TO BE ARGUED ON JANUARY 14, 2004

UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

NUCLEAR ENERGY INSTITUTE, Petitioner, v. ENVIRONMENTAL PROTECTION AGENCY, Respondent.	<u>Case No. 01-1258</u> Consolidated with 01-1268, 01-1295, 01-1425, 01-1426, 01-1516, 02-1036, 02-1077, 02-1116, 02-1179, 02-1196, 03-1009, 03-1058

PETITIONERS' MOTION TO REQUIRE RESPONDENTS TO SUPPLEMENT THE RECORD ON REVIEW

Petitioners the State of Nevada, Clark County, Nevada, and Las Vegas, Nevada, move pursuant to FED.R.APP.P. 16 and 17 to require Respondents to supplement the record on review with certain key documents, which have only recently been disclosed in response to Petitioners' Freedom of Information Act ("FOIA") requests. These striking documents reveal that the Department of Energy ("DOE") had concluded that the risk of nuclear criticality in the casks in which nuclear waste will be shipped to the Yucca Mountain repository – in effect converting them into lethally efficient "dirty bombs" – had a far higher probability of occurring during a terrorist incident than was previously disclosed by DOE. Nevertheless, in its Final Environmental Impact Statement ("FEIS"), DOE simply ignored any consideration of the scenarios in which such criticalities, and criticality-induced cask explosions, could come to pass.

Consequently, in support of this Motion, Petitioners state as follows:

1. Among the claims raised in these consolidated cases is Petitioners' contention that

DOE's FEIS for its Yucca Mountain nuclear waste repository project is flawed for failure to address realistic sabotage scenarios involving spent fuel transport, and thus vastly understated the potential risks and consequences of such transport. In particular, Nevada claimed that DOE had failed to evaluate the potential for a "nuclear criticality" in the event of a terrorist attack on a spent fuel cask in transit with a commercially available portable armor-piercing weapon. "Criticality" is "the condition in which nuclear fuel sustains a *chain reaction.*" JA-1339.[1] A nuclear criticality event, if it occurred in a spent fuel cask, would sharply increase the heat and radioactive content of the cask and would likely cause "a violent event," *i.e*, an explosion of the cask that would powerfully disperse highly radioactive waste into whatever environment the cask happened to be in. *See* Supp-623-24; JA-633-36. In its FEIS, DOE stated it did not evaluate cask accident or sabotage scenarios in which the risk of occurrence was less than one in 10 million because they were not "reasonably foreseeable."[2] JA-1021. Though DOE recognized that cask penetration would occur in an attack by an armor-piercing weapon, criticality events associated with such perforation were dismissed on this asserted ground. *Id.*

2. Respondents' Certified List of Documents (filed April 8, 2002), purporting to comprise the Administrative Record in Case No. 02-1179, did not include a document in which DOE had determined, in evaluating long-term storage of spent fuel in casks, that rainwater seepage into a degraded spent fuel cask could credibly induce the criticality that would produce heightened releases or cask explosions. (Water creates the physical conditions inside the cask

[1] As used herein, the terms "JA" and "Supp" refer respectively to the Joint Appendix and Supplemental Appendix filed in *Nevada v. Department of Energy*, No. 01-1516.

[2] The FEIS likewise dismissed the risk and consequences of criticality occurring *inside* the Yucca Mountain repository, suggesting the odds of it happening were too remote to be considered. JA-966 (postulating that the probability of a criticality was less than 2 in 10 million in 10,000 years). Moreover, DOE concluded that, even if it occurred in the repository, a criticality "would not have a significant impact on repository performance." JA-633.

fostering a self-sustaining chain reaction. In technical terms, it is an effective "neutron moderator.") *See* Supp-568-666. *See also* JA-634 ("With the presence of moderating materials like water, the likelihood of fission can be greatly increased...."). The Court's adjudication of Petitioners' November 5, 2002 request that this document, the so-called "Continual Storage Analysis Report," be included in the Administrative Record was deferred to the merits hearing of this case. Order dated February 26, 2003. Oral argument is scheduled for January 14, 2003.

In briefing, Petitioners contended that any spent fuel cask perforated by an armor-piercing weapon could credibly be exposed to water through rainfall, firefighters' spray, or submersion (in the case of barge-mounted casks or casks damaged on bridges over waterways). Pet. Final Opening Br. at 97. Respondents countered that "[m]ere conjecture by Petitioners that a criticality could result from a missile attack is an insufficient basis for requiring further analysis under" the National Environmental Policy Act ("NEPA"). Resp. Final Br. at 98. Similarly, Intervenor/Amicus Nuclear Energy Institute and National Association of Regulatory Utility Commissioners countered that "criticality would not be expected as a result of a sabotage scenario in any event; even one involving flooding with water" merely because NRC regulations *require* that it should not occur. Int./Amicus Br. at 33.

3. Petitioners only recently discovered, through documents received in October and November, 2003, pursuant to FOIA requests, that, contrary to FED.R.APP.P 17(b)(1)(B), the Administrative Record for Case No. 02-1179, does not contain other key documents that bear directly on, and strongly support, Petitioners' claim concerning the very real dangers of these criticalities and cask explosions in a variety of contexts. Those documents, which are numbered Supp-904 through Supp-975, are attached to this motion. Specifically, the documents reveal that DOE's Senior Technical Review Panel for the FEIS was repeatedly concerned about criticality in

the event of water entering a ruptured or corroded spent fuel canister, and it recommended on several occasions that DOE "quantify the consequences" if such an event "is conceivable." Supp-926, 935, 950. Though DOE's studies concluded that such an event was not only conceivable but likely, DOE apparently never did such an analysis.

The documents show that DOE's own criticality analysts had "assumed that the ingress of water into a storage cask, without any change in geometry of the spent fuel and/or movement of the neutron poison, *would result in a critical event*," and that the probability of criticality was so high that DOE should not waste time analyzing it, but should proceed directly to analysis of the consequences. Supp-951 (emphasis added), 956-57. Even more astonishing, DOE's own numbers in its "Criticality Potential Curve Draft Report" for the Yucca repository suggest that, if waste packages corrode, permitting water ingress, up to 60 nuclear criticalities *will* occur *inside* Yucca Mountain, and the probability of a criticality happening in the repository may be greater than one in one thousand per year – far from the 2 in 10 million chance over 10,000 years that was stated in the FEIS. *See* Supp 906-17; *cf.* JA-966, 633. Logically, the impact of one such cask explosion on its neighboring casks inside the repository is potentially a chain of cask ruptures, releasing even more highly radioactive material from the repository, and throwing into question the value of "engineered barriers" if, as Petitioners contend, the geology of the site cannot independently isolate such waste. Again, no analysis of these scenarios was done.

Indeed, DOE's documents concluded that "[a] criticality event could affect radionuclide releases to the environment by damaging the uranium fuel matrix and cladding, so that the slow dissolution process which would normally occur is accelerated and radionuclides are released in a short time period. Such a release would be more concentrated and the air release pathway would become significant, so an evaluation of the effects of potential criticality events is in order." Supp-906.

4. Under well-settled principles of administrative and NEPA law, these recently-released records should be included in the certified administrative record, or at a minimum, in the record before this Court on its review of Petitioners' NEPA claims. For this Court's review of Respondents' actions and inactions to be meaningful, that review must "be based on the full administrative record that was before" the agency at the time of its decision. *Citizens to Preserve Overton Park, Inc. v. Volpe*, 401 U.S. 402, 420 (1971). *See also James Madison Ltd. by Hecht v. Ludwig*, 82 F.3d 1085, 1095 (D.C. Cir. 1996); *Environmental Def. Fund v. Costle*, 657 F.2d 275, 284 (D.C. Cir. 1981). Because, "[i]f a court is to review an agency's action fairly, it should have before it neither more nor less information than did the agency when it made its decision," *Walter O. Boswell Mem'l Hosp. v. Heckler*, 749 F.2d 788, 792 (D.C. Cir. 1984), the "complete administrative record" upon which the Court's review is to be based "consists of all documents and materials directly or indirectly considered by the agency." *Bar MK Ranches v. Yuetter*, 994 F.2d 735, 739 (10th Cir. 1993) (citations omitted). *See also Izaak Walton League of America v. Marsh*, 655 F.2d 346, 368 (D.C. Cir. 1981) ("the administrative record must disclose the studies and data used in compiling environmental impact statements"). Because the recently-released documents demonstrate on their face that DOE directly or indirectly considered the likelihood of criticality events in formulating its environmental analyses, they are properly considered part of the administrative record, whether or not they were formally designated as such by Respondents. *See Bar MK Ranches*, 994 F.2d at 739 ("An agency may not unilaterally determine what constitutes the Administrative Record.") (citation omitted); *Esch v. Yeutter*, 876 F.2d 976, 991 (D.C. Cir. 1989) (supplementation of administrative record allowed "when an agency considered evidence which it failed to include in the record").

In any event, this Court should include the materials at issue in the Court's record in

order to determine whether Respondents in fact complied with their obligations under NEPA to fully consider relevant environmental matters. One of Petitioners' central contentions is that DOE's FEIS failed to adequately consider and address the environmental impacts of various criticality scenarios. Almost by definition, matters outside the certified administrative record must be considered if the Court is to conduct a meaningful review of such a claim. *See, e.g., Esch*, 876 F.2d at 991 (supplementation appropriate "when the agency failed to consider factors which are relevant to its final decision"); *Environmental Def. Fund*, 657 F.2d at 285 (citing *Asarco, Inc. v. EPA*, 616 F.2d 1153, 1160 (9th Cir. 1980)); *Izaak Walton League*, 655 F.2d at 369 n.56.[3] This consideration is especially important in NEPA cases, where "a primary function of the court is to insure that the information available to the decision-maker includes an adequate discussion of environmental effects and alternatives, which can sometimes be determined only by looking outside the administrative record to see what the agency may have ignored." *County of Suffolk v. Secretary of Interior*, 562 F.2d 1368, 1384 (2d Cir. 1977) (internal citations omitted). *See also Asarco, Inc. v. EPA*, 616 F.2d 1153, 1160 (9th Cir. 1980) ("It will often be impossible, especially when highly technical matters are involved, for the court to determine whether the agency took into consideration all relevant factors unless it looks outside the record to determine what matters the agency should have considered but did not."); *Esch*, 876 F.2d at 991.

Accordingly, Petitioners respectfully request the Court to require Respondents to supplement the record on review before the Court with these documents (and any others like them that have not been disclosed) or, in the alternative, to defer ruling on the attached documents until the merits hearing.

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[3] *Compare Kent County v. EPA*, 963 F.2d 391, 396 (D.C. Cir. 1992) ("The documents relate to the position of the agency's own experts on the question central to this case. To deny their relevance would be inconsistent with rational decisionmaking by an administrative agency.").

Respectfully submitted,

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DATED: November 25, 2003

Attachment

CSAR FOIA - STILL AWAITING MORE ADX 10/27

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Office of Civilian Radioactive Waste Management
Office of Repository Development
P.O. Box 364629
North Las Vegas, NV 89036-8629

QA: N/A

OCT 0 6 2003

Mr. Charles J. Fitzpatrick, Esquire
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Dear Mr. Fitzpatrick:

This is in response to your August 14, 2003, Freedom of Information Act (FOIA) request submitted to the U.S. Department of Energy, Washington, DC, for a copy of the *Criticality Potential Curve Draft Report* and all supporting documentation, calculations or analyses prepared in connection with this report, which has been forwarded to my attention to prepare a response. Please reference ORD-FOIA 03-71 in any future correspondence regarding this matter.

At this time, we are providing you with a copy of the *Criticality Potential Curve Draft Report* as you requested (13 pages). Although we have completed our search for all supporting documentation, calculations, or analyses prepared in connection with the preparation of this report, we have not completed our review of these documents. Therefore, upon completion of our review of these documents, we will prepare our final response to your request. We anticipate completing our response not later than October 27, 2003. In your August 14, 2003, letter you stated your willingness to pay fees in an amount not to exceed $1,000 to process this request. Therefore, we will provide you with the total cost of processing this request at the time we prepare our final response.

If I can be of further assistance, please contact me at (702) 794-5004 or by e-mail at diane_quenell@ymp.gov.

Sincerely,

Diane Quenell

Diane Quenell
Freedom of Information/Privacy Act Officer

Enclosure:
As stated

INFORMATION

"Alan H. Wells, PhD" <ahwells@interserv.com> on 07/30/98 04:19:01 AM

To: Ralph Best/YD/RWDOE
cc: Joseph Ziegler/YD/RWDOE, dademoeller@cconnect.net, budnitz@pacbell.net, denning@battelle.org, sas@EQE.COM
Subject: Criticality Potential Curve Draft Report

Ralph,

I owed you a section of the report which addresses the criticality potential curve and provides the fraction of fuel which could go critical, so here it is. The analyses used the MCNP4A code and the isotopics came directly from the Yucca Mountain Waste Package Loading Curves. I will send you a CDROM with the input and output files for the analyses so that you have all of the data.

I included text that discusses the consequences of the criticality event in terms of releases. This section is where Jofu or someone should put their detailed explanation of releases - I just described the approach.

Please feel free to email any questions or comments you might have.

Alan - CRITRPT.ZIP

WELLS: A.H. 7/11/98

Criticality Events in Dry Storage

Existing storage systems have been designed to preclude criticality safety concerns by the use of moderator exclusion, in which the ingress of water is prevented so that the nuclear chain reaction can not be sustained. Such storage systems could experience a criticality event if the exclusion of water moderator is compromised by corrosion or damage, which might occur if loss of institutional controls were to remove surveillance and maintenance controls. A criticality event could affect radionuclide releases to the environment by damaging the uranium fuel matrix and cladding, so that the slow dissolution process which would normally occur is accelerated and radionuclides are released in a short time period. Such a release would be more concentrated and the air release pathway would become significant, so an evaluation of the effects of potential criticality events is in order.

Criticality Event Types

Essentially, there are three separate criticality event types to consider:

The "light bulb" type of event, in which a system achieves a delayed critical state (with several cents[1] of reactivity), in which fissions on the order of 10^{16} to 10^{17} are produced over a relatively long period of time (minutes or more). This event type does not produce high temperatures or regenerate significant quantities of radionuclides. The fuel dissolution continues at a slow rate, and the effect of the additional radionuclides produced is small because they are a fraction of the total inventory at the time of the event and because they are mainly short half-life so that they decay before they are released. This is the more likely event type, with a probability estimated at 1.2×10^{-3}. Since the fuel configuration is not changed by this event type, it might recur and take the form of an "Oklo" type of criticality, but there would still be minor consequences.

The "SL-1" type of event, in which a system goes prompt critical by a large reactivity (several dollars worth of reactivity or more) and fissions on the order of 10^{19} are produced. This event type can produce high temperatures that can lead to fuel unzipping and pellet degeneration. The radionuclide inventory produced is comparable to the inventory before the event, and it is released rapidly through the air pathway before it has time to decay. (The "black cloud" phenomenum.) This is a less likely event type, with a probability estimated at 3×10^{-4}.

The "Waste Package" type of event, in which a system goes critical by a large reactivity (several dollars worth or more) but the reactivity insertion is slow enough so that the fission rate and energy release is not enough to produce steam and shut off the event. This event continues over a long period of time (minutes to hours). This event type

[1] Reactivity for supercritical systems may be measured in dollars and cents, where a dollar is defined as k-effective minus one, divided by the delayed neutron fraction

differs from the "light bulb" in that the total potential reactivity insertion is large enough to overcome the shutdown which would be caused by system heating. Fissions on the order of 10^{21} to 10^{22} are produced, and a significant increase in radionuclide inventory results. This increase may be on the order of a factor of two or so due to the increase of long-lived radionuclide inventory. This is a less likely event type, with a probability estimated at 3×10^{-4}.

