confirm the Science Center conclusions that the pitting potential is far above the corrosion potential.

Considerable difficulty was experienced in meeting with BWIP investigators. I was able to meet with authors of two key reports, namely L. A. James, WHC (SD-BWI-TS-012) and S. G. Pitman, RHO (SD-BWI-TS-008). The meetings were conducted one-on-one in a conference room; I was not allowed to visit their laboratories and inspect their experimental facilities, nor was I given access to a number of more recent draft reports which are in the internal review process. Both scientists were extremely helpful and cooperative and, given the restrictions, the discussions were very informative.

The initial report on Short-Term Stress-Corrosion-Cracking Tests for A36 and A387-9 Steels in Simulated Hanford Groundwater described relatively short (~2000h) fracture mechanics tests in GR-4 solutions. James indicated that 20,000h tests have now been completed and that, again, no slow crack growth has been detected in either steel. Longer exposures will be examined, but James stated that absence of cracking in static tests, however long, is not considered to rule out cracking at longer time and, for this reason, a procedure involving cyclic stressing is being considered. He also indicated that the occurrence of any cracking would be considered to rule out a material. Of particular interest, he stated that the wrought steel A36 has been replaced by cast material of the same nominal composition, A27; and that the 9Cr-1Mo wrought steel (A387-9) has been eliminated as a candidate, possible because of cracking in the slow-strain-rate tests of Pitman (see below).

The cyclic stress method mentioned above was described. It should be noted immediately that it uses a range of frequencies, some quite high (>10 Hz), and is not intended to simulate container conditions. Rather it is a new procedure which uses cyclic stresses in an attempt to estimate K_{ISCC} for the static case. Essentially cyclic tests are conducted in GR-4 solution and in vacuum, and differences in crack growth rate are attributed to SCC. No specific mechanism for SCC is assumed; the stressing is considered to break films at the crack tip, exposing bare metal to the environment. While this method is very interesting, it is new and untested. An immediate question concerns the pumping action of cyclic stress which might cause the chemistry at the crack tip to be quite different from that in the static case. There is a clear need to publish the approach in the open literature without further delay to stimulate discussion and to establish its validity. For

example, it would be informative to apply the method to a system known to be susceptible to SCC, e.g., caustic cracking of low-carbon steels, where K_{ISCC} can be measured unambiguously (in static tests).

Several other points emerged from the discussion with James:

- All tests so far have been at open circuit in GR-4 under unirradiated conditions. Tests in a γ-flux are being undertaken but surprisingly, there are no plans to use applied potentials.

- Fracture mechanics tests are also being used on copper and its alloys. These tests, directed by Mills, are encountering problems due to load relaxation in the bolt loaded modified compact, MC(B), specimens, particularly in OFHC copper. No cracking has been observed so far. This suggests that perhaps tests of the MC(T) type should be conducted, i.e. under constant (rather than bolt) loading condition.

- The effectiveness of basalt as an oxygen getter was mentioned, due to the Fe^{2+}/Fe^{3+} redox reaction. However, as Wick and Chang pointed out later, this action may cease at long times as the surface becomes completely oxidized.

Pitman is primarily involved with slow-strain-rate (SRR) testing. He indicated that there has been essentially no further SSR tests of the BWIP steels since the informal report on "Slow-Strain-Rate Testing of 9% Cr, 1% Mo Wrought Steel and ASTM A27 Cast Steel in Hanford Grande Ronde Groundwater." This report indicated that the ductility was lower for both steels in tests in GR-4 compared to tests in air, establishing an environmental effect. The reduction was greater in the 9% Cr steel and was associated with branching intergranular cracks from pits. Shallow surface cracks were observed in the gauge length of A27 samples but, because the primary fracture surfaces were ductile, the occurrence of SCC was discounted in this steel. However, no explanation was given for the reduced ductility or for the surface cracks. Since A27 is a leading candidate material, it is surprising that these questions were not resolved, particularly since the effects of other environmental parameters, e.g., irradiation, temperature, and surface area to solution volume, were not investigated. During our discussions, Pitman suggested that the surface cracking may have been due to the rupture of a deposited surface film, formed in addition to magnetite, and that the ductility loss might have been associated with strain aging caused by absorbed hydrogen. It would seem that further testing is needed to clarify these important effects.

Pitman reported that he is currently conducting SSR tests on OFHC copper and Cu-10 Ni in GR-4 at 100 and 200 °C, using several strain rates (10^{-4}, 5×10^{-6}, $2 \times {}^{-7}$ s^{-1}). So far, tests have been at open circuit potentials with no irradiation; tests in γ fluxes are now being started. Results so far show Cu-10 Ni to be unaffected by the environment. A large loss in ductility was observed in tests on OFHC copper, particularly at the higher temperature and lowest strain rate. Failure was apparently intergranular but <u>not</u> environmentally induced, since it also occurred in air. I have observed similar failures in pure copper tested under constant load at temperatures in

the range 250-500 °C (Environment-Sensitive Mechanical Behavior, Gordon and Breach, 1966, p. 445), and also concluded that they are due to creep. Such failures have clear relevance to container service, and may well rule out the unalloyed metal as a viable candidate.

Appendix VII visit to Richland, Washington for BWIP

August 14, 1986 - Anna C. Fraker

This was a one day visit which followed an Appendix VII visit of others the previous week, Aug. 4 - 7, 1986. The day's activities are described as follows:

I arrived at the office of Bob Cook, the NRC representative for BWIP in Richland, Washington at 8:30 a.m. and was shown to a room with stacks of documents on a table. Bob Cook gave me the name and phone number of Lee James who works for Westinghouse on projects sponsored by DOE. I telephoned Lee James to see if it would be possible for me to visit his laboratory. He checked with his management and with DOE and arranged clearance for me to visit the laboratory in the afternoon.

****

Review of documents -- While Lee James was making arrangements for the laboratory visit, I reviewed the documents on the table. The information provided here is a list of the documents I received and reviewed. There were two large notebooks entitled (1) Barrier Materials Test Plan, March, 1984, Workshop and (2) Waste Package, SCP-CDR, SD-BWI-CDR-005, Draft. I decided that the workshop proceedings could be obtained and reviewed later. I was told that the Waste Package, SCP-CDR, SD-BWI-CDR-005 would be replaced and did not spend much time on this notebook.

I spent more time reviewing the following documents and test procedures. Overall, it would be useful if each test had a brief paragraph stating the relation of the test parameters to the problem or reaction studied. In cases where computer software is used, it would be useful to include the software as an appendix or to give a reference stating where the software could be obtained.

1. SD-BWI-TI-312, Progress Report on Hydrothermal Interaction of Defense Waste Glasses with Basalt and Groundwater at 150C, D. L. Lane, C. C. Allen, and R. R. Adee.

2. L2D2C Pitting Corrosion RSC-100, Rev. 3, 3/15/84

(a) Basalt Operating Procedure, Assembly of Electrodes to Autoclave.

(b) Basalt Operating Procedure for Sealing Autoclave Head, RSC 101, 4/8/85.

(c) Basalt Operating Procedure, Potentiodynamic Polarization Curves, RSC-102, 8/9/84.

(d) Basalt Operating Procedure, Corrosion Potential and Corrosion Rate Measurement, RSC-103, 3/13/84.

(e) Basalt Operating Procedure, Synthetic Groundwater Characterization, RSC-104, 6/20/84.

(f) Basalt Operating Procedure, Heat Treating Fe-9Cr-1Mo, RSC 105, 4/20/84.

(g) Basalt Operating Procedure, Pit Growth Kinetics, RSC- 106, 4/8/85.

(h) Electrochemical AC Impedance Measurement, RSC-107, 1/10/86.

(i) Basalt Operating Procedure, Locating and Sectioning Through-Wall Pits, RSC-108,

(j) Basalt Operating Procedure, Restarting a Corrosion Potential and Polarization Resistance Test After an Autoclave Malfunction, RSC-109, 1/2/86.

