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July 25, 1995

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High-Level Waste and Uranium  
Recovery Projects Branch  
Division of Waste Management  
Office of Nuclear Material Safety  
and Safeguards  
U.S. Nuclear Regulatory Commission  
Washington, D.C. 20555

Re: *Principles and Guidelines for Formal Use of Expert  
Judgment by the Yucca Mountain Site Characterization  
Project Office and Resolution of Site Characterization  
Analysis Comment 3*

Dear Mr. Holonich:

On June 5, 1995, Stephen J. Brocoum, Assistant Manager for Suitability and Licensing, Department of Energy Office of Civilian Radioactive Waste Management, Yucca Mountain Site Characterization Office, forwarded a document entitled *Principles and Guidelines for Formal Use of Expert Judgment by the Yucca Mountain Site Characterization Project Office* ("PGFUEJ") to you to provide "DOE's position on the explicit and formal application of expert judgment" and to "facilitate discussions prior to issuance of NRC guidance on the use of expert judgment."

There is no dispute that the complex technological undertaking in which the Department of Energy is involved at the prospective Yucca Mountain repository site will require reliance on the knowledge, opinion and quantitative probabilistic judgment of technical experts. The NRC has already recognized that, where such reliance is required, a formal process of memorializing that reliance is necessary to provide assurance regarding the quality and extent of the expertise elicited. NRC's recognition is incorporated in three documents: U.S. NRC, 1988, *Peer Review for High-Level Nuclear Waste Repositories*, Generic Technical Position, NUREG-1297; Bonano, E.J., S.C. Hora, R. L. Keeney, D. von Winterfeldt, 1990, *Elicitation and Use of Expert Judgment in Performance Assessment for High-Level Waste Repositories*,

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NUREG/CR-5411; and DeWispelare, A.R., L.T. Herren, E.J. Bonano, R.T. Clemen, 1994 *Background Report on the Use and Elicitation of Expert Judgment*, Center for Nuclear Waste Regulatory Analyses, CNWRA 94-019.

We have reviewed the document forwarded by Mr. Brocoum and offer the following comments.

A. Beyond The Quality Assurance Context.

We recognize that the DOE offers its PGFUEJ in the context of responding to NRC's SCA Comment 3, relating to quality assurance. Nevertheless, the implications of reliance on expert judgment in lieu of known facts or causal relationships goes well beyond quality assurance. It is also significant to proof of facts and demonstration of repository performance in a licensing setting. The burden of proof in a licensing proceeding falls upon the DOE. NRC's analysis of its satisfaction with DOE's PGFUEJ should be broadened to encompass DOE's and NRC's reliance upon expert judgment throughout site characterization, performance assessment and NRC licensing.

B. Open, Traceable, and Unambiguous Expert Judgment.

DOE's PGFUEJ does not make a clear commitment to an open, traceable and unambiguous process for the creation of expert judgment. These elements are basic to that reliance, as has been stated by DeWispelare, et. al.:

Because of the limitations in the state of science in many of the fields involved in modeling and long-term performance prediction associated with an High Level Waste repository, the use of expert judgment elicitation in license support activities by the parties involved is expected. The issue of granting a license to construct, operate and decommission and close an HLW repository has extreme public relevance, and the data and analyses contributing to the decision needs to be open, traceable, and unambiguous. The decision making process that will result in granting or denying a license involves the resolution of both scientific and policy issues. The scientific issues, such as the future climate, seismicity, and the volcanism of any proposed repository site, are extraordinarily complex and significant to outcomes, and data supporting these predictions are relatively scarce and sources are sometimes controversial. Similarly, policy issues--such as the need for and

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consideration of human intrusion, the nature and implementability of the attendant regulatory requirements, etc. present challenges, the resolution of which is neither straight forward nor uncontroversial.<sup>1</sup>

We recommend that DOE make a clear commitment to reliance only upon open, traceable and unambiguous expert judgment. This is particularly essential in light of the policy enunciated in the Nuclear Waste Policy Act that "high level radioactive waste and spent nuclear fuels have become major subjects of public concern, and appropriate precautions must be taken to ensure that such waste and spent fuel do not adversely affect the public health and safety and the environment for this or future generations." 42 U.S.C. 10131 (a)(7).