The "light bulb" and "Waste Package" types of criticality events do not result in substantial changes in the release rate from a failed storage cask; rather, the fuel dissolution continues at about the same rate and changes to the total radionuclide inventory have little overall effect over the long time periods involved. The "SL-1" type event, on the other hand, results in degradation of the uranium fuel matrix and possibly further damage to the storage cask seals, and it is this type of event which can release material through the air pathway.

Conditional Event Probabilities

The estimation of the event type probabilities is based upon estimation of the steps needed to attain a given critical configuration. The first step is to estimate the population of PWR and BWR fuel assemblies which might be able to cause a critical configuration in a storage cask, based upon the initial enrichment and burnup of the fuel. This is done by finding the burnup at which a storage cask just achieves critical (k-eff = 1.00) for a range of enrichments, a "criticality potential" curve. A vertical storage cask with a ferritic steel basket, containing no integral neutron absorbers, was used in the evaluation. The percentage of the commercial spent nuclear fuel inventory which could become critical can be obtained from the characteristics of the spent fuel. For this evaluation, a value of 4.1 percent of the fuel inventory could achieve a critical state in a failed, flooded storage cask.

The conditional probability of a given type of criticality event is the product of the percentage of the fuel inventory which can go critical times the probability of the other conditions which may be met:

The percentage of fuel stored in a given technology that can lead to a given type of criticality event. The percentage which can lead to the "SL-1" type of event was taken as 25 percent.

The percentage of corrosion sequences that could lead to the bathtub scenario and weakened internal structures . Assumed to be 25% here.

The likelihood of a mechanical upset that leads to the reactivity insertion, taken as ten percent here. Note that the "light bulb" scenario does not require that the basket internal structure be weakened while the "SL-1" scenario requires that the basket structure be weakened prior to an initiating event like an earthquake. If the horizontal basket is weakened and collapses incrementally over a long period of time, it looks like the "Waste Package" event.

Thus, for the "SL-1" type of event, the conditional probability is 0.041 (fuel percentage) times 0.25 (technology percentage) times 0.25 (corrosion percentage) times upset percentage equals 3.1 x 10^{-4} per cask. Since the number of assemblies which would go into the repository is known, and there are typically 24 assemblies per storage cask for PWRs, the total number of events of each type is defined.

Table I: Criticality Event Probabilities

Criticality Type	Fission Production / Scale Factor	Fuel Fraction	Technology Fraction ?	Corrosion Fraction ? (Bathtub)	Upset Fraction ?	Conditional Probability (per cask)
"Light Bulb"	10^{17} / 0.01	0.041	0.50	0.25	1.00	5.1 x 10^{-3}
"SL-1"	10^{19} / 1.00	0.041	0.25	0.25	0.10	2.6 x 10^{-4}
"Waste Package"	10^{22} / 1000	0.041	0.25	0.25	0.10	2.6 x 10^{-4}

Table I provides the probabilities of an event occurrence without specifying when the event would occur. The criticality events may be assumed to occur uniformly over the a time period beginning when the package first perforates and admits water and ending when the bathtub wall has corroded sufficiently to release the water. The total number of criticalities of each type is just the conditional probability per cask times the total number of casks, and these criticalities occur over the time period of the bathtub.

Criticality Event Consequences

The consequences of a given event type may be obtained by adding the radionuclides produced in the criticality event to the inventory already present, and deciding what release pathway is appropriate. The "SL-1" event type is the only event which leads to the prompt, air pathway type of release. The "light bulb" and "Waste Package" type of events remain slow water dissolution releases. The radionuclides produced can be obtained through a calculation of radioisotope buildup and decay such as the calculations performed by NUS for 10^{19} fissions. The radioisotopic inventories contained in the NUS calculation may be scaled to provide the additional radionuclides produced by the event.

The results of the calculation of radiological consequences of the criticality events may be expressed as dose and/or LCFs. If these results are kept separate from the other releases, then adjustments to the various probabilities that make up the criticality event conditional probabilities can be made, and the consequence results scaled so that the release calculations do not need to be reperformed.

In conclusion, the number of criticality events and their time of occurrence can be determined, and the consequences in terms of radionuclide releases can be calculated. The air pathway is only important for the relatively unlikely "SL-1" type event, and the effect of additional radionuclides added to the water pathway is limited by the short half-life of most of the isotopes. The methodology described here allows these effects to be quantified and documented. It is important to keep the data and write-ups of the release pathways separate so that adjustments to the criticality event probabilities do not cause schedule difficulties.

Criticality Potential Curve Calculation

A vertical storage cask with a ferritic steel fuel basket was analyzed for the criticality potential caused by loss of moderator exclusion and flooding of the container. The fuel basket was assumed to have no integral neutron absorbers and the spacing of fuel assemblies was as close as possible in a tightly packed lattice of square ferritic steel tubes. The MCNP4A computer code was used to calculate k-effective for the flooded cask with a variety of initial fuel enrichments and burnups. An analysis to determine the minimum fresh fuel enrichment which could provide a critical system state was performed, and this minimum fresh fuel enrichment is the base point of the criticality potential curve. Initial fuel enrichments of 3.0, 4.0, 5.0, and 6.0 weight percent were analyzed to determine the burnup at which the cask is critical, i.e. k-effective is equal to 1.0. These analyses provide the data points for the criticality potential curve. The isotopic inventory present in the spent fuel as a function of initial enrichment and burnup were obtained from an M&O analysis entitled "Principle Isotope Burnup Credit Loading Curves for the 21 PWR Waste Package", Document Identifier: BBA000000-01717-0210-00008.

The percentage of commercial fuel in the inventory which has burnups less than the critical burnup (for each initial enrichment) is the percentage of the inventory which can contribute to a criticality event, which was 4.1 percent.

Continued Storage Assumption - Criticality Potential Curve

Simulated Storage System Criticality Potential

Initial Enrichment (wt%)	Required Minimum Burnup (GWd/MTU)	
0.00	0.00	
1.50	0.00	
1.72	0.00	Maximum Fresh Fuel Enrichment Limit
3.00	17.30	
4.00	28.60	
5.00	40.30	
6.00	52.50	

Continued Storage Assumption		Fresh Fuel (No Burnup)			
Simulated Storage System Criticality Potential					
Case Name	Enrichment	k-calculated	sigma		k-effective
UCF001	1.5 wt%	0.93544	0.00147	1.50	0.958
UCF002	2.0 wt%	1.02696	0.00165	2.00	1.050
UCF003	2.5 wt%	1.09441	0.00196	2.50	1.118
UCF004	3.0 wt%	1.13967	0.00166	3.00	1.163
UCF005	3.5 wt%	1.18183	0.00158	3.50	1.205
UCF006	4.0 wt%	1.21464	0.00171	4.00	1.238
UCF007	4.5 wt%	1.24282	0.00174	4.50	1.266
UCF008	5.0 wt%	1.26166	0.00174	5.00	1.285

Continued Storage Assumption			3.00 Weight Percent	
Simulated Storage System Criticality Potential				
Case Name		k-calculated	sigma	k-effective
A3010	10 GWd/MTU	1.043	0.00159 10	1.066
A3015	15 GWd/MTU	0.995	0.00164 15	1.018
A3020	20 GWd/MTU	0.954	0.00161 20	0.977
A3025	25 GWd/MTU	0.915	0.00146 25	0.937
A3030	30 GWd/MTU	0.877	0.00148 30	0.900

Continued Storage Assumption			4.00 Weight Percent		
Simulated Storage System Criticality Potential					
Case Name		k-calculated	sigma		k-effective
A4010	10 GWd/MTU	1.12150	0.00151	10	1.145
A4015	15 GWd/MTU	1.07762	0.00156	15	1.101
A4020	20 GWd/MTU	1.03900	0.00146	20	1.062
A4025	25 GWd/MTU	0.99992	0.00155	25	1.023
A4030	30 GWd/MTU	0.96763	0.00165	30	0.991

A4035	35 GWd/MTU	0.93756	0.00131 35	0.960
A4040	40 GWd/MTU	0.90878	0.00164 40	0.932
A4045	45 GWd/MTU	0.88701	0.00158 45	0.910
A4050	50 GWd/MTU	0.86292	0.00150 50	0.886
A4055	55 GWd/MTU	0.83885	0.00158 55	0.862
A4060	60 GWd/MTU	0.81728	0.00163 60	0.841

Continued Storage Assumption				5.00 Weight Percent		
Simulated Storage System Criticality Potential						
Case Name			k-calculated	sigma		k-effective
A5020		20 GWd/MTU			20	0.020
A5025		25 GWd/MTU	1.06532	0.00166	25	1.089
A5030		30 GWd/MTU			30	0.020
A5035		35 GWd/MTU	1.00448	0.00159	35	1.028
A5040		40 GWd/MTU			40	0.020
A5045		45 GWd/MTU	0.95244	0.00167	45	0.976
A5050		50 GWd/MTU			50	0.020

Continued Storage Assumption				6.00 Weight Percent		
Simulated Storage System Criticality Potential						
Case Name			k-calculated	sigma		k-effective
A6040		40 GWd/MTU	1.04018	0.00195	40	1.064
A6050		50 GWd/MTU	0.98924	0.00179	50	1.013
A6060		60 GWd/MTU	0.94033	0.00186	60	0.964

Department of Energy
Office of Civilian Radioactive Waste Management
Office of Repository Development
1551 Hillshire Drive
Las Vegas, NV 89134-6321

QA: N/A

NOV 14 2003

OVERNIGHT MAIL

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Dear Mr. Fitzpatrick:

In our initial response on October 6, 2003, to your Freedom of Information Act (FOIA) request dated August 14, 2003, for a copy of the *Criticality Potential Curve Draft Report* and all supporting documents, calculations or analyses prepared in connection with this report, we provided you a copy of the *Criticality Potential Curve Draft Report*. In our response, we also stated that we had not completed our review of the supporting documents, calculations or analyses. This review has now been completed. Please reference ORD-FOIA 03-71 in any future correspondence regarding this matter.

In completing our response to your request, enclosed are:

1. Various calculations used in the preparation of the *Criticality Potential Curve Draft Report* (312 pages)
2. Report of Senior Technical Review Panel Meeting of February 9, 1998 (10 pages)
3. Report of Senior Technical Review Panel Meeting of February 10, 1998 (MOL.20020102.0087) (16 pages)
4. Report of Senior Technical Review Panel Meeting of April 3, 1998 (MOL.20020102.0088) (21 pages)
5. Report of Senior Technical Review Panel Meeting of June 5, 1998 (MOL.20020102.0090) (9 pages)

Under the provisions of the FOIA, documents held in government files will be disclosed to the public upon request with nine specific exemptions. One of those, Exemption 5 of 5 U.S.C. § 552, protects from disclosure information to which the deliberative process privilege applies. The general purpose of this exemption is to prevent injury to the quality of agency decisions while encouraging open, frank discussions on matters of policy between subordinates and superiors. We have determined that several informal communications between the Office of Repository Development (ORD) and contractor personnel meet the intent of the deliberative process privilege and, if released, could chill the deliberative process in the future (14 pages). The type of information withheld under Exemption 5 consisted of informal communications between ORD and contractor

personnel to discuss or clarify a draft presentation on criticality for dry storage systems, criticality event results, and dry storage system modeling. Therefore, your request for all supporting documentation, calculations or analyses used in the preparation of the *Criticality Potential Curve Draft Report* is partially denied.

I am the individual responsible for the determination to withhold the informal communications exchanged between ORD and contractor personnel in preparing the *Criticality Potential Curve Draft Report.*

This decision may be appealed, in writing, within 30 days after your receipt of this letter, to the Director, Office of Hearings and Appeals, HG-1, U.S. Department of Energy, 1000 Independence Avenue, SW, Washington, DC 20585. The written appeal must contain all other elements required by 5 C.F.R. § 1004.8. Judicial review will thereafter be available to you in the district where you reside, where you have your principal place of business, where the Department's records are situated, or in the District of Columbia.

In your August 14, 2003, letter, you stated your willingness to pay fees in an amount not to exceed $1,000. Research, review and copying costs are itemized as follows:

FOIA/PA Officer GS 13/6=$37.54	
2 hrs x $37.54	$75.08
Plus 16%	12.01
Subtotal	$87.09
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Total	$105.49

Upon receipt of the responsive documents, please send your check made payable to the U.S. Department of Energy in the amount of $105.49 to: U.S. Department of Energy, Office of Repository Development, Attn: Diane Quenell, 1551 Hillshire Drive, Las Vegas, NV 89134-6321. This completes our response to your FOIA request. If we can be of further assistance, please contact Diane Quenell, of my staff, at (702) 794-5004.

Sincerely,

Kenneth W. Powers for
W. John Arthur, III
Deputy Director

Enclosures:
As stated

Dade W. Moeller
February 16, 1998

REPORT OF SENIOR TECHNICAL REVIEW PANEL
Meeting of February 9, 1998

I. Introduction

The U.S. Department of Energy has established a Senior Technical Panel to review the critical assumptions and plans for preparing the "Continuous Storage Analysis Report" (CSAR) that is to accompany the Total System Performance Assessment - Viability Assessment being prepared by the Yucca Mountain Site Characterization Office of the U.S. Department of Energy. This report summarizes the conclusions and recommendations of the Panel, based on its initial meeting on February 9, 1998, held at the offices of Jason Associates Corporation in Las Vegas, NV. Dr. Dade W. Moeller was appointed Chairman of the Panel. A list of the members of the Panel is shown in Appendix A; a copy of the Charter for the Panel is shown in Appendix B. In accordance with its Charter, this report is being submitted to the Project Manager, Jason Technologies.

II. Details of Initial Meeting

Members of the Panel were welcomed by Wendy Dixon, DOE Assistant Manager for Environmental Health and Safety. She provided them with a brief outline of the questions they face and the information she desires for them to provide. This was followed by an introduction to the background on the CSAR and related technical aspects. This was provided by Dee Walker. In the course of the ensuing discussions, it was made clear that the Panel was not to serve as a Peer Review Group; rather it is to assist the DOE technical support staff in assuring that the assumptions underlying their analyses are sound, that the key issues have been properly defined, that the approaches being applied are adequate and justified, and that an acceptable format was being developed for the presentation of the study results. The Panel was instructed to focus on radiological, as contrasted to cost, impact issues.

The opening presentations were followed by about seven hours of indepth reviews of various aspects of the CSAR. These were provided by key members of the technical support staff. Throughout the technical briefings, Panel members interacted with the individual technical staff members and obtained detailed information on various aspects of the project. These exchanges resulted in the sharing of many comments and suggestions among the Panel

members and the technical staff. A copy of the agenda for the meeting is shown in Appendix C.

III. Recommendations, Suggestions, and Comments of the Panel

Subsequent to the technical briefings, the Panel members met in executive session to summarize their preliminary findings and recommendations. This was followed by an oral briefing for Wendy Dixon, Dee Walker, and the DOE technical support staff of these findings and recommendations. In all, the Panel offered findings, conclusions, and recommendations in twelve technical areas related to the CSAR. Also included in this report is a summary (part 13) of other factors that the staff preparing the CSAR should be cognizant of and refer to as appropriate. The purpose of this written report is to present the views of the Panel members in a formal manner.