****

Other test procedures reviewed were:

HEDL-MG-184 Technical Procedure

1. CGS-1-1, Data and Specimen Control for Crack Growth Studies.

2. CGS-2-1, Static-Load Crack Growth Testing

3. CGS-3-1, Fatigue Crack Growth Testing

4. MD-23-1, Procedure for Operating Autoclaves in Support of BWIP SCC Tests.

****

and

1. Gamma Irradiation Procedure for Pitting Kinetics Studies, ESG-204, 1/23/86, uses RSC 103 and 102.

2. Procedure and Results of NBS Calibration of Radiochromic Film, Gamma Radiation Dosimeters, QA for gamma radiation exposure of devices and components for qualification to IEEE-323-1974.

****

and
PNL Test Procedure for BWIP, MD-82-7, Slow Strain Rate Studies, Unirradiated.

****

and
CMC-1-2, 6/24/84, Data and Sample Control for Container Materials Corrosion Studies - Describes system for tracing test materials and data.

CMC-2-1 Autoclave Operations and Testing

CMC-3-1 Static Pressure Vessel Testing

CMC-4-1 Air/Steam Corrosion Testing

CMC-5-1 Prep. of Basalt and Packing Materials

CMC-5-2 Prep. and Control of Ground Water

CMC-6-1 Cor. Specimen Prep. and Analysis

****

I telephoned Kien Chang to discuss the visit, copied approximately 150 pages of the last document on the table, SD-BWI-TI-287 and left this office.

****

Laboratory Visit

I met Lee James at 1:00 p.m., checked in with security and went to his laboratory. One of his colleagues from management joined us for the visit. This visit included a description of the work he is doing to evaluate the potential for stress corrosion cracking (SCC), fatigue and corrosion fatigue cracking (at frequencies ranging from 0.005 to 10 Hz) and crack propagation under static and cyclic conditions. Lee James pointed out that he had not been able to observe SCC and was obtaining crack growth and fatigue data for use in making predictions about the integrity of the material and for determining the static crack growth threshold, K_{ISCC}. He indicated that tests were conducted on steels, titanium alloys and copper and copper alloys. It appears that more work has been done on steels. Mr. James suggested that I obtain his report from the Waste Management Conference, Tuscan, AR, 1986 for a more complete description of his work.

Plans were in progress to put some long term SCC tests in autoclaves, and also to carry out tests under irradiated conditions. Equipment was ready for both types of tests. There are twenty five mechanical testing machines in this laboratory with provisions for various types of testing. A Hewlitt-Packard, 9825 computer is used for running and collecting data from some tests. A notebook of test procedures was available in the laboratory. Notebooks containing data were observed. Time did not permit a study and match-up of the laboratory data with the data given in reports.

Mr. James has one technician, and this technician was calibrating an instrument when we went through the laboratory. An additional technician would be useful since mechanical tests should be reproduced and various materials and test parameters need to be considered. Mr. James indicated that he had been active in the ASTM G-106 Committee on Slow Crack Growth, but was not too active at present. ASTM testing procedures are used in the laboratory. ASTM activity and interaction can be beneficial for all participants. There is one other professional person and technician working in this laboratory.

I appreciated the efforts of Lee James in arranging for the Laboratory visit. I thought he was highly competent and that the laboratory was well equipped. I would need to study some of the reports to comment more specifically on additional testing or materials to be studied.

Cracking can occur rapidly and unexpectedly. The limited data available and the observations of surface film cracks in the slow strain rate tests indicate that more work is needed to determine the potential for catastrophic cracking and to show the effects of varied environment such as a lower pH, ions present and alternate wetting and drying conditions.
I met with Bob Cook in the evening and discussed the day's visit.

****

Earlier in the week, I visited the laboratories of S. G. Pitman to observe other work he is doing in addition to the work for BWIP. I did see some slow strain rate equipment which was used for BWIP tests.

Performance Assessment of Spent Fuel As a Waste Form in a Geologic Repository

Mick Apted
Al Liebetrau
Task Leaders

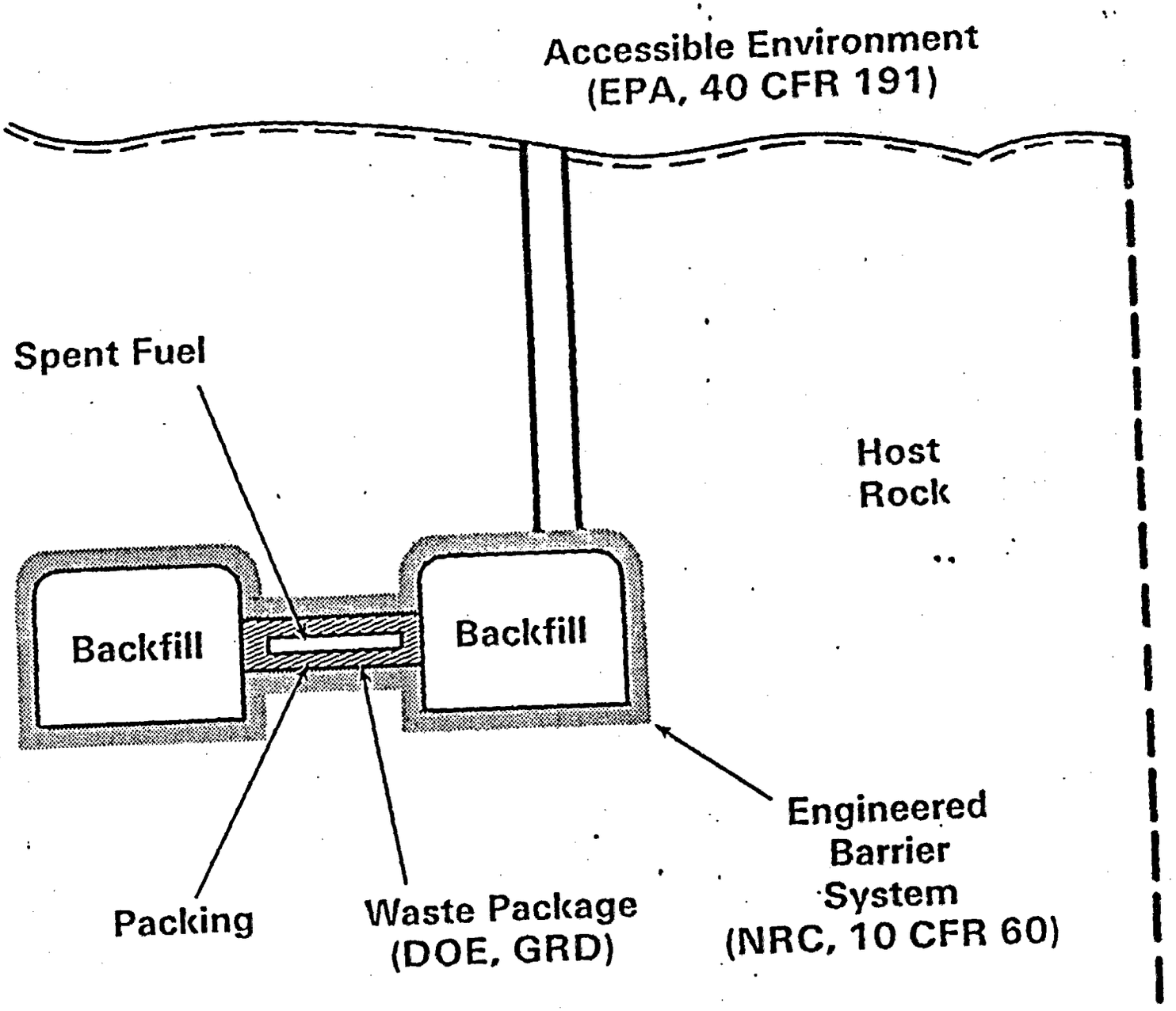
Marty Altenhofen, Dave Engel, Bob Erickson
Ken Johnson, Carl Reid, Denis Strachan,
Rick Williford