1. Loss of Institutional Control

The technical staff has developed two scenarios for conducting the CSAR. These are the: (1) No-Action Scenario, assuming that institutional control continues over the long-term; and the (2) No-Action Scenario, assuming that institutional control is lost after an initial period of 100 years. In accord with its Charter, the Panel concentrated on the second Scenario. One of the immediate needs identified was a clear definition of what was meant by "loss of institutional control." According to EPA (40 CFR 191), it is a "loss of government." However, the Panel believes that those responsible for preparing the CSAR also need to know whether loss of institutional control is assumed to take place in an orderly manner, in which case the facilities in question would undergo an orderly shutdown, or whether the loss of institutional control is assumed to take place abruptly, with sudden abandonment of the facilities. The Panel recommended that this matter be resolved. One approach, which should be used only if DOE cannot resolve the issue discussed immediately above, might be to evaluate the impacts assuming both orderly and abrupt loss of institutional control.

Another question that arose was whether there would be a significant difference if institutional control were lost after 200 or 300 years, versus 100 years. Based on its review, the Panel concluded that the time difference was not important.

2. Assuring Comparability of the Analyses

One of the goals of the technical staff is to assure that the assumptions and analytical techniques used in preparing the CSAR are comparable to those in the TSPA-VA. This includes being as consistent as possible in the models and analytical approaches being used. Ultimately, consistency with the TSPA-VA

may be more important than accuracy because a major use of the CSAR will be to provide a comparison of the environmental risks of continued storage to those of geologic disposal. To assure that this goal is achieved, the Panel urged that the CSAR technical staff be thoroughly grounded in all aspects of the TSPA-VA. This will entail keeping abreast of changes that are taking place, almost on a daily basis, in terms of the assumptions and approaches being used in preparing the TSPA-VA. In a similar manner, it is vital that members of the Senior Technical Panel be provided with detailed descriptions of the models being used to develop the TSPA-VA.

Also to be recognized is that the degrees of realism and conservatism are not equivalent in all aspects of the TSPA-VA. For this reason, the Panel recommended that, to the extent practical, the staff preparing the CSAR adopt similar assumptions and analytical techniques. Recognizing, however, that in some cases there may be reasons for adopting different assumptions and approaches, the Panel urged that the technical staff be careful to stipulate and justify (including the rationale for) these differences. Depending on the circumstances, the CSAR technical staff may want to consider presenting two outcomes -- one using the assumptions and analytical techniques being employed in developing the TSPA-VA; and one using the assumptions and analytical techniques that the CSAR staff has decided are more appropriate for the CSAR case. A specific example of the last consideration relates to the effect of cladding in retarding the migration of radionuclides from spent nuclear fuel.

3. Development of a Base Case Scenario

In the course of its review, the Panel observed that there was a lack of definition within the CSAR of the detailed time line and sequence of events that are assumed to occur as part of the Base Case Scenario. This is extremely important in assuring the transparency of the Continued Storage Analysis Report.

The benefits to developing details of the Base Case Scenario will be several, one of the most important being that it will help identify and quantify the uncertainties associated with the various steps in the processes that are postulated to lead to radionuclide releases. Specific examples where development of such scenarios will be helpful are in terms of the deterioration of the concrete in the NUHOMS storage casks, the accompanying failure of the canister housing the spent nuclear fuel, the resulting failure of the cladding, etc. In a similar manner, similar scenarios are needed to clarify the sequence assumed to take place in the failure of the borosilicate glass in which the high-level radioactive waste has been incorporated, and in the deterioration in the performance of the steel containers housing certain types of waste.

4. Delineation of Uncertainties

In the opinion of the Panel, there appear to be three major categories of uncertainties associated with the CSAR. If viewed as a hierarchy, the largest uncertainties are those associated with the identification and assumed sequence of events that comprise the base case scenarios. Of these, the most important is the scenario in which it is assumed that institutional control is lost after 100 years. The next (middle level) category involves the sequence of events that is assumed to transpire within this scenario, the interrelationships of these events, and the uncertainties associated with each sequence. The third (lowest level) category of uncertainties are those associated with the analytical models used and the input data required to exercise these models.

Although it will not necessarily reduce the uncertainties, the Panel believes (as noted above) that it is imperative that, to the extent practical, the CSAR staff use the same models that are being used in developing the TSPA-VA. In any case where a different model is being used, care must be taken to assure that it has been validated, preferably through acceptance and endorsement by appropriate Federal agencies, such as the U.S. EPA and the U.S. NRC, through cooperative evaluation programs at the international level, or through widespread validated use in the private sector.

5. Uncertainties Associated With Specific Calculations

On the basis of its review to date, the Panel has concluded that there will be large uncertainties associated with a range of estimates being made in conjunction with the development of the CSAR. These include those associated with (a) the failure modes and timing of failure of the Zircaloy cladding; (b) the mechanisms of the corrosion of the stainless steel and the failure modes of the DSC; (c) water ingress and egress assumptions for the DSC; and (d) water dissolution of the waste form and subsequent environmental transport of the associated radionuclides. A key uncertainty is that related to the basis and meaning of the TSPA-VA solubility limit concentrations.

In addition, there are similar uncertainties associated with estimates of (a) the collective population dose, and (b) the peak dose rate to the reasonably maximally exposed individual and the time when it will occur. In terms of the collective dose, the National Council on Radiation Protection and Measurements (NCRP, 1995) cautions that a single value of collective dose may be useful and meaningful only if "no individual dose or risk is predominant." If the range of doses to individuals covers several orders of magnitude, the distribution of doses

must also be included in order to characterize the risk adequately, that is, to assure that a few cases at either extreme of the dose distribution range do not drive or disproportionately affect the characteristics of the risk. In fact, the NCRP goes on to suggest that the "distribution might be best characterized by dividing it into several ranges of individual doses, each covering two or three orders of magnitude, with the population size, average individual dose, collective dose, and uncertainty given for each range."

Estimates of the peak dose rate and the time of its occurrence will be even more complicated. This is due, among other things, to the multiple pathways and multiple sites that must be considered. In contrast, the TSPA-VA involves only one site and one principal pathway (via groundwater). Due to the magnitude of the associated uncertainties, the Panel questions whether the outcomes of such an exercise will have any practical value. Most importantly, will it provide any useful insights? Unless such an exercise is required, or useful insights are identified, the Panel recommends that it not be done.

6. Input Data to Risk Assessments

In addition to the evaluation of uncertainties, it is also important to recognize the multitude of conservatisms involved in certain of the techniques used in conducting the risk assessments. At one level, there is the use of techniques for the design of concrete structures as a vehicle for assessing the performance of such structures over long periods of time. Design procedures were not developed, and should not be used, for assessing risk. At another level, many of the philosophies and concepts being used in assessing the health impacts of radiation exposures were developed for purposes of radiation protection. They should not be used for purposes of risk assessment without carefully evaluating the fundamental concepts on which they were based. Examples are the linear-no-threshold hypothesis and the tissue weighting factors developed for converting organ doses into effective (whole body) doses.

7. Application of Bounding Calculations

In certain cases, it may be useful to conduct bounding calculations to determine that a given sequence of events is not important in terms of radionuclide releases and accompanying exposures to the public. In such cases, however, the CSAR staff should recognize the high degree of conservatisms incorporated into such analyses. So long as they yield doses that are in a range considered to be trivial, such calculations are useful. If they yield doses that are significant, more detailed analyses using site-specific input data will be required. As part of

such analyses, the CSAR staff should give careful consideration to the screening models that have been developed by the NCRP (1996).

In the sense that they can save time and effort, the Panel recommends that the CSAR staff take advantage of generic calculations as part of their risk assessment process. Such calculations, for example, could be very useful in analyzing certain release scenarios for "wet," versus "dry," sites.

8. Impacts of External Phenomena

External phenomena that can have adverse impacts on waste storage facilities include earthquakes, tornadoes, hurricanes, floods, and aircraft crashes. The Panel understands that the CSAR staff has tentatively decided that all such events are bounded by the impacts of an aircraft crash. Before the staff makes a decision not to evaluate the impacts of the other events, the Panel recommends that they perform a simple, scoping analysis to estimate the probability of each such event at one of more key waste storage sites. In those cases in which the estimated probability appears to be sufficiently high, the Panel recommends that the CSAR staff evaluate the associated consequences. There are two reasons behind the Panel's expression of concern on this matter: (a) The occurrence of an earthquake, for example, can significantly change the time when a significant radionuclide release may occur; and (b) The suggested approach would be more consistent with that being used in the TSPA-VA.

9. Radionuclide Releases, Pathways, and Mechanisms

The Panel endorses the plan of the CSAR staff to conduct sensitivity analyses to identify those input parameters that must be quantified in a more exacting manner. The Panel also encourages the CSAR staff to continue their efforts to compare the relative magnitudes of the radionuclide releases associated with each of the major pathways – airborne, surface water, and groundwater.

One approach for achieving the latter objective may be to assume that the entire radionuclide source term is available for release to the air, to surface water, and to groundwater. If one combines with these estimates the fraction of the total source term that is likely to be released to the given pathway, and the fraction that will be in a chemical and physical (for example, in a respirable particle size range in the case of releases to the atmosphere) form that is amenable to uptake by humans, such analyses could provide very useful information.

10. Evaluation of Inadvertent Criticality

One of the scenarios involves the possibility that deterioration of a NUHOMS storage cask could lead to an accumulation of spent nuclear fuel in a form that could become critical. This is based on the assumption that water enters a canister that has been ruptured and serves as a moderator for spent fuel that does not contain any neutron poisons. The Panel recommends that the CSAR staff conduct an analysis and, if such an event is conceivable, that they quantify the consequences. Since it is anticipated that vertical storage casks will be in use at many commercial nuclear power plant sites, similar analyses should be performed for these types of casks. Those responsible for such analyses should take into consideration the fact that vertical casks are based on ferritic (versus stainless) steel technology, that they will be subject to general corrosion (versus stress corrosion) cracking, and that the closure lid welds are highly stressed and will be a likely site of water entry. The longitudinal welds in these canisters are also subject to cracking.

11. Human Intrusion.

Just as staff members who are responsible for conducting the TSPA-VA recognize that at some future time an intruder may drill into the proposed high-level radioactive waste repository and establish a farm on top of the repository, the Panel believes that there is a distinct possibility that humans will intrude into certain DOE areas now restricted (for example, sites such as Idaho Falls, Savannah River, and Hanford). Such intrusions are certainly plausible for those time periods after institutional control is assumed to have been lost.

For this reason, the Panel believes that the staff responsible for preparing the CSAR must include an assessment of the dose rates to people who may, in the future, establish residence on the various DOE sites. For purposes of analysis, it should be reasonable to assume (as in the case of the TSPA-VA) that the population density of such settlements will be similar to those in these same regions today and that the living habits of the people involved will be similar to those of today.

12. Transparency of the Continuous Storage Analysis Report

One of the primary audiences for any type of Environmental Impact Statement and/or Assessment is the general public, especially those groups who might be considered to be stakeholders in the particular activity being evaluated. One of the key steps for ensuring such transparency is to include in the CSAR the description of the base case scenario described in item #3 above. Another step

is to assure that the words, as written, express exactly what the CSAR technical staff intends, and that all assumptions and uncertainties are acknowledged.

Another step that might be considered in this regard is for the CSAR staff to assure that the final report addresses each of the public comments on the "No Action Alternative" as summarized in Table A.3 (page A-23) of the "Summary of Public Scoping Comments" developed in conjunction with the EIS being prepared for the proposed high level radioactive waste repository at Yucca Mountain (U.S. DOE, 1997). Another report that may be useful (and which the CSAR staff probably has already reviewed in detail) is the "Standard Review Plan for Spent Fuel Dry Storage Facilities" prepared by the U.S. NRC (1996).

13. Background Information of Importance

Although it will may not be appropriate to include in the CSAR certain facts relative to the health effects of ionizing radiation and associated conservatisms, the Panel recommends that the CSAR staff be fully aware of these so that they can share them with appropriate groups if and when appropriate. These include the fact that:

a. The NCRP has taken care to state that:

"Based on the hypothesis that genetic effects and some cancers may result from damage to a single cell, the Council assumes that, *for radiation-protection purposes, the risk of stochastic effects is proportional to dose without threshold, throughout the range of dose and dose rates of importance in routine radiation protection*. Furthermore, the probability of response (risk) is assumed, for radiation-protection purposes, to accumulate linearly with dose. ... Given the above assumptions, radiation exposure at any selected dose limit will, by definition, have an associated level of risk." (Italics in original statement, as published). (NCRP, 1993, page 10, first full paragraph).

b. The NCRP has stated that:

"... whenever the collective dose is smaller than the reciprocal of the relevant risk coefficient, *e.g.*, less than 10 percent, the risk assessment should note that the most likely number of cancers deaths (in the exposed population) is zero." (NCRP, 1995, page 54, Section 5.2).

c. The NCRP has stated that:

"At some future time, it is possible that a greater proportion of somatic diseases cause by radiation will be treated successfully. If, in fact, an increased

proportion of the adverse health effects of radiation prove to be either preventable or curable by advances in medical science, the estimate of long-term detriments may need to be revised as the consequences (risks) of doses to future population could be very different." (NCRP, 1995, page 51, Section 4.2.2.3).

d. The ICRP has stated that:

"If the damage caused by radiation occurs in the germ cells, this damage (mutations and chromosomal aberrations) may be transmitted and become manifest as hereditary disorders in the descendants of the exposed individual. Radiation has not been identified as a cause of such effects in man, but experimental studies on plants and animals suggest that such effects will occur and that the consequences may range from the undetectably trivial, through gross malformations or loss of function, to premature death." (ICRP, 1991, page 21, paragraph [87]).

In a similar manner, the NCRP has stated that:

"... based on the human data alone, there is no clear evidence of genetic effects to which collective dose concepts should be applied." (NCRP, 1995, page 45, Section 3.4.2).

e. The ICRP has stated that:

"... the dose equivalent limits are intended to apply to the mean dose equivalent in a reasonably homogeneous group. In an extreme case, it may be convenient to define the critical group in terms of a single hypothetical individual, for example, when dealing with conditions well in the future which cannot be characterized in detail. Usually, however, the critical group would not consist of one individual nor would it be very large for then homogeneity would be lost. The size of the critical group will usually be up to a few tens of persons. In a few cases, where large populations are uniformly exposed, the critical group may be much larger. This guidance on size has certain implications; for example, in habit surveys it is not necessary to search for the most exposed individual within a critical group in order to base controls on that one person. The results of a habit survey at a particular point in time should be regarded as an indicator of an underlying distribution and the value adopted for the mean should not be unduly influenced by the discovery of one or two individuals with extreme habits." (ICRP, 1985, page 15, paragraph 67).

f. The NCRP has stated that:

A review of the literature suggests that "^{129}I does not pose a meaningful threat of thyroid carcinogenesis in people." (NCRP, 1985, page 41).

References:

International Commission on Radiological Protection, "Principles of Monitoring for the Radiation Protection of the Population," Publication 43, Annals of the ICRP, Vol. 15, No. 1, Pergamon Press (1985).

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National Council on Radiation Protection and Measurements, "Induction of Thyroid Cancer by Ionizing Radiation," Report No. 80, Bethesda, MD (March 30, 1985).

National Council on Radiation Protection and Measurements, "Limitation of Exposure to Ionizing Radiation," Report No. 116, Bethesda, MD (March 31, 1993).

National Council on Radiation Protection and Measurements, "Principles and Application of Collective Dose in Radiation Protection," Report No. 121, Bethesda, MD (November 30, 1995).

National Council on Radiation Protection and Measurements, "Screening Models for Releases of Radionuclides to Atmosphere, Surface Water, and Ground," Report No. 123, Volumes I and II, Bethesda, MD (January 22, 1996).

U.S. Department of Energy, "Summary of Public Scoping Comments Related to the Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Wasste at Yucca Mountain, Nye County, Nevada," Yucca Mountain Site Characterization Office, Las Vegas, NV (May, 1997).

U.S. Nuclear Regulatory Commission, "Standard Review Plan for Spent Fuel Dry Storage Facilities," Draft Report for Comment, NUREG-1567, Washington, DC (October, 1996).

REPORT OF SENIOR TECHNICAL REVIEW PANEL
Meeting of February 10, 1998

I. Introduction

The U.S. Department of Energy has established a Senior Technical Panel to review the critical assumptions and plans for preparing the "Continuous Storage Analysis Report" (CSAR) that is to accompany the Total System Performance Assessment - Viability Assessment (TSPA-VA) being prepared by the Yucca Mountain Site Characterization Office of the U.S. Department of Energy. This report summarizes the conclusions and recommendations of the Panel, based on its initial meeting on February 10, 1998, held at the offices of Jason Associates Corporation in Las Vegas, NV. Dr. Dade W. Moeller was appointed Chairman of the Panel. A list of the members of the Panel is shown in Appendix A; a copy of the Charter for the Panel is shown in Appendix B. In accordance with its Charter, this report is being submitted to the Project Manager, Jason Associates Corporation.

II. Details of Initial Meeting

Members of the Panel were welcomed by Wendy Dixon, DOE Assistant Manager for Environmental Health and Safety. She provided them with a brief outline of the questions they face and the information she desires for them to provide. This was followed by an introduction to the background on the CSAR and related technical aspects. This was provided by Dee Walker. In the course of the ensuing discussions, it was made clear that the Panel was not to serve as a Peer Review Group; rather it is to assist the DOE technical support staff in assuring that the assumptions underlying their analyses are sound, that the key issues have been properly defined, that the approaches being applied are adequate and justified, and that an acceptable format was being developed for the presentation of the study results. The Panel was instructed to focus on radiological, as contrasted to cost, impact issues.

The opening presentations were followed by about seven hours of in depth reviews of various aspects of the CSAR. These were provided by key members of the technical support staff. Throughout the technical briefings, Panel members interacted with the individual technical staff members and obtained detailed information on various aspects of the project. These exchanges resulted in the sharing of many comments and suggestions among the Panel members and the technical staff. A copy of the agenda for the meeting is shown in Appendix C.

III. Recommendations, Suggestions, and Comments of the Panel

Subsequent to the technical briefings, the Panel members met in executive session to summarize their preliminary findings and recommendations. This was followed by an oral briefing for Wendy Dixon, Dee Walker, and the CSAR technical support staff of these findings and recommendations. In all, the Panel offered findings, conclusions, and recommendations in twelve technical areas related to the CSAR. Also included in this report is a summary (part 13) of other factors that the staff preparing the CSAR should be cognizant of and refer to as appropriate. The purpose of this written report is to present the views of the Panel members in a formal manner.

1. Loss of Institutional Control

The technical staff has developed two scenarios for conducting the CSAR. These are the: (1) No-Action Scenario, assuming that institutional control continues over the long-term; and the (2) No-Action Scenario, assuming that institutional control is lost after an initial period of 100 years. In accord with its Charter, the Panel concentrated on the second Scenario. One of the immediate needs identified was a clear definition of what was meant by "loss of institutional control." There does not appear to be a clear definition in EPA's existing standards for WIPP (10 CFR 191 and 194) which form the basis for DOE's current anticipation that EPA will likely adopt a similar provision in its upcoming new standard for the proposed Yucca Mountain repository. However, the Panel believes that those preparing the CSAR need a clear definition in order to complete their analysis. Given the lack of clarity from EPA, the Panel believes that it will be necessary for DOE to specify whether loss of institutional control is assumed to take place in an orderly manner, in which case the facilities in question would undergo an orderly shutdown, or whether the loss of institutional control is assumed to take place abruptly, with sudden abandonment of the facilities. The Panel recommended that this matter be resolved. One approach, which should be used only if DOE cannot resolve the issue discussed immediately above, might be to evaluate the impacts assuming both orderly and abrupt loss of institutional control.

Another question that arose was whether there would be a significant difference if institutional control were lost after 200 or 300 years, versus 100 years. Based on its review, the Panel concluded that the time difference was not important.

2. Assuring Comparability of the Analyses

One of the goals of the technical staff is to assure that the assumptions and analytical techniques used in preparing the CSAR are comparable to those in the TSPA-VA. This includes being as consistent as possible in the models and analytical approaches being used. Ultimately, consistency with the TSPA-VA may be more important than accuracy because a major use of the CSAR will be to provide a comparison of the environmental risks of continued storage to those of geologic disposal. To assure that this goal is achieved, the Panel urged that the CSAR technical staff be thoroughly grounded in all

aspects of the TSPA-VA. This will entail keeping abreast of changes that are taking place, almost on a daily basis, in terms of the assumptions and approaches being used in preparing the TSPA-VA. In a similar manner, it is vital that members of the Senior Technical Panel be provided with detailed descriptions of the models being used to develop the TSPA-VA.

Also to be recognized is that the degrees of realism and conservatism are not equivalent in all aspects of the TSPA-VA. For this reason, the Panel recommended that, to the extent practical, the staff preparing the CSAR adopt similar assumptions and analytical techniques. Recognizing, however, that in some cases there may be reasons for adopting different assumptions and approaches, the Panel urged that the technical staff be careful to stipulate and justify (including the rationale for) these differences. Depending on the circumstances, the CSAR technical staff may want to consider presenting two outcomes -- one using the assumptions and analytical techniques being employed in developing the TSPA-VA; and one using the assumptions and analytical techniques that the CSAR staff has decided are more appropriate for the CSAR case. A specific example of the last consideration relates to the effect of cladding in retarding the migration of radionuclides from spent nuclear fuel.

3. Development of a Base Case Scenario

In the course of its review, the Panel observed that there was a lack of definition within the CSAR of the detailed time line and sequence of events that are assumed to occur as part of the Base Case Scenario. This is extremely important in assuring the transparency of the Continued Storage Analysis Report.

The benefits to developing details of the Base Case Scenario will be several, one of the most important being that it will help identify and quantify the uncertainties associated with the various steps in the processes that are postulated to lead to radionuclide releases. Specific examples where development of such scenarios will be helpful are in terms of the deterioration of the concrete in the NUHOMS storage casks, the accompanying failure of the canister housing the spent nuclear fuel, the resulting failure of the cladding, etc. In a similar manner, similar scenarios are needed to clarify the sequence assumed to take place in the failure of the borosilicate glass in which the high-level radioactive waste has been incorporated, and in the deterioration in the performance of the steel containers housing certain types of waste.

4. Delineation of Uncertainties

In the opinion of the Panel, there appear to be three major categories of uncertainties associated with the CSAR. If viewed as a hierarchy, the largest uncertainties are those associated with the identification and assumed sequence of events that comprise the base case scenarios. Of these, the most important is the scenario in which it is assumed that institutional control is lost after 100 years. The next (middle level) category involves the sequence of events that is assumed to transpire within this

scenario, the interrelationships of these events, and the uncertainties associated with each sequence. The third (lowest level) category of uncertainties is that associated with the analytical models used and the input data required to exercise these models.

Although it will not necessarily reduce the uncertainties, the Panel believes (as noted above) that it is imperative that, to the extent practical, the CSAR staff use the same models that are being used in developing the TSPA-VA. In any case where a different model is being used, care must be taken to assure that it has been accepted by appropriate Federal agencies such as the U.S. EPA and the U.S. NRC, through cooperative evaluation programs at the international level, or through widespread use in the private sector.

5. Uncertainties Associated With Specific Calculations

On the basis of its review to date, the Panel has concluded that there will be large uncertainties associated with a number of estimates being made in conjunction with the development of the CSAR. These include those associated with (a) the failure modes and timing of failures of the Zircaloy cladding; (b) the mechanisms of the corrosion of the stainless steel and the failure modes of the dry shielded canister (DSC); (c) the failure modes and timing of failures of the concrete envelopes; (d) water ingress and egress assumptions for the DSC; and (e) water dissolution of the waste form and subsequent environmental transport of the associated radionuclides. To estimate the release of radionuclides from the storage package, the CSAR staff plans to use solubility limit concentrations that have been developed by the TSPA-VA staff. The Panel recommends that the CSAR staff review the technical bases for the tabulated values.

In addition, there are similar uncertainties associated with estimates of (a) the collective population dose, and (b) the peak dose rate to the reasonably maximally exposed individual and the time when it will occur. In terms of the collective dose, the National Council on Radiation Protection and Measurements (NCRP, 1995) cautions that a single value of collective dose may be useful and meaningful only if "no individual dose or risk is predominant." If the range of doses to individuals covers several orders of magnitude, the distribution of doses must also be included in order to characterize the risk adequately, that is, to assure that a few cases at either extreme of the dose distribution range do not drive or disproportionately affect the characteristics of the risk. In fact, the NCRP goes on to suggest that the "distribution might be best characterized by dividing it into several ranges of individual doses, each covering two or three orders of magnitude, with the population size, average individual dose, collective dose, and uncertainty given for each range."

Estimates of the peak dose rate and the time of its occurrence will be even more complicated. This is due, among other things, to the multiple pathways and multiple sites that must be considered. In contrast, the TSPA-VA involves only one site and one principal pathway (via groundwater). Due to the magnitude of the associated

uncertainties, the Panel questions whether the outcomes of such an exercise will have any practical value. Most importantly, will it provide any useful insights? Unless such an exercise is required, or useful insights are identified, the Panel recommends that it not be done.

6. Input Data to Risk Assessments

In addition to the evaluation of uncertainties, it is also important to recognize the multitude of conservatisms involved in certain of the techniques used in conducting the risk assessments. At one level, there is the use of techniques for the design of concrete structures as a vehicle for assessing the performance of such structures over long periods of time. Design procedures were not developed with risk assessment applications in mind, nor should they be used directly for risk assessments. At another level, many of the philosophies and concepts being used in assessing the health impacts of radiation exposures were developed for purposes of radiation protection. They should not be used for purposes of risk assessment without carefully evaluating the fundamental concepts on which they were based. Examples are the linear-no-threshold hypothesis and the tissue weighting factors developed for converting organ doses into effective (whole body) doses.

7. Application of Bounding Calculations

In certain cases, it may be useful to conduct bounding calculations to determine that a given sequence of events is not important in terms of radionuclide releases and accompanying exposures to the public. In such cases, however, the CSAR staff should recognize the high degree of conservatism incorporated into such analyses. So long as they yield doses that are in a range considered to be trivial, such calculations are useful. If they yield doses that are significant, more detailed analyses using site-specific input data will be required. As part of such analyses, the CSAR staff should give careful consideration to the screening models that have been developed by the NCRP (1996).

To account for large uncertainties, conservative assumptions are often made in the analysis of safety and environmental impacts. Because, as noted in Section 3 above, the results of the CSAR analyses will be used to compare alternative waste disposal strategies, the CSAR staff must be careful to avoid conservative assumptions that could distort that comparison.

In the sense that they can save time and effort, the Panel recommends that the CSAR staff take advantage of generic calculations as part of their risk assessment process. Such calculations, for example, could be very useful in analyzing certain release scenarios for "wet," versus "dry," sites.

8. Impacts of External Phenomena

External phenomena that can have adverse impacts on waste storage facilities include earthquakes, tornadoes, hurricanes, floods, and aircraft crashes. The Panel understands that the CSAR staff has tentatively decided that all such events are bounded by the impacts of an aircraft crash. Before the staff makes a decision not to evaluate the impacts of the other events, the Panel recommends that they perform a simple, scoping analysis to estimate the probability of each such event at one or more key waste storage sites. In those cases in which the estimated probability appears to be sufficiently high, the Panel recommends that the CSAR staff evaluate the associated consequences. There are two reasons behind the Panel's expression of concern on this matter: (a) The occurrence of an earthquake, for example, could significantly advance the time when a significant radionuclide release may occur; and (b) The suggested approach would be more consistent with that being used in the TSPA-VA. Another reason for concern about the impacts of a seismic event is that the waste material may not be covered in a rubble pile as is assumed if the surrounding structure fails due to deterioration over time.

9. Sensitivity Studies

The Panel endorses the plan of the CSAR staff to conduct sensitivity analyses to identify those input parameters that must be quantified in a more exacting manner. The Panel also encourages the CSAR staff to continue their efforts to compare the relative magnitudes of the radionuclide releases associated with each of the major pathways – airborne, surface water, and groundwater.

One approach for achieving the latter objective may be to assume that the entire radionuclide source term is available for release to the air, to surface water, and to groundwater. If one combines with these estimates the fraction of the total source term that is likely to be released to the given pathway, and the fraction that will be in a chemical and physical (for example, in a respirable particle size range in the case of releases to the atmosphere) form that is amenable to uptake by humans, such analyses could provide very useful information.

10. Evaluation of Inadvertent Criticality

One of the scenarios involves the possibility that deterioration of a NUHOMS storage cask could lead to an accumulation of spent nuclear fuel in a form that could become critical. This is based on the assumption that water enters a canister that has been ruptured and serves as a moderator for spent fuel that does not contain any neutron poisons. The Panel recommends that the CSAR staff conduct an analysis and, if such an event is conceivable, that they quantify the consequences. Since it is anticipated that vertical storage casks will be in use at many commercial nuclear power plant sites, similar analyses should be performed for these types of casks. Those responsible for such analyses should take into consideration the fact that vertical casks are based on

ferritic (versus stainless) steel technology, that they will be subject to general corrosion (versus stress corrosion) cracking, and that the closure lid welds are highly stressed and will be a likely site of water entry. The longitudinal welds in these canisters are also subject to cracking. These characteristics are important in terms of criticality as well as the base case scenario.

11. Human Intrusion.

Just as staff members who are responsible for conducting the TSPA-VA recognize that at some future time an intruder may drill into the proposed high-level radioactive waste repository or establish a farm near the repository, the Panel believes that there is a distinct possibility that humans will intrude into certain DOE areas now restricted (for example, sites such as Idaho Falls, Savannah River, and Hanford). Such intrusions are certainly plausible for those time periods after institutional control is assumed to have been lost.

For this reason, the Panel believes that the staff responsible for preparing the CSAR must include an assessment of the dose rates to people who may, in the future, establish residence on the various DOE sites. For purposes of analysis, it should be reasonable to assume (as in the case of the TSPA-VA) that the population density of such settlements will be similar to those in these same regions today and that the living habits of the people involved will be similar to those of today.

12. Transparency of the Continuous Storage Analysis Report

One of the primary audiences for any type of Environmental Impact Statement and/or Assessment is the general public, especially those groups who might be considered to be stakeholders in the particular activity being evaluated. One of the key steps for ensuring such transparency is to include in the CSAR the description of the base case scenario described in item #3 above. Another step is to assure that the words, as written, express exactly what the CSAR technical staff intends, and that all assumptions and uncertainties are acknowledged.