ENCLOSURE 3

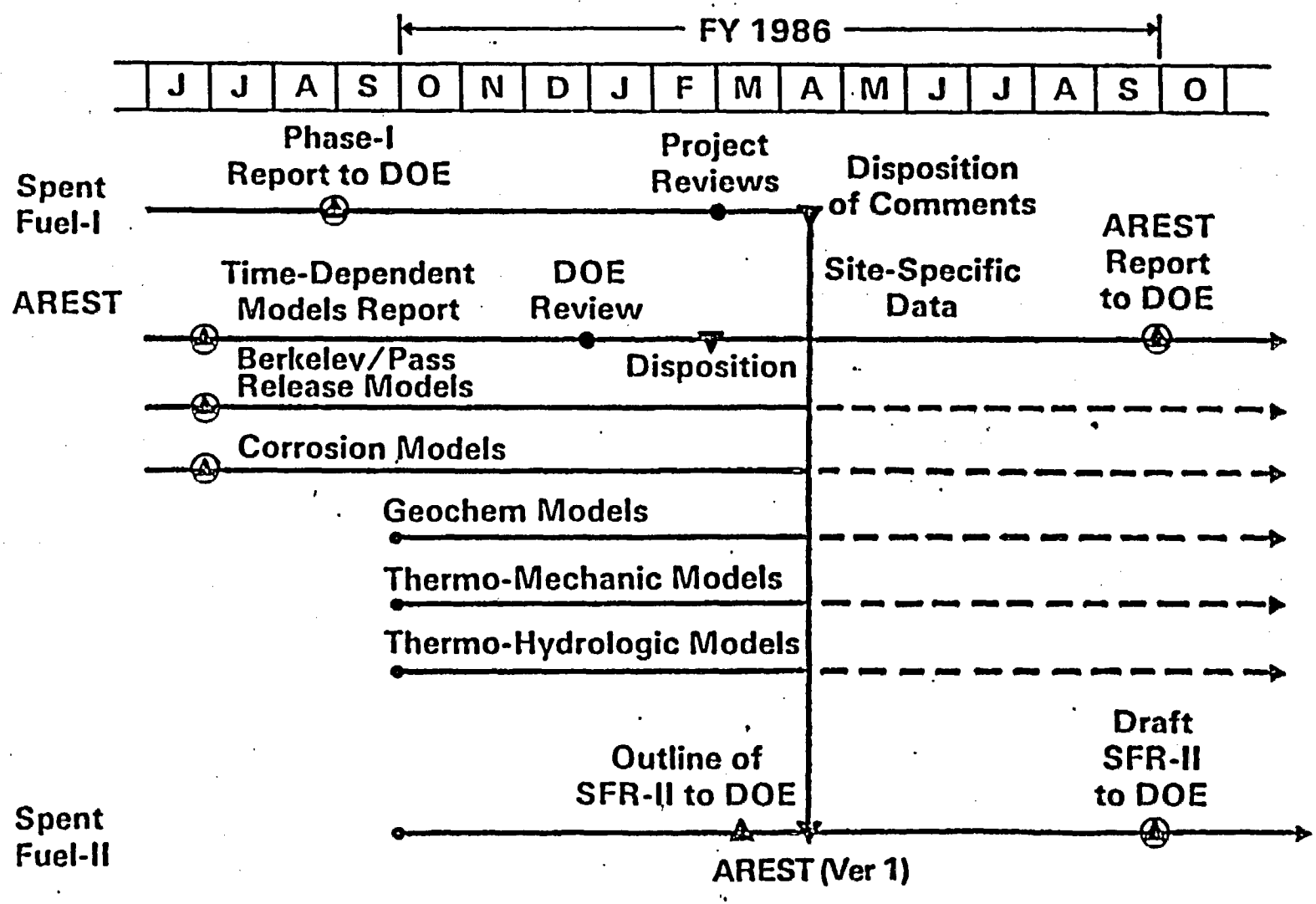
Objective

Assess compliance of spent nuclear fuel with regulatory requirements on acceptably low, controlled release of radionuclides.

Radionuclide Release Boundaries (not to scale)



Spent Fuel Report Schedule



FY1986 Budget for Spent Fuel Report

AREST (Process Models)	$100K
AREST (Probablistic Models)	95K
AREST (Other)	37K
Spent Fuel Report	90K
	$322K

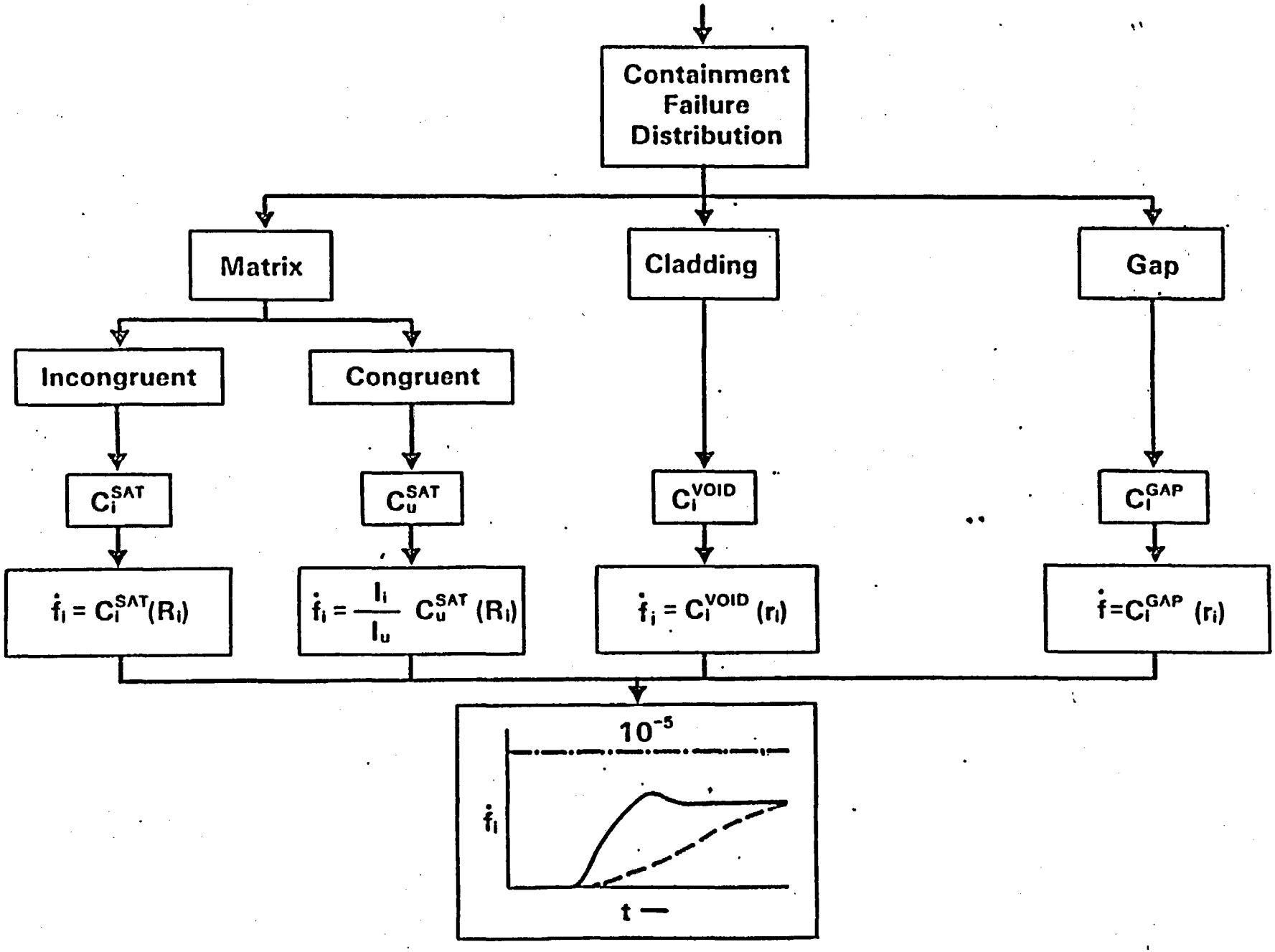
$$\frac{\text{Spent Fuel FY1986}}{\text{Pass FY1986}} = \frac{\$322K}{\$2900K} = 11\%$$