Another step that might be considered in this regard is for the CSAR staff to assure that the final report addresses each of the public comments on the "No Action Alternative" as summarized in Table A.3 (page A-23) of the "Summary of Public Scoping Comments" developed in conjunction with the EIS being prepared for the proposed high level radioactive waste repository at Yucca Mountain (U.S. DOE, 1997). Another report that may be useful (and which the CSAR staff probably has already reviewed in detail) is the "Standard Review Plan for Spent Fuel Dry Storage Facilities" prepared by the U.S. NRC (1996).

13. Background Information of Importance

Although it will may not be appropriate to include in the CSAR certain facts relative to the health effects of ionizing radiation and associated conservatisms, the Panel recommends that the CSAR staff be fully aware of these so that they can share them with appropriate groups if and when appropriate. These include the fact that:

a. The NCRP has taken care to state that:

"Based on the hypothesis that genetic effects and some cancers may result from damage to a single cell, the Council assumes that, *for radiation-protection purposes, the risk of stochastic effects is proportional to dose without threshold, throughout the range of dose and dose rates of importance in routine radiation protection.* Furthermore, the probability of response (risk) is assumed, for radiation-protection purposes, to accumulate linearly with dose. ... Given the above assumptions, radiation exposure at any selected dose limit will, by definition, have an associated level of risk." (Italics in original statement, as published). (NCRP, 1993, page 10, first full paragraph).

b. The NCRP has stated that:

"... whenever the collective dose is smaller than the reciprocal of the relevant risk coefficient, *e.g.*, less than 10 percent, the risk assessment should note that the most likely number of cancers deaths (in the exposed population) is zero." (NCRP, 1995, page 54, Section 5.2).

c. The NCRP has stated that:

"At some future time, it is possible that a greater proportion of somatic diseases cause by radiation will be treated successfully. If, in fact, an increased proportion of the adverse health effects of radiation prove to be either preventable or curable by advances in medical science, the estimate of long-term detriments may need to be revised as the consequences (risks) of doses to future population could be very different." (NCRP, 1995, page 51, Section 4.2.2.3).

d. The ICRP has stated that:

"If the damage caused by radiation occurs in the germ cells, this damage (mutations and chromosomal aberrations) may be transmitted and become manifest as hereditary disorders in the descendants of the exposed individual. Radiation has not been identified as a cause of such effects in man, but experimental studies on plants and animals suggest that such effects will occur and that the consequences may range from the undetectably trivial, through gross malformations or loss of function, to premature death." (ICRP, 1991, page 21, paragraph [87]).

In a similar manner, the NCRP has stated that:

"... based on the human data alone, there is no clear evidence of genetic effects to which collective dose concepts should be applied." (NCRP, 1995, page 45, Section 3.4.2).

e. The ICRP has stated that:

"... the dose equivalent limits are intended to apply to the mean dose equivalent in a reasonably homogeneous group. In an extreme case, it may be convenient to define the critical group in terms of a single hypothetical individual, for example, when dealing with conditions well in the future which cannot be characterized in detail. Usually, however, the critical group would not consist of one individual nor would it be very large for then homogeneity would be lost. The size of the critical group will usually be up to a few tens of persons. In a few cases, where large populations are uniformly exposed, the critical group may be much larger. This guidance on size has certain implications; for example, in habit surveys it is not necessary to search for the most exposed individual within a critical group in order to base controls on that one person. The results of a habit survey at a particular point in time should be regarded as an indicator of an underlying distribution and the value adopted for the mean should not be unduly influenced by the discovery of one or two individuals with extreme habits." (ICRP, 1985, page 15, paragraph 67).

f. The NCRP has stated that:

A review of the literature suggests that "^{129}I does not pose a meaningful threat of thyroid carcinogenesis in people." (NCRP, 1985, page 41).

Respectfully submitted,

Dade W. Moeller, Ph.D.

February 20, 1998
(date)

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International Commission on Radiological Protection, "1990 Recommendations of the International Commission on Radiological Protection," Publication 60, Annals of the ICRP, Vol. 21, No. 1-3, Pergamon Press (1991).

National Council on Radiation Protection and Measurements, "Induction of Thyroid Cancer by Ionizing Radiation," Report No. 80, Bethesda, MD (March 30, 1985).

National Council on Radiation Protection and Measurements, "Limitation of Exposure to Ionizing Radiation," Report No. 116, Bethesda, MD (March 31, 1993).

National Council on Radiation Protection and Measurements, "Principles and Application of Collective Dose in Radiation Protection," Report No. 121, Bethesda, MD (November 30, 1995).

National Council on Radiation Protection and Measurements, "Screening Models for Releases of Radionuclides to Atmosphere, Surface Water, and Ground," Report No. 123, Volumes I and II, Bethesda, MD (January 22, 1996).

U.S. Department of Energy, "Summary of Public Scoping Comments Related to the Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada," Yucca Mountain Site Characterization Office, Las Vegas, NV (May, 1997).

U.S. Nuclear Regulatory Commission, "Standard Review Plan for Spent Fuel Dry Storage Facilities," Draft Report for Comment, NUREG-1567, Washington, DC (October, 1996).

Appendix A

List of Senior Technical Panel Members

1) radionuclide multimedia transport, biosphere, and risk assessment

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Appendix B

Charter
Continued Storage Analysis Senior Technical Panel

DESCRIPTION OF GROUP

The Continued Storage Analysis Senior Technical Panel ("Technical Panel") consists of at least three but no more than five senior technical experts who possess significant qualifications and experience covering the disciplines of:

1) radionuclide multimedia transport, biosphere, and risk assessment,
2) spent nuclear fuel and high level radioactive waste storage container degradation,
3) waste form degradation and environmental release,
4) facility degradation and failure mechanisms, and
5) integrated performance assessment.

Individuals who make up this Technical Panel will be independent from full time day-to-day Yucca Mountain Site Characterization Project functions, but members of the panel may be employed by companies who are involved in such day-to-day functions. The Technical Panel will report to the Jason Technologies Project Manager (Report Preparer) for all work performed. Each Technical Panel member is explicitly authorized to contact the OCRWM Director directly if that member believes the Report Preparer is being unresponsive or is otherwise not listening to their input regarding the continued storage analysis.

An ex officio group member will be named to act as a group facilitator, be a focal point to provide information to the group, ensure group participation, handle logistical details of group activities, and ensure written Technical Panel reports are timely and represent the opinions of each Technical Panel member. One of the Technical Panel members will be appointed to chair the panel.

TASK TO BE PERFORMED

Review and assist the Report Preparer with refinement of the critical assumptions and plans for preparing the "Continued Storage Analysis Report" (Analysis Report) to be completed in the same time frame as the Viability Assessment (VA) Report being prepared by the Yucca Mountain Site Characterization Office (YMSCO).

Scope: This task will focus on the intended purposes, scope, and audience of the Analysis Report, and involve review of key underlying assumptions. This task will also involve analysis of, and development of recommendations for, fundamental issues associated with the Analysis Report. The Technical Panel will have the benefit of a presentation in February 1998 to describe the methodology planned for the continued

storage analysis, the underlying assumptions to be used in the analysis, significant issues that must be addressed, and the process that will be followed in conducting the analysis. The presentation will be interactive, with the Technical Panel expected to ask relevant questions necessary to perform their function. Upon presentation of the analysis plans and guidance received from the DOE, the Technical Panel will meet independently and develop preliminary comments and input regarding the planned analysis for the Analysis Report. This preliminary input will be followed within 10 working days by written input submitted to the Report Preparer.

It is expected that the Technical Panel will conduct an ongoing dialogue with the Analysis Report preparation team to facilitate appropriate incorporation of the Technical Panel's advice into the analysis. Additional briefings may be given to the Technical Panel regarding progress on the continued storage analysis, any problems or concerns regarding the conduct of the analysis, and the preliminary results of the analysis. After each briefing, the Technical Panel will meet independently and develop preliminary input regarding the status of the analysis and progress to date, and present its input to the Report Preparer. Dialogue will be conducted between the Technical Panel and the Report Preparer regarding preliminary observations and input, followed by development of written Technical Panel input within 10 working days of each working session. The ultimate goal of Technical Panel participation is to apply the significant experience and qualifications of the Technical Panel members in the development of a reasonable set of assumptions for the Continued Storage Analysis. Written acknowledgment by the Technical Panel of such reasonableness, once their input is incorporated, is expected.

ESTIMATE OF PARTICIPATION REQUIREMENTS

The following estimates of the participation requirements, between February and May 1998 for each Senior Technical Panel member, are presented for planning purposes.

- Initial presentation by Analysis Report preparation team and preparation of Technical Panel input regarding analysis plans [including underlying assumptions].

24–32 hours per member for pre-review of planning and background documents
16–24 hours to attend initial working session in Las Vegas
16–32 hours to participate in drafting and reviewing first written Technical Panel report

Ongoing Technical Panel participation.

40–80 hours to interface with Analysis Report preparation team and to review background documents prior to subsequent working sessions
16–48 hours to attend working sessions in Las Vegas or other specified locations
16–48 hours to participate in drafting and reviewing written Technical Panel reports

Appendix C

AGENDA FOR SENIOR TECHNICAL PANEL WORKING SESSION - 2/10/98

1. Welcome and Introduction, Wendy Dixon/Ken Skipper - 15 minutes

2. Goals, Walker - 10 minutes

3. Structure of EIS Alternatives, Walker - 10 minutes

    a. action

    b. no-action, 2 scenarios

    c. This report focuses on consequences of continued storage of SNF and HLW

4. Desk Drawer viewgraphs to frame problem, Walker - 10 minutes

5. Summary of Barrett instructions, Walker - 15 minutes

    a. timing with VA

    b. comparability--"apples to apples" re: VA

    c. impact parameters, peak dose, latent cancer fatalities, cost

    d. Defensibility and role of technical panel in this respect.

6. Summary of primary technical problems, Walker - 15 minutes

7. Basis for Selecting Panel Members, Ziegler - 10 minutes

    a. Makeup of panel

    b. Charter

    c. Expectations

    d. Schedule and timing of written input

8. No-Action, Rollins - 15 minutes

    a. Scenarios and why selected

    b. comparison of EIS analysis and analysis for this report

BREAK - 10 minutes

9. Walk through of analytical technical areas and approach.

a. Inventory, Walker - 20 minutes

- Issues/Assumptions necessary to perform analysis

b. Facility degradation, Poe - 30 minutes

Summary of existing analysis report. Analysis approach and basis. Is it sufficient for an SNF storage facility? If not what do we plan to do?

-assumptions necessary to perform analysis

c. Storage container degradation, Mishima or Poe - 45 minutes

-Approach proposed and basis

-Presentation on TSPA model and its applicability to continued storage conditions (support available from TSPA modelers)

-Work still needed

-Issues/Assumptions necessary to perform analysis

LUNCH - 15 minute break and continue working while we eat

d. Waste form degradation and radionuclide release - 45 minutes

-Approach selected, Mishima

-Presentation on TSPA model and its applicability to continued storage conditions (support available from TSPA modelers)

-Assumptions necessary to perform analysis

-Work still needed

e. Source term splits between liquid and air pathways - 30 minutes

- Data available- Mishima

- possible approaches for estimates, Rollins

-Issues/Assumptions necessary to perform analysis

-Work still needed

f. Liquid pathway splits between surface water and groundwater, Rollins - 30 minutes

- data available

- Issues/Assumptions necessary to perform analysis
  - possible approaches to produce estimates
  - potential for bounding calculations to limit groundwater pathway dose calculations

BREAK - 10 minutes

g. Other analytical topics and issues, discussion - 30 minutes

- Natural Phenomena
- Accidents
- Other?
- Issues/Assumptions necessary to perform analysis

10. Consequence calculations, Rollins - 30 minutes

a. MEPAS code and basis for its selection

b. Expected timing of peak doses for repository and continued storage cases. Comparability?

c. Population doses (integrated doses), for 10,000 years and for period to peak dose, comparability.

d. Difficulties in generating meaningful total integrated dose numbers (requires calculations to 1 million years plus).

11. Technical Panel Discussion (w/o Jason) - 90 minutes

12. Technical Panel Feedback to Jason Team - 30 minutes

13. Path forward - 30 minutes

Note: Will stay until 8:00 PM if necessary - time estimates are expected minimums

REPORT OF SENIOR TECHNICAL REVIEW PANEL
Meeting of April 3, 1998

I. Introduction

The second meeting of the Senior Technical Panel was held at the offices of the Jason Associates Corporation in Las Vegas, NV, on April 3, 1998. The Panel has been assigned the task of reviewing the critical assumptions and plans for preparing the "Continuous Storage Analysis Report" (CSAR) or the "No Action" scenario that is to accompany the Total System Performance Assessment - Viability Assessment being prepared by the Yucca Mountain Site Characterization Office of the U.S. Department of Energy. This report summarizes the conclusions and recommendations that were developed by the Panel, as a result of its second meeting. At the request of Joe Ziegler, Technical Panel Administrator, the report includes a summary of the status of each of the items identified in our initial report (based on the meeting held by the Panel on February 10, 1998). The agenda for the meeting on April 3, 1998, is shown in Appendix A. In accordance with the Charter for the Panel, this report is being submitted to the Project Manager, Jason Associates Corporation.

II. Details of Second Panel Meeting

1. Opening Comments

The meeting convened at 8:00 a.m. and members of the Panel were welcomed by Dee Walker. Mr. Walker immediately followed with a discussion of the decisions that had been made regarding major issues identified at the first meeting, such as the "Loss of Institutional Control" and "Comparability Analysis." He also reminded the Panel of the goals of this meeting – namely, for the Panel to:

a. Hear a report on the status of impact analysis and planned approaches;
b. Be briefed on the principal issues and to provide feedback;
c. Review assumptions in the analysis and to provide feedback; and
d. Discuss potential approaches to uncertainty analysis.

Time did not permit the Panel to discuss item "c" in detail. However, a list of the assumptions being made in the "Continued Storage Analysis Report" was distributed (see Appendix B), and each Panel member was asked to submit his individual comments on each assumption within the next few weeks.

The major problems identified and discussed by Mr. Walker included:

a. Fuel dissolution rate;
b. Cladding failure;
c. Nature of container failure;
d. Latent Cancer Fatality calculations
e. Population distribution; and
f. Climate change.

A key difference in the nature of the events that can occur under the "No Action" approach, versus the development and operation of the proposed repository at Yucca Mountain, is that water is anticipated to be far more readily available at the multiple above ground storage facilities/sites postulated under the "No Action" scenarios. In addition, it was noted that the initiating events that are postulated to lead to radionuclide releases are entirely different in the two cases.

2. Impact Estimates – Review of Biosphere Analyses

Next were a series of presentations by Gene Rollins and Al Toblin. These pertained to the fate and transport of radionuclides, exposure scenarios and impact calculations, intruder scenarios, and bounding calculations.

One difference noted by the Panel was that, whereas a review of applicable biosphere models by the team preparing the TSPA-VA for the proposed repository led them to select the GENII-S code as being most appropriate, a similar review by the team analyzing the "No Action" scenarios led them to conclude that the MEPAS code is more appropriate. One of the justifications for the selection of MEPAS for analyses of the "No Action" scenarios is that it has been recommended for EPA for use in the analyses of Superfund sites. Another more fundamental reason for the selection is that MEPAS has the capabilities for analyzing changes in radionuclide concentrations during ground water transport, whereas the GENII-S code does not. In fact, the GENII-S code appears to be limited primarily to the analysis of atmospheric releases. Doses due to contaminants in ground water can be estimated only if the analyst is provided data on the concentrations of the individual radionuclides within the ground water at the point of interaction with the exposed population group. This will certainly be an area that the Panel will want to follow and explore.