$322K ≈ 2.5 Man-Years

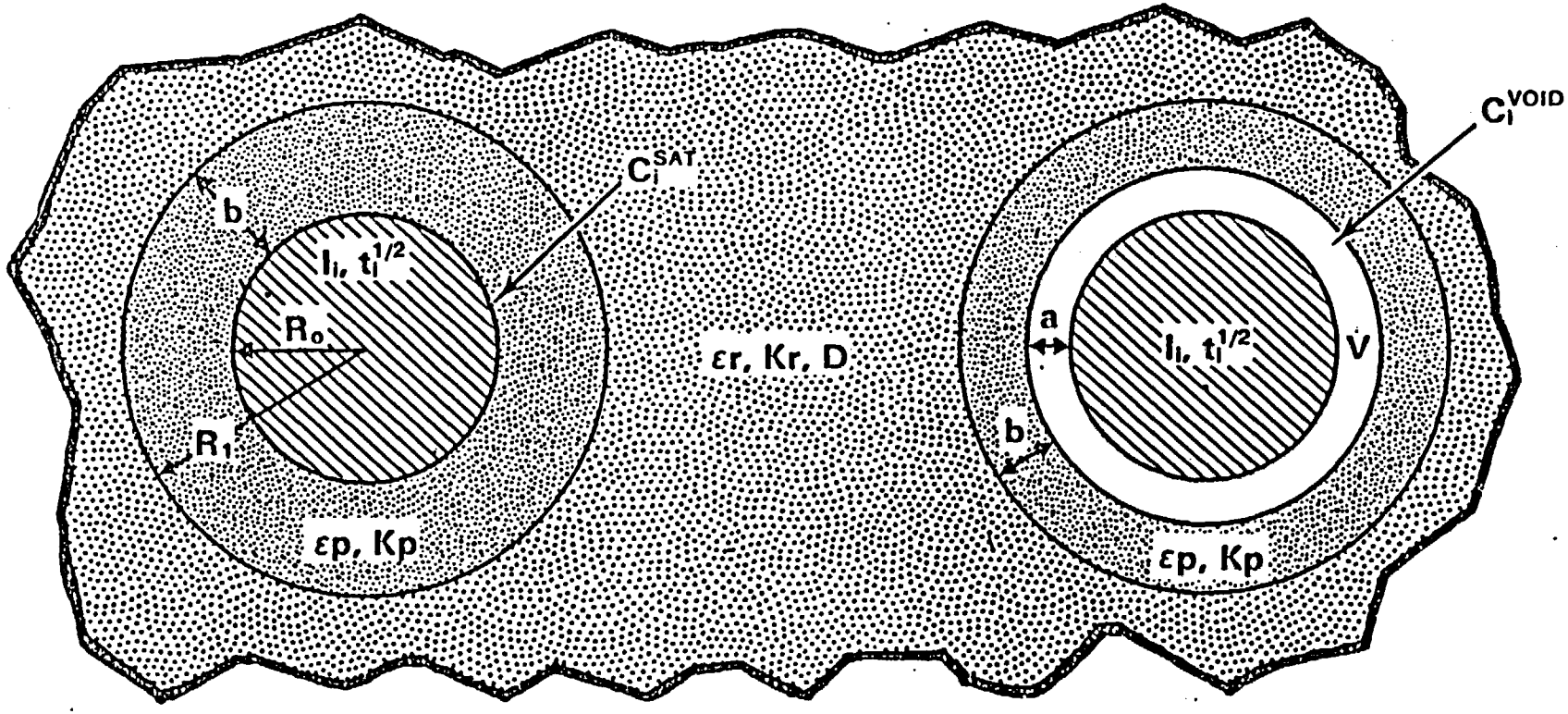
Approach

- Use AREST/WPR module
- Analytical mass transfer models (Pigford/Berkeley)
- EA source
  - WP design
  - Site-specific data
- Spent fuel characterization
- Containment failure distribution
  - AREST/WPC module
  - Probabilistic models

Structure of Waste Package Release Module



Parameters for WP Release Module



Matrix Release

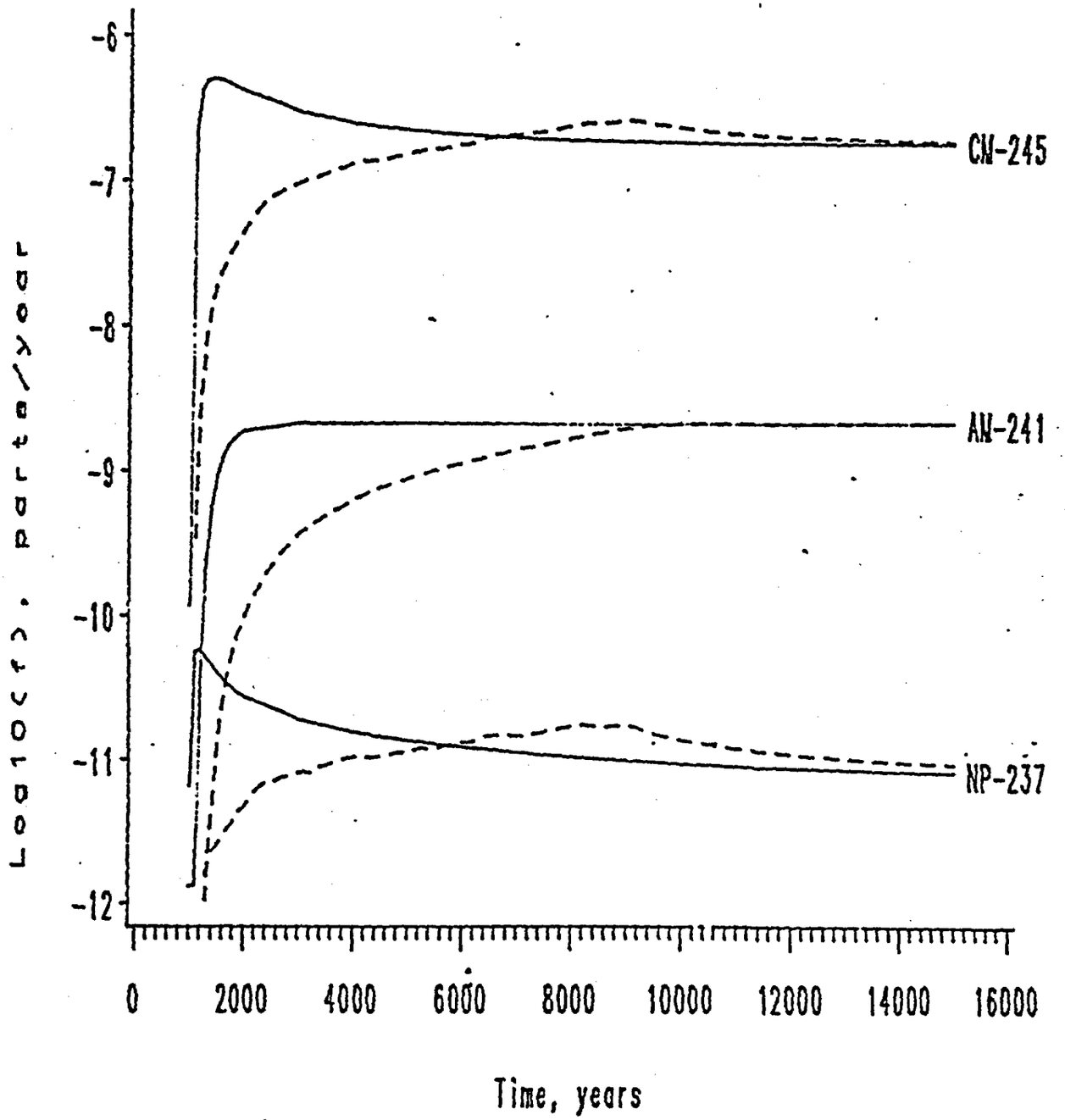
Gap Release

Matrix for Spent Fuel Release Scenarios

	Symmetric			Asymmetric		
	Instantaneous	Uniform	Normal	Weibull	Other	WPC/AREST
Basalt (Anticipated)	●		●			
Basalt (Conservative)	●		●			
Salt (Anticipated)	●		●			
Salt (Conservative)	●		●			
Tuff (Anticipated)	●		●			
Tuff (Conservative)	●		●			