Another area of difference is that the MEPAS code is designed to estimate collective risk, while GENII-S is not. As such, whereas the "No Action" analyses will include doses to population groups (which is a measure of collective risk), the TSPA-VA for the proposed repository will not. Another apparent advantage of MEPAS is that it can handle solute transport; it cannot, however, analyze the impacts of particulates suspended in water and the effects of the accompanying

sedimentation. One question raised by the Panel was whether, assuming identical concentrations of radionuclides in water, the MEPAS and GENII-S codes would yield the same estimates of dose?

Although, in the main, it is anticipated that analyses associated with the "No Action" scenarios will primarily involve the evaluation of the impacts of radionuclide contaminants in surface water, several Panel members pointed out that, in some cases, contaminants in ground water may be a factor. In these cases, the values of the soil adsorption K_ds, that are selected and/or assumed, can have orders of magnitude impacts on the magnitudes of the resulting dose estimates.

As a result of these discussions, the Panel requested that the team conducting the "No Action" analyses provide the Panel with an indication of the contribution to the population dose from ground water, surface water, and the airborne pathway, as a function of time into the future.

Gene Rollins pointed out that, in terms of the dose estimates being calculated for biosphere transport, every effort will be made to assure that the analyses for the "No Action" scenarios are comparable to those being done for the TSPA-VA. In terms of the "No Action" analyses, dose estimates will be made for the maximally exposed individual (MEI). This will include, in some cases, a residential intruder (comparable to the residential farmer for the proposed Yucca Mountain repository), and the doses due to contamination of surface waters. The latter will include doses for rivers and streams to the point downstream where the water enters the ocean. In this regard, the MEPAS code permits the analysts to take into account the removal of radionuclides provided by treatment processes applied to surface waters prior to consumption. Even with the loss of institutional control, however, the assumption is made that downstream users of surface waters will continue to treat the water prior to consumption. For atmospheric releases, the dose estimates will be extended out to a range of 80 kilometers (50 miles).

On the basis of preliminary analyses, it appears that the population (collective) dose will be controlling, not the dose to the MEI. This will depend, however, on the nature of the EPA standards. A key item will be the limits that are placed on radionuclide concentrations in ground water. Although, in the past, EPA has indicated that such concentrations must be limited so that the annual effective dose due to the consumption of such waters not exceed 4 mrem, in its planned revisions of the National Primary Drinking Water Standards EPA has indicated that they may impose more restrictive limits. Their justification for the proposed approach is that it is required by the Safe Drinking Water Act of 1996. The proposed changes could have major impacts on the ability of DOE to demonstrate that the proposed repository meets the proposed EPA standards.

As these assessments continue, it is important to recognize that the form and nature of the EPA standards have not yet been announced. If the standards prescribe a dose limit for individuals, there may not be a need to estimate collective (population) doses. If this proves true, there may also not be a need to estimate the accompanying numbers of excess latent cancer fatalities that may occur within the exposed population groups.

At the end of the discussion, the Panel requested that the report of the analyses of the "No Action" scenarios include a table so that comparisons can be made between the dose estimates to the various population groups exposed under these scenarios and those exposed through operation of the proposed Yucca Mountain repository. In addition, it was requested that the Panel be provided a list of the key assumptions that are being made in estimating the doses in each of the two cases.

3. Environmental Flux Calculations

The next session included presentations on engineered barrier and storage container failures by Lee Poe and Pete Pelto, on waste form degradation by Pete Pelto, and on improved/more realistic models by Jofu Mishima.

Lee Poe indicated that two types of casks had been selected to bound the analyses – the NUHOMS horizontal cask and a "vertical steel cask." Failure analyses include the impacts of rain (containing various impurities) and freeze/thaw weather cycles in degrading concrete storage casks. Preliminary analyses indicate that the freeze/thaw effects will be the dominant failure mechanism for surface concrete casks. For subsurface concrete vaults, roof collapse due to corrosion of reinforcing bar appears to be the dominant failure mechanism. The Panel noted, however, that the analyses do not take into account conservatisms in the factors used in designing the casks. For purposes of analyses of concrete casks at the multitude of nuclear power plants sites in the U.S., the staff plans to assign the surface casks to one of 5 bins in terms of precipitation and failure times after loss of institutional control, and the subsurface casks to 2 bins in terms of humid (Savannah River Site) and arid (Hanford and Idaho) regions.

In a follow-up presentation, Pete Pelto shared with the Panel his preliminary thinking in terms of the analyses of failures of ferritic steel and stainless steel storage containers. At present, these analyses are in the earliest stages. The Panel noted that, if the results are to be useful, they must be made available relatively soon. Panel members also reminded the staff that the TSPA-VA being prepared for the proposed Yucca Mountain repository indicates that the fuel that has stainless steel clad, although constituting less than 1.5% of the total, is

estimated to dominate the radionuclide releases. The Panel was informed, however, that the analysts for the "No Action" scenarios had recognized this potentiality and taken it into consideration. As a result, the analyses being conducted for the "No Action" scenarios are based on the assumption that, for those facilities/sites having fuel with stainless steel clad (for example, Millstone and Indian Point), the fuel has no clad; in the case of facilities having fuel with zirconium clad, credit is being taken for the retention capabilities of the clad. This is similar to the approach being used for the TSPA-VA. Although the models for analyzing the zirconium fuel are yet to be confirmed, initial results indicate that it will require some tens of thousands of years for the zirconium clad to fail. A key factor in determining radionuclide release rates from zirconium fuel is what are called "juvenile" failures – that is, releases from the 0.1% of the fuel that is assumed to already have failed clad at the time it is placed in storage.

The final presentation in this session was made by Jofu Mishima who addressed a mechanistic approach for developing preliminary radionuclide release estimates from various types of fuel/waste. Included in his estimates were assumptions and/or analyses for predicting the impacts of loss of protection of the fuel due to weather effects on buildings, water infiltration, cladding dissolution, radionuclide release, and near-field transport. Included in the assessment of each of these events are assumptions that must be made relative to a host of input parameters. As a result of these discussions, the Panel recommended that the staff provide information on the approaches being used for analyses of the failure rates for each type of spent fuel/waste, as well as time lines for their anticipated failures. Suggested examples include commercial spent nuclear fuel, DOE vitrified HLW at Savannah River, and the N-Reactor fuel at Hanford.

4. Analysis of Extreme Events and Criticality

The next session was devoted to an analysis of extreme events, with emphasis on aircraft crashes, as contrasted to seismic and other events. These presentations were made by Dee Walker, Pete Davis, and Larry Kripps. In his opening remarks, Dee Walker emphasized how important it is that the analysts not appear, either directly or by implication, to be unduly exaggerating the analyses of the "No Action" scenarios in order to ensure that the accompanying dose estimates will exceed those for the TSPA-VA. In this regard, he pointed out that, on the basis of their reviews and evaluations, the team conducting the analyses had concluded that the impacts of an aircraft accident at one or more of the sites, where commercial nuclear fuel is to be stored, could readily result in a risk that was in excess of that from the proposed repository at Yucca Mountain. With an estimated total of 75 sites where it is anticipated that spent fuel and waste will be stored, it is almost certain that over the next 10,000 years at least one will be involved in a direct hit as a result of an airplane crash. The

accompanying risk appears clearly to exceed that for other natural events such as tornadoes, or earthquakes.

Expanding on this, Pete Davis indicated that they have population demographics for all proposed fuel/waste storage sites and that, for purposes of analyses, they plan to assume that all the radionuclides in one fuel assembly are released to the atmosphere. In commenting on this approach, the Panel cautioned that care should be taken to recognize that most of the commercial nuclear power plant sites are located in areas of the U.S. that have higher densities of air traffic (by an order of magnitude) than the national average. Unless this difference is taken into account, the analyses may not be accurate.

In his analysis of criticality, Larry Kripps assumed that the ingress of water into a storage cask, without any change in geometry of the spent fuel and/or movement of the neutron poison, would result in a critical event. Exacerbating the problem is that the stored fuel will include some with very low burn-up. Adding to the increased probability of such an event is the long time period (10,000 years) in question. This being the case, it appears that the best approach is to analyze the consequences, without devoting too much time to establishing the associated probabilities for occurrence. In order to bound the impacts, the analytical team hopes to define the reasonably possible criticality that could occur at several representative sites. At the same time, however, the Panel urged that the staff recognize that, unless the time span for the development of criticality is extremely short, the resulting impacts will not be that severe. Also to be recognized is that, while the amount of fission product activity generated by such an event could be large, most is associated with relatively short lived radionuclides.

As a result of this discussion, the Panel recommended that the staff ensure that a sufficient variety of casks and spent fuels are to be analyzed to establish that the impacts of a criticality event are bounded.

In his closing remarks for this session, Dee Walker indicated that, in terms of uncertainty analyses, the staff may be compelled, due to the lack of time, to depend on expert elicitation for input. The Panel responded by pointing out that, such an approach – using expert elicitation versus developing the data – violates one of the basic guidelines on the use of this technique. If this approach is nevertheless used, it must be carefully documented.

5. Comparative Risks and Insights

In a final session, Andy Dykes shared with the Panel some thoughts on the tasks that analyses of the "No Action" scenarios entail. He suggested that there was a need to distinguish parameter uncertainty from model uncertainty; to conduct

sensitivity studies to establish which factors dominate the estimated doses; and that the analyses of the two approaches – the "No Action" scenario versus placing the waste in the proposed Yucca Mountain repository – be restricted to time periods when the risks can be quantified. The Panel responded by indicating that it is also important to include in the analyses certain qualitative, and/or intuitive assessments, that provide insights that might otherwise be missed. An example is to compare the impacts of a glacier on above ground stored fuel/waste versus the impacts on the same waste if placed in a geologic repository. In the latter case, the glacier will most likely have no impact. In the former case, the glacier will spread the fuel/waste around and make it readily accessible to the public both then and in the future. Another example is that fuel/waste on the surface will have the potential ultimately to contaminate a large fraction of the U.S. This is not the case if the fuel/waste is placed in a repository.

In terms of the impacts of all aspects of climate change, the Panel believes that the analyses should be presented in a qualitative manner, taking care to avoid any implications that the estimates are meaningful in a quantitative sense. The underlying assumptions should be comparable to those used in the analyses of the proposed Yucca Mountain repository.

III. Recommendations, Suggestions, and Comments of the Panel

Subsequent to the technical briefings, the Panel members met in executive session to summarize their preliminary findings and recommendations. This was followed by an oral briefing for Wendy Dixon, Dee Walker, and the DOE technical support staff. In all, the Panel offered findings, conclusions, and recommendations in twelve technical areas related to the Continuous Storage Analysis. These are summarized below. As will be noted, several of them repeat comments of the Panel that were noted in the previous sections of this report.

1. *Goals of the Analyses*

In planning the analyses and presentation of the results, care should be taken to ensure that the analysts keep in mind the goals of the process as well as the best ways to achieve these goals. In this regard, the Panel was impressed by the thoughts and suggestions shared by Andy Dykes regarding the tasks that analyses of the "No Action" scenarios entail. The Panel concurs that there is a need to distinguish parameter uncertainty from model uncertainty; to conduct sensitivity studies to establish which factors dominate the estimated doses; and that comparisons of the results of the analyses of the two approaches – the "No Action" scenarios versus placing the waste in the proposed Yucca Mountain repository – be restricted to time periods when the risks can be quantified.

2. Presentation of Results

It is important that the results of the analyses for the two contrasting approaches ("No Action" versus placement of the spent fuel/waste in the proposed repository) be presented in a manner so as to permit the impacts for the two approaches to be directly compared one with the other. One possible step would be to include in the report of the analyses of the "No Action" scenarios a table that will enable the reader to readily compare the impacts on the various population groups exposed under these scenarios to those on equivalent (or comparable) groups who might be exposed as a result of the operation of the proposed Yucca Mountain repository. Included as an integral part of such a presentation should be a list of the key assumptions that were applied in estimating the doses in the two cases.

There is a similar need to present the results of the analyses of the "No Action" scenarios so that the impacts with and without institutional control can be appropriately compared. In this regard, the Panel recommends that Scenario #1 (continued institutional control) and Scenario #2 (loss of institutional control) be compared during equivalent time periods and only during those periods when the estimates can be quantified.

To accomplish these and other objectives, the Panel recommends that the project team prepare a draft set of figures and tables that show how the results of the study will be presented and how comparisons will be made with the Yucca Mountain repository option. It is important to agree on the approaches to the presentation of results in order both that the project team will perform the appropriate analyses, and that the need for reanalysis or additional analyses will be minimized. Approaches to the presentation of the results the project team should consider include:

A table that shows how the maximally exposed individual and population doses are defined for the Yucca Mountain and "No Action" studies and how they will be compared.

Figures showing how storage cask degradation and radionuclide releases as a function of time will be compared and how accident results will be shown in this format.

Figures or tables showing how sensitivity study results will be presented.

- An indication of the contribution to the maximally exposed individual and to the exposed population group through each of the more prominent pathways (ground water, surface water, and airborne releases) as a function of time.

3. Sensitivity Analyses and Uncertainties

Although the staff has indicated that they do not have time to develop an approach for conducting sensitivity analyses and assessing the associated uncertainties, the Panel urges that care be taken not to pass off the decisions on these key issues to outside people (even though they may be considered to be experts). On the basis of the information that Andy Dykes shared, the Panel believes that he may have useful guidance to offer in resolving this issue.

4. Quantification of Conservatisms

There is a need to quantify the conservatisms in the analyses for the "No Action" scenarios versus placement of the spent fuel/waste in the proposed geologic repository. In this regard, care must be taken by the analysts not to appear, either directly or by implication, that they are incorporating into the analyses of the "No Action" scenarios an overabundance of conservative assumptions in order to ensure that the accompanying dose estimates will exceed those for the TSPA-VA. Possible examples of potential errors that could be made include the use of average aircraft densities in conducting the analyses of the impacts of an aircraft crash, and assuming an excessive number of fissions in the analyses of criticality.

5. Failures of Storage Containers and Fuel Containers

Two types of casks had been selected to bound the analyses for failures of storage casks and containers. Preliminary analyses indicate that the freeze/thaw effects will be the dominant failure mechanism for surface concrete casks. For subsurface concrete vaults, roof collapse due to corrosion of reinforcing bar appears to be the dominant failure mechanism. In this regard, the Panel recommends that the analyses be expanded to take into account conservatisms that have been incorporated into the factors used in designing the casks. Although the analyses of failures of the ferritic steel and stainless steel storage containers have been initiated, they are presently only in a preliminary stage.

The Panel is anxious to be provided with the results of these analyses, as they are developed. The Panel is encouraged to note that assumptions related to failure rates for spent fuel with stainless steel clad, and procedures for taking into account the impacts of "juvenile" failures and the performance of zirconium clad, are similar to those being used in the analyses for the proposed geologic repository.

As part of the analyses of failure rates of the containers for each type of spent fuel/waste, the Panel recommends that the staff provide information on the approaches being used, as well as time lines for the occurrence of the anticipated failures. Examples should include commercial spent nuclear fuel, DOE vitrified HLW at Savannah River, and the N-Reactor fuel at Hanford. In this regard, the project team that is conducting the TSPA-VA analyses is apparently not assuming explicit credit for the stainless steel pour canister enclosing the high level waste. They are, however, taking credit for the CAM/CRM waste package external to the steel shell. In the "No Action" case, the steel pour canister should be considered as the analog of the CAM/CRM package in the repository analysis and its effect should be included in the analysis.

6. Improved Aircraft Analysis

Preliminary analyses indicate that an aircraft crash has the potentially highest airborne source term with comparatively high consequences to nearby individuals. To some decision makers, this accident may have particularly high weight in differentiating between the TSPA and the "No Action" case. For this reason, it is important that the analyses be conducted in a detailed manner and that all assumptions and the values of all input parameters be documented. At the same time, improvements should be made in the prediction of both the frequency and consequences of such an accident. Attention should be specifically directed to the higher density of aircraft over-flights in the northeastern U.S., with particular attention to those commercial nuclear power plant sites whose locations are in the proximity of landing strips. With regards to the refinement of the consequence analysis, the number of containers affected should be based on the intersection of the penetrating components of the aircraft. The effect of plume rise from burning aircraft fuel should be credited when calculating downwind doses to avoid the improper calculation of unrealistic doses in the immediate neighborhood of the storage location.

7. Analyses of Potential Criticality

As part of the analyses of the "No Action" scenarios, the potential for criticality must be considered. It is important that such analyses be performed with sufficient rigor to withstand critical review. Based on a review by Panel member, Alan Wells, it is likely that the project team will determine that criticality as the result of water flooding of a spent fuel storage cask is a credible event that will require consequence analysis. It is expected that the conditions that could lead to such criticality would involve fuel that for some reason had very low burn-up, e.g. one cycle of exposure. The project team must determine if indeed there are containers with low burn-up fuel and if water flooding of these specific containers *would indeed result in a* k_{eff} in excess of unity. Because this condition would

appear to be in conflict with the double contingency criterion, contact should be made with appropriate staff members in the U.S. NRC to determine if they have been convinced that the flooding of the container would indeed not lead to criticality.

If criticality is determined to be credible, the project team does not have to spend a large amount of effort in determining the frequency of the accident. A discussion of the conditions that could result in criticality (i.e. the cask configuration and burn-up of the fuel) is probably adequate to result in a qualitative understanding of the frequency. It will be important, however, to evaluate the consequences of a criticality event. The magnitude of the excursion that results and the resulting integrity of the fuel pins are key to the size of the consequences. In this regard, the Panel notes that there are two possible views on the criticality issue: the first being a significant criticality excursion that results in fuel failures and radionuclide dispersal; the second being an insignificant "mini-Oklo" event that is accompanied by no fuel failures and negligible radionuclide releases.

Some members of the Panel who have performed analyses of criticality accidents in the past believe that the magnitude of the event that may occur in the case of the storage casks is of the second type, rather benign. In this case, the rate of reactivity addition at the time the cask goes critical is expected to be very low, limited by the rate of rainfall and ingress of water into the storage cask. The resulting increase in fuel temperature will result in heatup of water in the channel and a return to a subcritical condition due to boiling of the water and Doppler feedback in the fuel. As the rain continues, the system could return to a critical state and remain at a low power condition in which the water addition rate is balanced by the power generation rate in the covered portion of the fuel rods (the power generated in the uncovered portion of the rods would be substantially less than in the moderated region). When the rain ceases, the system would return to a slightly subcritical condition until occurrence of the next rain. The cladding temperature would probably never become significantly hotter than the boiling point of the water and the cladding integrity would not be challenged. This benign criticality scenario would be repeated a large number of times until burn-up of the fuel resulted in a condition in which the system would no longer go critical. A reasonable bound to the total fission products produced through prior irradiation and through recurrent reactivity transients is the total fission product inventory produced by the normal exposure of the fuel (assuming that fully exposed fuel cannot go critical in this scenario). The difference would be, however, that the fission events from accidental criticality will have occurred more recently. If the subsequent event that results in failure of the cladding and exposure of the fuel surface to water is delayed a significant period after the criticality cycles have ended, the impact on the environmental source term will be negligible.

The second, alternative scenario of concern is that the reactivity insertion rate is large enough at the time the system becomes critical for an excursion of sufficient magnitude to occur that the fuel would be ruptured and radionuclides would be immediately released. The consequences of this type of accident would be substantially larger than the benign scenario because of the atmospheric release and the presence of shorter half-life radionuclides at higher activity levels. Experiments performed at the Idaho National Engineering Laboratory in the SPERT series of tests indicated that, in order for rupture of the rods to occur, the energy addition to the fuel would have to be somewhat in excess of 200 cal/gm. This is energy density required to burst the fuel rods. Also to be considered is the possibility of fuel failure due to creep rupture (1300 to 1400°F for a week or so in a steam environment). The Panel recommends that kinetics analyses be performed to evaluate which scenario would occur under the conditions expected. These analyses could be performed in a point kinetics quasi-static approximation, with RELAP, with RAMONA (BNL code for the analysis for space-time kinetics in boiling water reactors), or with a space-time kinetics model. Once the suggested analyses have been completed, it should be possible to place the consequences of accidental criticality in the proper perspective.

8. Selection of Different Values for Key Input Parameters

Although (as noted in item #2 above), every effort should be made to ensure that the analyses of the "No Action" scenarios and the proposed geologic repository are performed so that they can be directly compared, if a situation develops in which it is important, for purposes of the analyses, to select a different value for a key input parameter in evaluating the "No Action" scenarios, then the staff ought to feel free to do so. The reason for the selection of a different value, and the effects of it on the outcome of the analyses, however, should be carefully documented as part of the presentation of the results.

9. Selection of MEPAS vs. GENII-S Code

The staff indicated that, on the basis of a careful review, they had selected the MEPAS code to analyze the impacts of the various "No Action" scenarios. This contrasts to the team that is developing the TSPA-VA who, on the basis of a similar review, selected the GENII-S code. Since these selections may appear confusing to people who review and evaluate the outcomes of the "No Action" scenarios, versus those of the TSPA-VA, care should be taken to explain this difference. Also in need of evaluation is how this may affect the goal of having the two analyses be conducted so that the outcomes can be compared on an "apples to apples" basis.

In this regard, the Panel notes that the form and nature of the EPA standards have not yet been announced. If the standards prescribe a dose limit for individuals, there may not be a need to estimate the accompanying numbers of excess latent cancer fatalities. However, there will probably still be a need to estimate the collective (population) doses.

10. Initiating Events

The Panel notes that the initiating events for analyses of the impacts of radionuclide releases under the "No Action" scenarios and the proposed geologic repository are significantly different. Yet this difference was not acknowledged in the procedure outlined for conducting the analyses of the continuous storage scenarios. The Panel recommends that the events that are assumed to be responsible for the various radionuclide release scenarios in the "No Action" evaluations be identified and documented.

IV. Resolution of Issues Raised in Initial Panel Report

In its first report, the Panel identified and offered comments on thirteen issues. These comments included recommendations for actions on the part of the staff that is preparing the analyses of the "No Action" scenarios. Of the items that were listed, those that have not been subsequently resolved are:

2. Assuring Comparability of the Analyses

As noted above, the Panel has offered a range of suggestions for presenting the results of the evaluation of the "No Action" scenarios to ensure that the outcomes can be readily compared for the "Loss of Institutional Control," versus no "Loss of Institutional Control," as well as for the outcomes of the evaluation of the "No Action" scenarios versus those for the case where the spent fuel/waste is placed in a geologic repository. The Panel will withhold judgment on this issue until the staff has had time to respond to the recommendations and/or suggestions in this report.

4. Delineation of Uncertainties
5. Uncertainties Associated With Specific Calculations

Both of these items deal with uncertainties. Since the staff is still in the process of developing an approach for conducting sensitivity analyses and assessing the associated uncertainties, the Panel will reserve judgment on this issue until such time as the staff has confirmed their plans and has responded to our latest recommendations.

8. Impacts of External Phenomena

As noted above, the Panel has recommended approaches that might be considered in evaluating the effects, for example, of aircraft crashes, glaciers, rainfall, and climate change. A judgment on the adequacy of the responses on this item will be provided after the staff has had an opportunity to review and react to our recommendations.

10. Evaluation of Inadvertent Criticality

This item, as noted above, is still being evaluated. The Panel will reserve judgment on its resolution until the criticality analyses have been completed.

12. Transparency of the Continuous Storage Analysis Report

It will not be possible to render a decision on this item until the project team has completed the "No Action" report and the Panel has had an opportunity to review it.

The Panel is satisfied with the progress on the other six items and believes that the analytical approaches that have been adopted by the project team adequately address our concerns. For purposes of the record, these items are:

1. Loss of Institutional Control
3. Development of a Base Case Scenario
6. Input Data to Risk Assessments
7. Application of Bounding Calculations
9. Radionuclide Releases, Pathways, and Mechanisms
11. Human Intrusion.

Respectfully submitted,

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Dade W. Moeller, Ph.D.

April 20, 1998
(date)

Appendix A

Agenda for April 3, 1998 Working Session of Senior Technical Panel – 8:00 AM PST

I. Introduction – Dee Walker 10 minutes

II. Resolution of Miscellaneous Issues – Dee Walker 15 minutes

- A. Assumptions List
- B. Loss of Institutional Control
- C. Comparability Analysis
- D. Base Case Scenario – time line
- E. Major Problems
  - i. Fuel dissolution rate
  - ii. Cladding failure
  - iii. Nature of container failure
  - iv. LCF calculations
  - v. Population distribution
  - vi. Climate change

III. Miscellaneous Administration – Joe Ziegler 10 minutes

- A. Charter
- B. Push Towards Closeout
- C. Use of Vendor Names

IV. Impact Estimates – Gene Rollins/Al Toblin 60 minutes

- A. Fate and Transport – Al Toblin
- B. Exposure Scenarios – Gene Rollins
- C. Impact Calculations – Gene Rollins
  - i. LCFs
  - ii. Peak dose (MEI or RMEI)
  - iii. ICRP 2 vs 30
- D. Intruder Scenarios – Gene Rollins
- E. Bounding Calculations for Ground Water Pathway (why appropriate) – G. Rollins

Break 10 minutes

V. Environmental Flux Calculations – P. Pelto/Jofu Mishima/Paul Nakayama/Lee Poe

- A. Outer Engineered Barrier Failure – Lee Poe 20 minutes
- B. Storage Container Failure 30 minutes
  - i. Types of containers – Lee Poe
  - ii. Failure of ferritic steel and stainless steel – Pete Pelto
  - iii. Expected failure mechanisms and timing – Pete Pelto
  - iv. Criticality (covered under extreme events)
- C. Abstraction Approach – Comparative Case

Waste Form Degradation & Release (including cladding) -- Pelto	20 minutes
D. Mech approach -- Improved/more realistic model -- Mishima	20 minutes
Lunch	60 minutes
VI. Extreme Events/Criticality -- P. Davis/D. Walker/L. Kripps/Al Wells	60 minutes

A. Aircraft Accidents vs Seismic and Other Events -- Pete Davis
B. Criticality
   i. Approach to Criticality (including linkage to cladding model) -- Larry Kripps
   ii. Additional information -- Al Wells
C. Severe Weather -- Dee Walker

VII. Uncertainty Estimates -- Dee Walker	20 minutes

A. Approach
B. Comparison Viability

VIII. General Discussion	30 minutes
IX. Technical Panel Discussion (w/o Jason team)	60 minutes
X. Technical Panel Feedback to Jason Team	30 minutes
XI. Path Forward	30 minutes

Continued Storage Analysis Report
Assumptions

General

1. For analyzing no-action impacts, it will be assumed that Highly Radioactive material is left at the generator sites. The assumed analysis period is 10,000 years.

2. Two No-Action Scenarios will be analyzed. They were selected for analysis to bound potential impacts.

   a. Continued institutional control for 10,000 years.

   b. Loss of institutional control (after 100 years).

3. For the continued storage analysis report, two types of impacts will be evaluated:

   a. Financial impacts (bounded by scenario 1)

   b. Radiological impacts (bounded by scenario 2)

4. The RIP process models and data bases will be used to the extent practicable for analyzing radionuclide release to the environment (fluxes) for No-Action Scenario 2 ("apples to apples") approach.

5. For the purposes of the No-Action Scenario 2 analysis, bins representing typical environmental conditions (yearly temperature cycles, precipitation, etc.) for a group of sites with similar characteristics will be used in calculating radionuclide fluxes to the environment (5 to 10 bins are expected).

6. For No-Action Scenario 2, environmental transport and dose impact calculations will be performed for four DOE sites and 75 commercial nuclear reactor sites using the appropriate environmental fluxes (see 5 above).

7. It will be assumed that SNF and HLW is stored in dry storage facilities at the beginning of the no-action period.

8. Pre-emplacement cooling times for SNF and HLW will be assumed to be average cooling times.

Timeline for Scenarios

Scenario 1

1. For the purposes of analysis, it will be assumed a facility overhaul occurs after 60 years; it is assumed that after 100 years a new replacement facility would be built and the stored material would be repackaged. Cost calculations will be performed repeating 100-year cycles to 10,000 years. The cost of an initial storage facility will be included in the cost estimates.

2. Radiological doses will be estimated for facility workers for the following tasks:

   a. Periodic inspection of the packaged and stored waste

   b. Facility maintenance/overhaul at the midpoint of each 100-year cycle

   c. Repackaging of stored SNF and HLW each 100 years

   d. Construction of a new storage facility each 100 years.

Scenario 2

1. It is assumed that institutional control is lost after 100 years. Cost impacts will be evaluated for the first 100 years only. Radiological impacts will be estimated for 10,000 years.

2. For this scenario, it will be assumed that all facility operations cease and power is lost. No credit will be taken for operator action that could enhance performance of the storage facility relative to extending radionuclide release times.

Structural Failure

1. Commercial SNF will be stored in above ground, dry storage facilities.

2. Three types of storage facility/cask designs will be analyzed.

   a. For commercial SNF, horizontal stainless steel storage containers.

   b. For commercial SNF, vertical ferritic steel containers.

   c. For DOE SNF and HLW, vertical stainless steel containers.

3. DOE HLW will be stored in below-grade facilities. The SRS/HLW storage facility will be used for the purposes of the analysis.

4. DOE SNF will be assumed to be stored in a vertical configuration that is below grade. The proposed facility for storing N-reactor SNF will be used for the purpose of analysis.

Storage Containers

1. Three types of storage facility/cask designs will be analyzed.

   a. FOR SNF, horizontal stainless steel containers.

   b. For SNF, vertical ferritic steel containers.

   c. For DOE SNF and HLW, vertical stainless steel containers.

2. The RIP process models for waste package degradation will be modified and used to the extent practicable for estimating times at which rainwater can enter the waste package.

Waste Form Degradation and Radionuclide Release

1. The RIP process models for waste form degradation and radionuclide release will be utilized for calculating radionuclide fluxes to the environment.

2. The RIP process models for waste form degradation and radionuclide release that include credit for SNF cladding will be used to account for the role of the cladding in delaying radionuclide release to the environment.

Radionuclide Transport and Dose Impact

1. The MEPAS code will be used to calculate the transport and dilution of radionuclide environmental fluxes.

2. It is assumed that waste form is covered by debris is the normal state during periods of radionuclide release. Hence the dominant release is via dissolution to the liquid pathway. Large releases to the airborne pathway will be evaluated as upset conditions.

3. The split between the liquid pathways source to surface water and the source to groundwater will be calculated with the MEPAS code using site specific parameters (e.g., rainfall, soil properties).

4. It will be assumed that leachate dryout and suspension by wind is not a significant transport pathway (sensitivity calculations to demonstrate).

5. For impacts via surface-water transport, impact calculations will consider the downstream watershed to a point where impacts are minimal (threshold needs to be defined).