Matrix Release/Individual Solubilities

Fractional Release Rate (f) -vs- Time

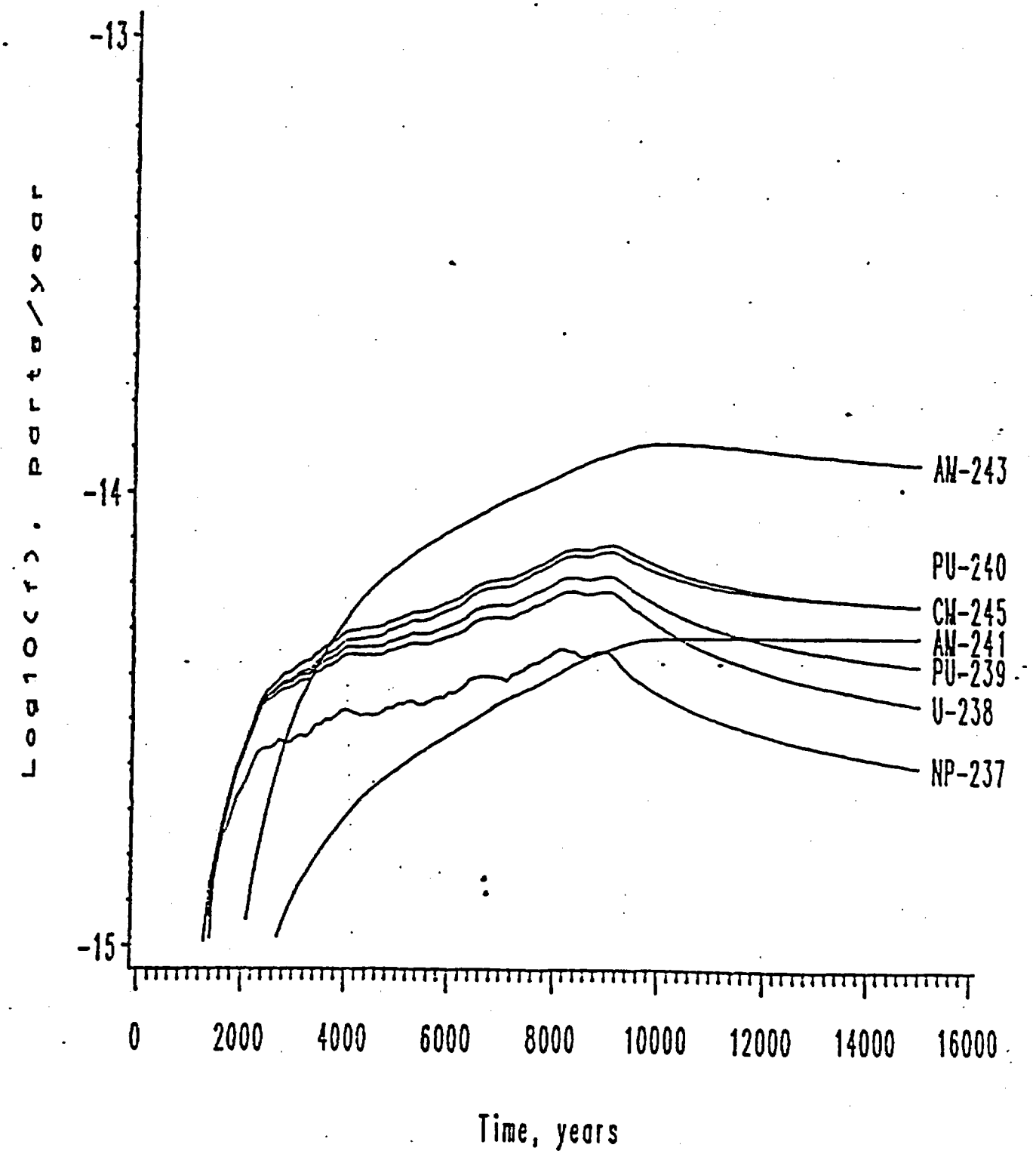


Solid Line —> Container Failure = 1000 years
Dotted Line —> Container Failure = U(1000, 9000) years

Matrix Release/UO2 Solubilities

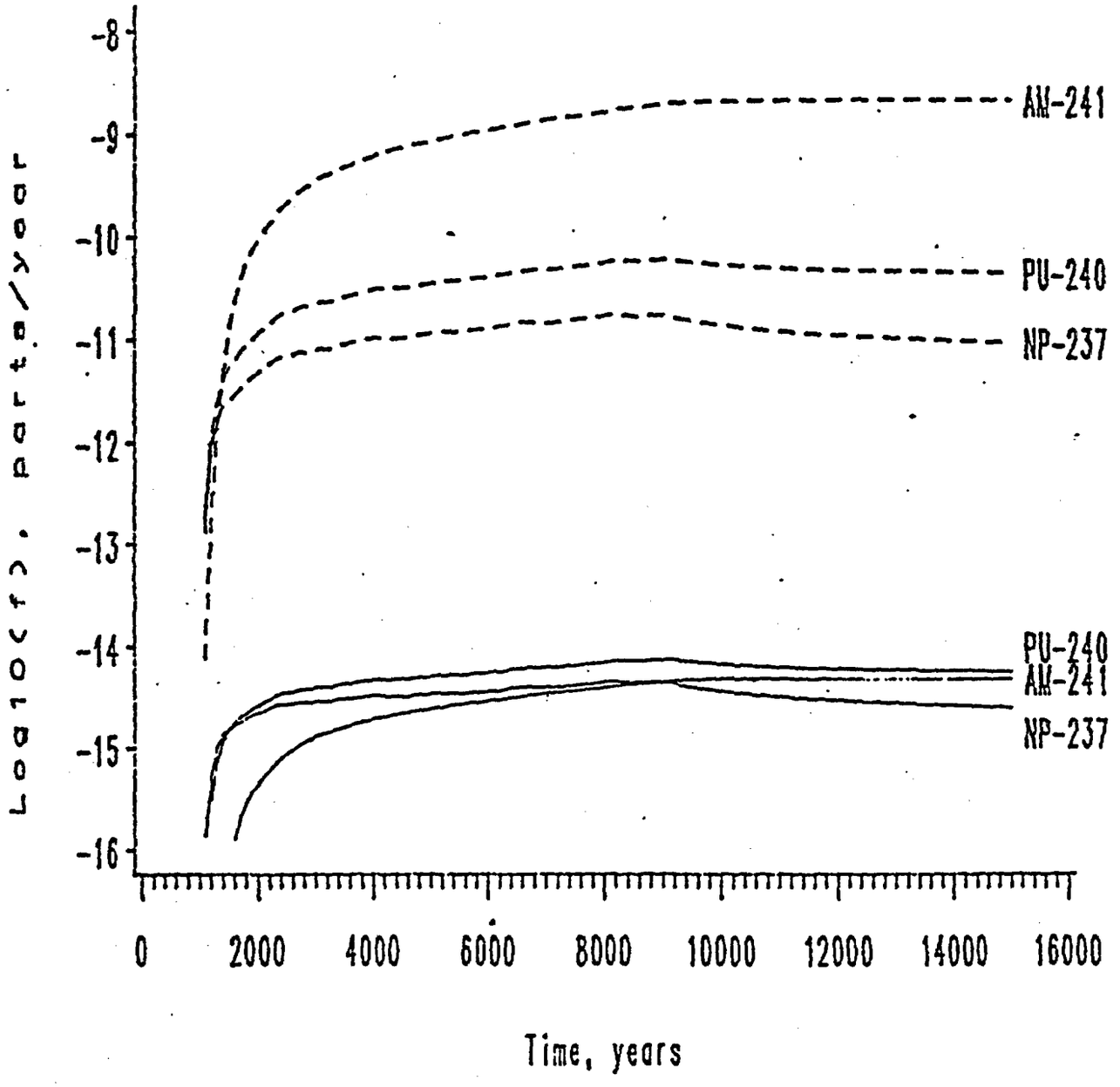
Container Failure = U(1000, 9000) years

Fractional Release Rate (f) -vs- Time



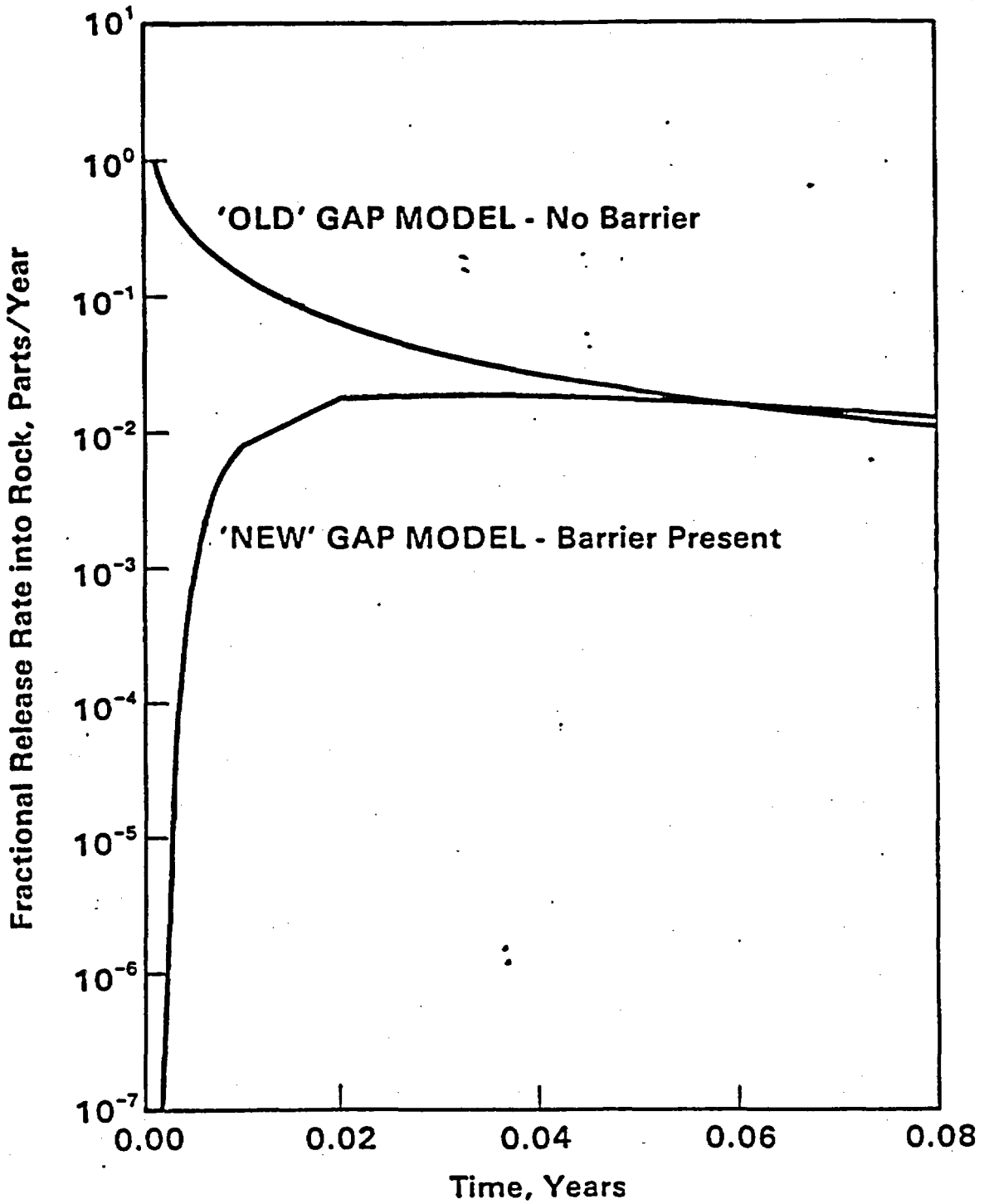
Matrix Release

Fractional Release Rate (f) -vs- Time
Container Failure = U(1000, 9000) years

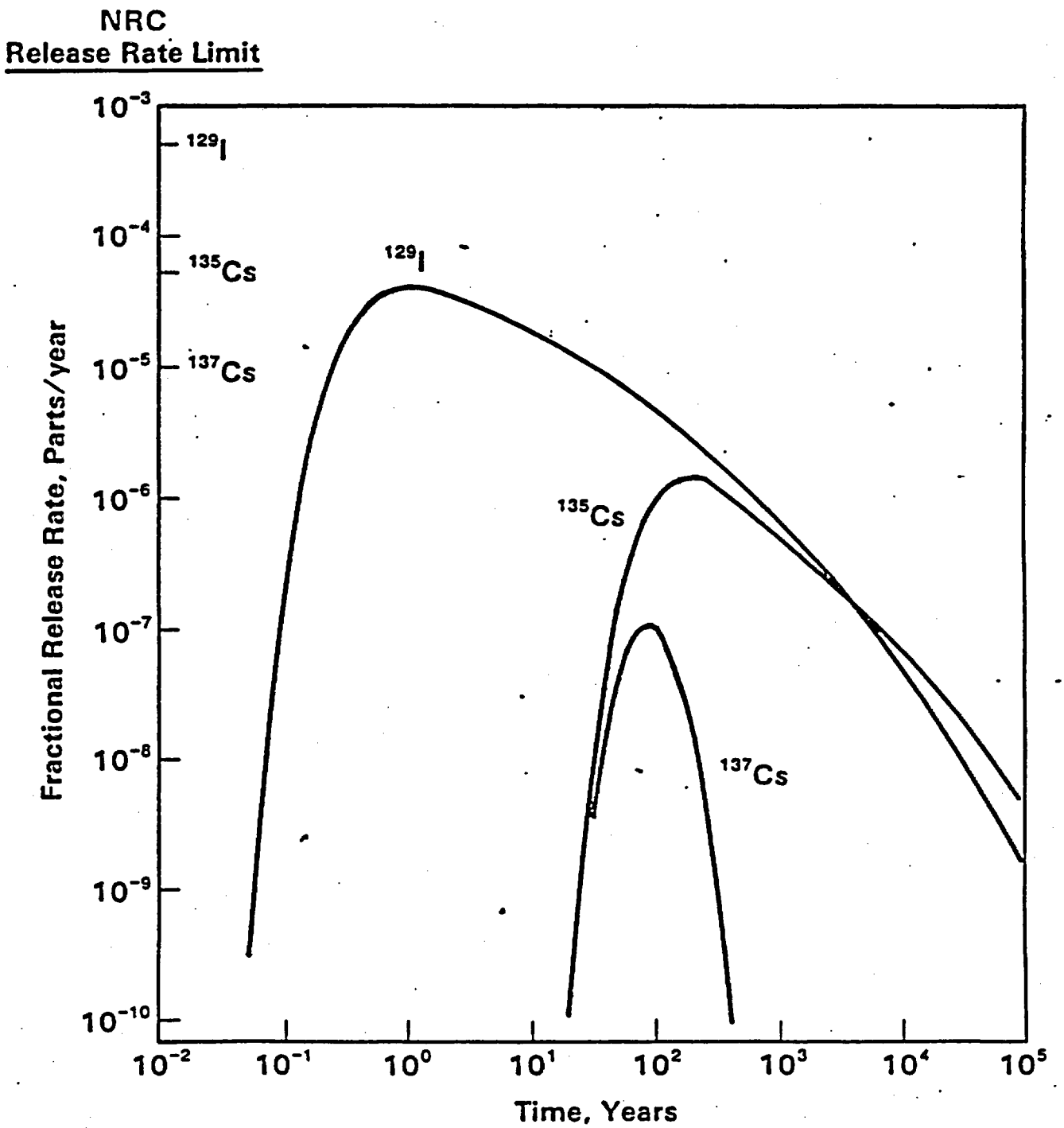


Solid Line —> UO2 Solubility
Dotted Line —> Individual Solubility

Comparison of Gap Release Rate Models for ^{135}Cs



Fractional Release Rate verses Time for Gap Model



Summary of Accomplishments

Activity	Percent Complete
• Coding of AREST	
- Matrix model	100%
- Gap and cladding model	100%
- WPC module	80%
• Waste Package Designs (EA)	100%
• Repository Data	100%
• Spent Fuel Characterization	100%
• Thermal Model	100%
• Geochem Model	100%
• AREST Report	80%
• Spent Fuel Assessment Report	25%

Factors in Spent Fuel Assessment

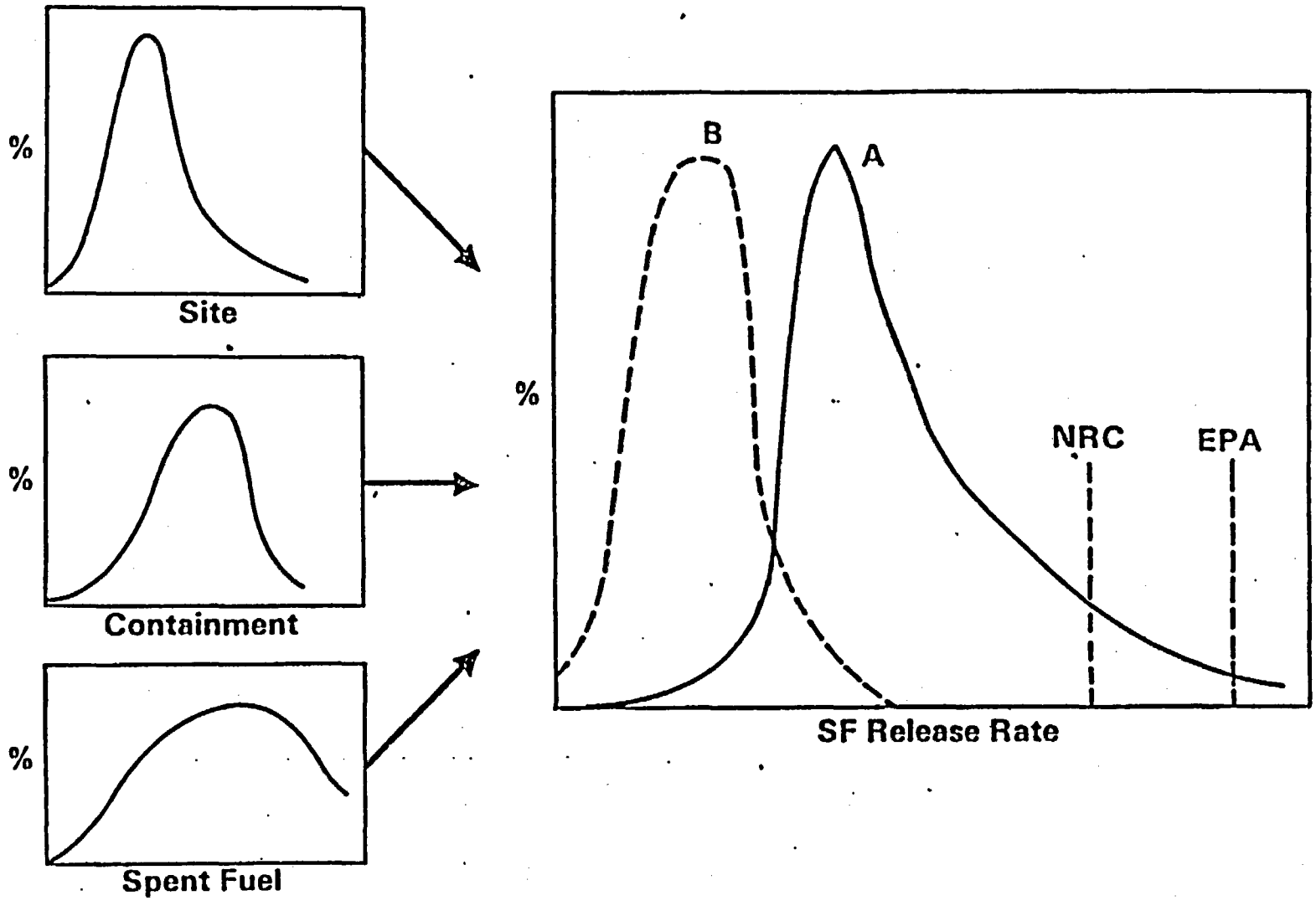
Release Depends on:

- Waste package design
- Waste package materials
- Interpretation of NRC, EPA
- Spent fuel characteristics
- Site characterization
- Solubility data
- Long-term corrosion models
- Monitored retrievable storage

Conclusion:

A "yes" or "no" assessment of spent fuel adequacy will be conditional on available database and programmatic decisions. DOE should expect probabilistic reasonable assurance of spent fuel performance.

Probabilistic Basis for Reasonable Assurance of Spent Fuel Adequacy



Preliminary Conclusions

- If UO_2 matrix dissolution is incongruent, release rates are close to NRC limits
- If UO_2 matrix dissolution is congruent, release rates are far below NRC limits (early confirmation of congruent dissolution is needed)
- Release of highly soluble nuclides in gap and cladding are below NRC limits (uncertainty of ^{14}C inventory and distribution needs resolution)
- Release rates below NRC limits may occur even if early (<300 Yr) loss of containment

WRAPUP

PASS Program Status

1. Milestone Summary - (See Chart)

- The first four PASS deliverables were submitted to DOE-RL on time, and forwarded to RW-23 for review and comment