Cost Impacts

1. Cost impacts for a 10,000=year period will be estimated for No-Action Scenario 1.

2. Costs will not be estimated for periods following loss of institutional control (No-Action Scenario 2) based on the assumption there are no functioning institutions to provide continuous monitoring or control.

Accidents

1. Radiological impacts to the public of accidents will be evaluated. Accidents initiated by both severe environmental phenomenon and events related to human activities will be considered (during a 10,000-year period, the likelihood of some accident at one or more sites is significant).

2. The impact of severe environmental events on the facilities, packages and debris bed (which protect the waste form from suspension by wind) will be evaluated as an upset condition.

REPORT OF SENIOR TECHNICAL REVIEW PANEL

Meeting of June 5, 1998

I. Introduction

The third meeting of the Senior Technical Panel was held at the offices of the Jason Associates Corporation in Las Vegas, NV, on June 5, 1998. The primary purpose of the meeting was to provide an opportunity for the members of the Panel to interact with the staff of Jason Associates who are preparing the "Continuous Storage Analysis Report" (CSAR) that is to accompany the Total System Performance Assessment - Viability Assessment being prepared by the Yucca Mountain Site Characterization Office of the U.S. Department of Energy.

The meeting afforded an opportunity for in-depth discussions and reviews of the work in progress. As will be noted in the comments that follow, the Panel concluded that considerable progress has been made during the past several months.

Due to scheduling conflicts, Richard Denning and Alan Wells were unable to attend the meeting. However, both of these individuals had submitted written reports and have interacted closely with their counterparts on the team that is preparing the CSAR. In addition, Dr. Wells joined in by telephone for the discussions on criticality. In a similar manner, Peter Davis of the CSAR staff joined in by telephone for the discussions of the impacts of an aircraft crash on above ground dry storage casks. Those Technical Panel members present for the meeting were Robert Budnitz, Stephen Short, and Dade Moeller. In accordance with the Charter for the Panel, this report is being submitted to the Project Manager, Jason Associates Corporation.

II. Topics Covered

The meeting convened at 8:00 a.m. with members of the Panel being welcomed by Dee Walker. He followed with a review of what had been accomplished since the last Panel meeting on April 3, 1998. As may be noted by the meeting agenda (Appendix A), this was followed by technical discussions on the following topics: Accident analysis; Criticality; Mechanisms for radionuclide releases; Radionuclide transport, uptake and dose calculations; and Miscellaneous topics including horizontal and vertical storage containers and concrete degradation.

In terms of potential accidents, the sessions included briefings on the relative potential impacts of an aircraft crash and an earthquake on dry cask storage facilities, located at commercial nuclear power plant sites. It was noted that the aircraft crash would affect one or two casks but that the accompanying fire (due to the anticipated combustion of jet fuel) would enhance the release by a factor of perhaps 10. Although an earthquake could affect a hundred times as many casks, the associated radioactive materials would not be pulverized, as they might be as a result of the impacts of a large jet aircraft. In terms of the effects of a fire on the concrete casks, it was acknowledged that concrete is resistant to fires. Nonetheless, the Panel concluded that the possible effects on the casks of the associated heat release should be reviewed and evaluated. On the basis of the information presented, the Panel concurred that, of the two postulated accident scenarios, the aircraft crash would dominate in terms of potential radionuclide releases.

In subsequent presentations, Stephen Short, a member of the Technical Review Panel, reviewed the results of concrete degradation and failure analyses. Addition information was provided by Lee Poe. On the basis of the analyses, the estimated times to failure ranged from 40 to 200 years for facilities located at commercial nuclear power plant sites subject to freeze/thaw damage, to as much as 11,000 years for facilities located at sites not subject to freeze/thaw conditions. Also taken into consideration were the potential effects of chlorides, sulfates, and magnesium that could accompany precipitation at the various sites. Considering the assumptions made, the Panel concluded that the estimated failure times were reasonable.

III. Recommendations, Suggestions and Comments

Subsequent to the technical briefings, the Panel discussed its preliminary findings and recommendations and presented an oral briefing and meeting summary to Wendy Dixon, Dee Walker, and the DOE technical support staff. In the course of this briefing, the Panel offered recommendations, suggestions, and comments in seven areas related to the analyses being conducted in the preparation of the CSAR. These may be summarized as follows:

1. General Impressions

Overall, the Technical Panel was favorably impressed by the progress being made by the CSAR team. The methods and approaches being used are based on sound scientific principles and they are well documented. The progress to date will serve as a solid framework for the preparation of a final report that should provide the required information.

2. Dealing With Moving Target

The Panel noted that the CSAR team is hampered by the fact that it is facing what can best be described as a "moving target." To assure that the approaches being used in preparing the CSAR will be compatible with, and comparable to, those used in the TSPA, it is mandatory that the TSPA staff confirm its approaches to certain key issues and relay these decisions to the CSAR staff. Examples of such issues include whether credit will be taken in the analyses for protective features of the cladding on Spent Nuclear Fuel, or for the pour canister that will surround vitrified High Level Waste, as well as how to consider SNF from the Nuclear Navy in the Continued Storage analysis? With regard to the pour canister, the Panel recommended that credit be taken in the preparation of the CSAR, even though the staff preparing the TSPA may elect not to do so. The reasons are that conditions in the CSAR (or "No Action Analysis") are different than those in the TSPA and the fact that ignoring credit for the pour canister will lead to an assumption that initial releases of radionuclides from the DOE HLW will begin after only 150 years (that is, 50 years after institutional control is lost), versus 900 years if credit for the protective features of the pour canisters is incorporated into the analyses. Ignoring the benefits of the pour canister could very well lead to accusations that the CSAR staff had purposefully biased their analyses to enhance the population impacts of the No Action Alternative. This represents a compelling reason for taking this barrier into account in the analyses for the CSAR.

3. Examples of Good Science and Practices

The Technical Panel was impressed by several examples of the use of sound scientific principles by the CSAR staff to resolve difficulties in the analyses required in the preparation of the CSAR. These include taking account for the presence of chlorides in precipitation in assessing the rate of degradation of concrete dry storage casks and using input factors, such as the chemical characteristics of specific radionuclides, and the pH and clay content of soils at each specific commercial nuclear power plant site, in estimating the appropriate K_ds to apply in assessing the adsorption of radionuclides. The Panel was similarly impressed by the innovative approaches being applied by the CSAR staff. These include the use of N-reactor fuel as a surrogate for all types of DOE spent nuclear fuels; documentation of the reasons for selecting the MEPAS code to analyze the impacts of radionuclide releases; the detail being used to estimate population doses due to radionuclide releases to surface waters from commercial nuclear power plant dry cask storage facilities; and the approaches being developed to provide insights and perspective on the relative importance of various spent fuel and waste sources, and for comparing the impacts of the Action and No Action Alternatives. Although work remains to bring this last effort

to a conclusion, the results will lead to a CSAR that is far more transparent and understandable. This last effort is discussed in more detail in item #7 below.

4. Accident Analyses

The primary discussions pertained to accidents involving above ground dry cask storage facilities for SNF from commercial nuclear power plants. Two types of accidents have been determined to be controlling: the crash of an aircraft into such a facility, and inadvertent criticality. With respect to aircraft crashes, the Panel noted that considerable progress had been made since the last meeting and that most of the issues had been resolved. In terms of the approach to be used, the Panel recommended that the CSAR staff seek to demonstrate that the risks are real, rather than attempt to develop a detailed risk assessment. In the way of commentary, the Panel also observed that, for purposes of the analyses, routine commercial aircraft operations are assumed to have continued even though institutional control of the SNF storage facilities has been lost. In conjunction with the associated analyses, the Panel suggested several groups that the CSAR staff may want to contact for useful technical input.

In terms of the analysis of criticality, the Panel was pleased to note that consensus is being reached on the proper approaches that are to be applied. This has been accomplished through discussions by Panel members, Richard Denning and Alan Wells, with Ralph Best and Jofu Mishima of the CSAR staff, supplemented by input from Panel member, Robert Budnitz. Three types of events are being analyzed: the so-called "Light Bulb" cycling event, which is assumed to occur as a result of filling and refilling of a cask following periodic precipitation; a "Violent Excursion" short time event, assumed to occur as a result of the sudden collapse (for example, following an earthquake) of a weakened fuel support structure; and a "Boiler" type event, assumed to occur as a result of the gradual degradation and collapse of the fuel support structure. The Panel recommended that bounding calculations be performed to demonstrate that such events are possible, without seeking to quantify the associated probabilities. In concert with this approach, the Panel recommended that the probabilities of each type of event be expressed as "likely," or "unlikely." These efforts should be followed by consequence analyses to show that the impacts of the assumed accident scenarios are acceptable. In this regard, some type of quantitative estimates will probably be necessary to demonstrate the acceptability of the outcomes.

5. Presentation of Uncertainties

The basic question is whether differences in the uncertainties could have an impact on the comparison of the outcomes of the "No Action" analyses and those for the proposed Yucca Mountain repository. If the uncertainties prove to be of the same order of magnitude as the differences in the outcomes of the two analyses, such a comparison would be difficult. To resolve this issue, the CSAR staff is applying a "sliding scale" approach wherein the amount of detail applied to the analysis of each issue will be that judged to be commensurate with its importance. The Technical Review Panel concurs with this approach. At the same time, the Panel cautions that the CSAR staff not lose sight of the fact that the uncertainties associated with estimating the doses and health impacts accompanying the projected radionuclide releases may also be important. For this reason, the Panel recommends that the CSAR staff review and evaluate the analyses for the "No Action" scenario and the proposed Yucca Mountain repository to assure that the uncertainties associated with the dose and health effects estimates in the two cases are comparable and will not unduly influence a comparison of the outcomes of the two analyses.

6. Period of Analyses

The Panel concurs that estimates of dose rates should be confined to the first 10,000 years. In fact, for the No Action Alternative the Panel recommends that the CSAR staff initially concentrate on the first hundred to one thousand years, the thought being that the insights and lessons learned will lead to better evaluations of the subsequent time periods up to 10,000 years. At the same time, the Panel wants to remind the CSAR staff that estimating the peak dose at some hundreds of thousands of years into the future is essentially meaningless since one or more ice ages will have occurred within that time period and a major portion of North America may well be covered by glaciers at the projected time of peak dose.

7. Providing Perspective

As noted above (item #3), the Panel was favorably impressed with the efforts being made by the CSAR staff to develop new approaches for providing insights and perspective on the relative importance of various spent fuel and waste sources, and for comparing the impacts of the Action and No Action Alternatives. Immediate outcomes have been the dominance of the surface water pathway for radionuclide releases from commercial nuclear power plant dry cask storage facilities; the differences in the radionuclides of importance for the radionuclide releases for the No Action Alternative (postulated to occur in an earlier time

frame) versus the proposed Yucca Mountain repository; the dominance of the postulated impacts from the N-reactor surrogate fuel over other DOE waste sources; the dominance of the postulated impacts of radionuclide releases from the stainless steel, versus zirconium clad spent fuel at the commercial nuclear power plant sites; and the dominance of the early radionuclide releases by juvenile failures, versus the dominance of later releases by corrosion and other degradation mechanisms. These observations, and the detailed tables and graphs being developed for presenting the outcomes of the analyses should considerably enhance the clarity and transparency of the final CSAR.

IV. Resolution of Issues Raised in Previous Reports

At the time of the issuance of Report #2 of the Senior Technical Panel, there were six issues that had not been resolved. The status of each of these is discussed below.

2. Assuring Comparability of the Analyses

As noted in Section III, item #2 (above), the CSAR staff must await decisions on the part of the TSPA staff to confirm the assumptions that are to be made on several factors that are important in terms of the analyses. Nonetheless, these issues are being resolved and the Panel is comfortable with the approaches being taken. Therefore, the Panel considers this issue to be resolved.

4. Delineation of Uncertainties
5. Uncertainties Associated With Specific Calculations

As indicate in Section III, item #5 (above), the Panel has reviewed the approaches being used by the CSAR staff and is satisfied. As a result, the Panel considers issues related to uncertainties to be resolved.

8. Impacts of External Phenomena

As a result of its most recent meeting, the Panel believes that the primary issues related to the impacts of external phenomena, particularly aircraft crashes (Section III, item #4 above), have been satisfactorily resolved.

10. Evaluation of Inadvertent Criticality

As noted in Section III, item #4 (above), the CSAR staff and Panel have agreed on the essential approaches to be used in evaluating criticality. The Panel considers this issue to be resolved.

On the basis of this evaluation, there is only one issue remaining to be resolved. That is:

12. Transparency of CSAR Report

As noted by the comments in Section III, items #3 and #7 (above), the Panel believes that significant progress has been made to assure that the final CSAR will resolve any questions that remain on this issue. The Panel, however, will reserve judgment on the resolution of this item until it has had an opportunity to review and comment on the draft of the final CSAR.

V. Future Schedule

The CSAR staff indicated that they planned to have a draft report completed within the next two weeks and will distribute copies promptly to all Panel members for review and comment. Subsequently, a conference call will be scheduled to enable Panel members to resolve any differences or to come to a conclusion on any unresolved issues. Barring unforeseen circumstances, no additional meetings of the Panel will be scheduled.

Respectfully submitted:

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Dade W. Moeller, Ph.D.

June 12, 1998
(date)

Appendix A

AGENDA FOR 6/5/98 SENIOR TECHNICAL PANEL WORKING SESSION

A. Progress and Status -- 45 Minutes	Walker, Poe	8:00 -- 8:45

1. Summary of what has been accomplished since last meeting
   - a. Progress
   - b. Status
   - c. Event Time Line for Release and Transport of Radionuclides
   - d. Inventories of Materials Available for Release in First 10,000 years
   - e. Schedule

B. Technical Discussions

4. Accident Analysis -- 45 minutes	Walker, Davis	8:45 -- 9:30
BREAK -- 15 minutes		9:30 -- 9:45
5. Criticality, Discussion of Additional Analysis and Implications -- 60 minutes	Best	9:45 -- 10:45
6. Radionuclide Release -- 45 minutes	Pelto, Poe	10:45 -- 11:30

- a. Cladding Corrosion
- b. Relative release rates from materials exposed in first 10,000 years
- c. Implications of inventory and relative release Rate Numbers

WORKING LUNCH -- 30 minute break and then continue while eating		11:30 --12:00
7. Radionuclide Transport, Uptake, and Dose Calculations -- 45 minutes	Rollins	12:00 --12:45

- a. GEN-II and MEPAS
- b. Estimates of Relative Importance of transport via the three pathways.

c. Discussion of how population will he handled at individual sites

d. Key assumptions in uptake and dose calculations

8. Uncertainty – 45 minutes	Dykes	12:45 – 1:30
9. Impact table structure for *Summary Information Sheets* – 30 minutes	Walker	1:30 – 2:00
BREAK – 15 minutes		2:00 – 2:15
10. Miscellaneous – 30 minutes		2:15 – 2:45
a. Comments on No-Action Assumptions	Ziegler	
b. Horizontal and vertical storage containers	Poe	
c. Concrete degradation in coastal zones	Poe, Short	
11. General Discussion – 30 minutes		2:45 – 3:15
12. Technical Panel Discussion (w/o Jason team) – 60 minutes		3:15 – 4:15
13. Technical Panel Feedback to Jason Team – 30 minutes		4:15 – 4:45
14. Path Forward – 30 minutes		4:45 – 5:15

CERTIFICATE OF SERVICE

I hereby certify that a true and correct copy of the foregoing document was served this 25th day of November, 2003, via messenger on:

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