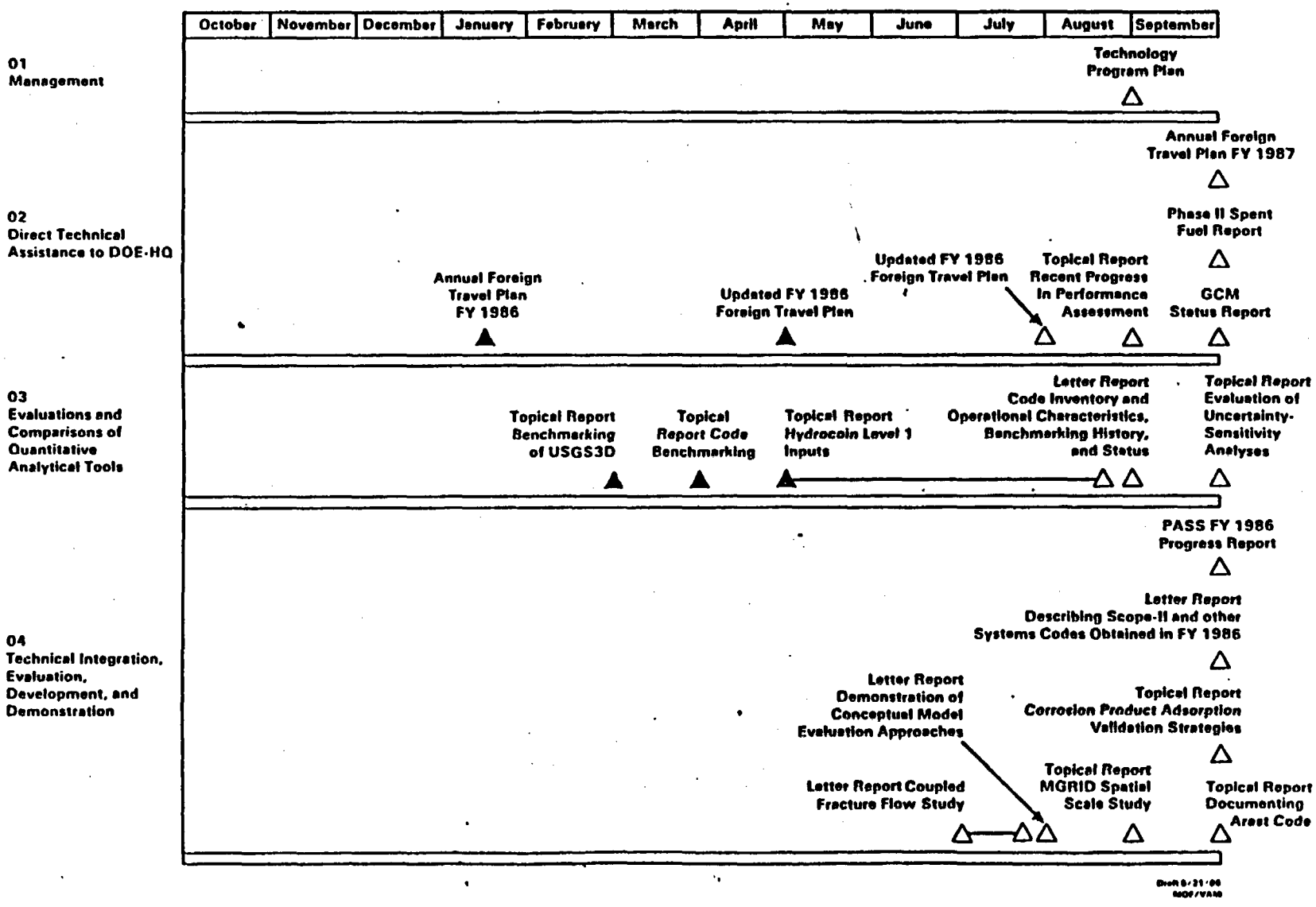
- One milestone report was shown to the RW-23 project monitor, who suggested a major addition be made to the report, so it is rescheduled

- One milestone report is currently two weeks late, in part because of the lead author's now being located in Washington, D.C. The report should be delivered shortly

- Key summer and end-of-fiscal year deliverables are in progress and prospects are for timely completion and delivery of all remaining milestones

FY 1986 Milestone Summary

Performance Assessment Scientific Support
A.E. Van Luik, Program Manager



WRAPUP

PASS Program Status (cont'd)

2. Financial Status - Approximately $300K underrun currently:

- A major subcontract has had its most labor-intensive phase delayed almost three months to develop a system responsive to QA requirements. (Global Climate Modeling is operating under the licensing QA requirements of the OGR Projects)

  Impact: About $100K below projections for this date

  Prospect: In order to achieve FY 1986 goals, the subcontractor is proceeding at an accelerated pace now that work has begun, and expects to come in on budget

- Planned software purchases for MicroVAXs 04, 05, and 06 were delayed until the delivery dates were firm for these machines

  Impact: About $125K of software was not ordered earlier in the year, as originally expected.

  Prospect: Procurements are in progress. Receipt of software is expected this FY

- Loss of staff member has had some short-term impact on projected spending

  Impact: About $75K or approximately a man month

  Prospect: A number of persons have been brought in on a part-time basis to fill the void. A replacement is being interviewed, and when one comes on board the cost of the new person plus the part-time staff should bring this task in on budget

WRAPUP

PASS Program Status (cont'd)

3. Coordination

- Working relationship with Tom Pigford, Paul Chambre, Bill Lee, and others of the LBL staff is very productive and mutually beneficial
- Project reviews of the draft Phase I spent fuel report were generally constructive and represented serious reviews by persons working in the subject areas. It was encouraging that some of the reviews were complimentary about parts of the work
- PASS participation in the Waste Package Coordination Group has helped PASS in its engineered barrier performance assessment work, and PASS staff feels it has contributed to the overall program through this participation
- The PASS team feels that its involvement in the review of NNWSI SCP sections has been of benefit to OGR, NNWSI, and PASS

WRAPUP

PASS Program Status (cont'd)

4. Open Concerns

- An ongoing concern is the potential sensitivity of the Phase II spent fuel evaluation report:

  - The spent fuel report will present analytical results from which a judgement can be made regarding the suitability of this waste form in mined geologic disposal systems in basalt, salt, and tuff

  - Parts of this information can be misused to provide ammunition for those who feel strongly that site-selection is not taking sufficient advantage of the technical information available

  - It is therefore suggested that OGR and OGR Project staff be given ample time to review the forthcoming draft material thoroughly and analyze both its technical merits and the adequacy of its caveats in terms of preventing misuse of the information it contains

WRAPUP

PASS Program Status (cont'd)

4. Open Concerns (cont'd)

- The same concerns exist about the potential sensitivity of the Phase IV postclosure risk assessment:

  - The postclosure risk assessment to be produced by PASS next year is even more obviously useful as a site ranking tool, and its timing is particularly sensitive in view of the legal challenges to the process of selecting sites for characterization

  - Although PASS staff has no objection to credible postclosure risk assessments being used in site selection, PASS staff is acutely aware of the inherent limitations in the technical credibility of any postclosure risk assessments that is based on the limited site data presently available. Postclosure risk assessments that provide reasonable assurance should not be expected until after site characterization.

  - It is therefore suggested that the PASS postclosure risk assessment be kept to a level of simplicity appropriate to the nature and the availability of site data. In keeping with this suggestion, only a very limited scenario analysis is presently contemplated so as to avoid, as much as possible, pitting one site's performance against another site's performance in terms of scenarios for which no defensible probabilities can presently be assigned

WRAPUP

PASS Program Status (cont'd)

5. Recommended Directions of Future Performance Assessment Work

- A number of performance assessment issues of general applicability will likely need to be addressed by OGR. Many of these issues are currently under study
- A defensible method for including scenarios in the performance assessment required for licensing
  - Identifying and screening scenarios
  - Assigning probabilities to scenarios
  - Assigning probabilities to scenario consequences

WRAPUP

PASS Program Status (cont'd)

5. Recommended Directions of Future Performance Assessment Work (cont'd)

- Identifying the mainfold sources and levels of uncertainty in performance assessments as a way of determining the attainment of 'reasonable assurance'
  - Uncertainties in the data and its representativeness of actuality
  - Uncertainties in the conceptualization of the system and its operation
  - Uncertainties in the model of the system and its operative processes
  - Uncertainties in the subjective judgements and assumptions made to run a model and interpret its results
  - Unknowns for which only conservative educated guesses or extremely conservative bounds are available

- Building general confidence in the applicability and ability of performance assessment methods
  - Partial validation
  - Verification, benchmarking, analogs
  - Performance confirmation testing

WRAPUP

PASS Program Status (cont'd)

5. Recommended Directions of Future Performance Assessment Work (cont'd)

- Experimentally answering questions which have been raised over the past year by preliminary performance assessment results
  - Experimentally determining the significant mechanisms operating in the release of radionuclides from the waste form after containment failure
  - Experimentally determining the performance role(s) of container corrosion products, if any
  - Experimentally determining the nature of the selected long-term consequences of major coupled processes, such as transient pressure/temperature effects on hydraulic properties
  - Experimentally determining the extent to which colloids and pseudo-colloids form at the waste form surface, and the extent to which they are filtered out and/or dissaggregate as dilution lowers component concentrations
  - Experimentally quantifying the nature and amount of water flow possible in bedded salt formations
- Developing and/or documenting performance assessment tools for use in licensing analyses

ENCLOSURE 4

~~Exit Meeting~~ Interview

BWIP Appendix 7 Waste Package Visit

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