### C. Independence.

Although we concede that the Nuclear Regulatory Commission has already capitulated to the massive fiscal dominance of the Department of Energy in the employment of expertise in the peer review context,<sup>2</sup> Nevada, and apparently the Center for Nuclear Waste Regulatory Analysis, continues to believe that independence of expert judgment cannot be attained with dominant use of DOE or DOE contractor personnel.

DeWispelare, et. al. state:

In addition to substantive demonstrated knowledge in the subject matter of interest, experts should also exhibit several other attributes. Some examples are: (i) independence; (ii) lack of motivational, personal, or organizational biases; and (iii) willingness and ability to provide judgments in a clear and traceable manner. Independence refers to an individual's ability to discard explicit or implicit influences by other experts, whether these experts are other individuals or a specific piece of information. That is, an expert should be able to analyze the available information and articulate judgments that are based on his/her thought processes and ideas as opposed to depending on another individual's thought process or ideas. Lack of motivational, personal, or organizational biases refers to the selection of experts that do not stand to benefit in any way from the outcome of the elicitation. It is preferable to select experts that are devoid of any such biases. However, care should be exercised to ensure that the best qualified individuals in a given subject are not disqualified due to potential biases. A good normative

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expert should be able to recognize such biases and will ensure that they are articulated and compensated for in the elicitation. Finally, experts must be willing to participate and provide judgments that will be explicitly attributed to them. The experts should be willing and able to clearly articulate not only the judgments, but also their reasoning, assumptions, and analysis approach.<sup>3</sup>

DOE's PGFUEJ gives lip service to independence,<sup>4</sup> yet the process envisioned by the PGFUEJ permits participation by "Experts associated with the Project"<sup>5</sup> "[I]t is not practical for membership on a peer review panel, or selection as an external expert for an elicitation, to be predicated on an absolute standard of no prior involvement in, or review of, DOE-sponsored work."<sup>6</sup> This statement is clearly inconsistent with that of DeWispelare, et. al.

While the PGFUEJ claims to be consistent with NUREG-1297, the two documents are significantly inconsistent on this subject. The NRC's position, related to peer review, is stronger and better:

Members of the peer review group should be independent of the original work to be reviewed. Independence in this case means that the peer, a) was not involved as a participant, supervisor, technical reviewer or adviser in the work being reviewed, and b) to the extent practical, has sufficient freedom from funding considerations to assure the work is impartially reviewed.

. . . . In those cases where total independence cannot be met, a documented rationale as to why someone of equivalent technical qualifications and greater independence was not selected should be placed in the peer review report.<sup>7</sup>

Responding to Nevada's concern regarding independence of peer reviewers, NRC responded:

[I]t may not be possible to exclude every member of the "DOE-industrial complex" from participating in a peer review. However, in those cases where independence cannot be met, a documented rationale as to why someone of equivalent technical qualifications and greater independence was not selected should be placed in the peer review report. It is expected that acceptable peers "representing the interests of the affected

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States and Tribes" could become members of a peer review group.<sup>8</sup>

DOE's proposed reliance upon expert judgment fails NRC's standard altogether. DOE's PGFUEJ does not even require balance of bias. It permits the participation of project participants, whereas NUREG-1297 prohibits their participation as well as that of anyone else without sufficient freedom from funding considerations to assure the work is impartial. DOE's PGFUEJ makes no mention of any effort to minimize interference with independence or to demonstrate that alternative independent expertise was unavailable.

Peer review and the formal use of expert judgment are, of course, not the same.<sup>9</sup> The independence of experts in the formal use of expert judgment is even more important, however. Bonano, et. al. state:

It is very important to avoid any potential conflict of interest between the specialists and the results of the performance assessment. A frequent concern is whether the prospective specialists derive their employment or any income from organizations charged with conducting the overall performance assessments or with constructing the repository. Other potential conflicts may involve close working relationships with individuals involved in the performance assessment or professional viewpoints viewed as unalterable by conflicting data or reason. Each possible specialist should be asked to provide a written statement of any potential or potentially perceived conflict of interest. Those specialists with no conflicts should be chosen based on their expertise.

Individuals with a perceived or real conflict of interest may not allow this conflict to influence their professional judgments. Furthermore, we would not like to exclude crucial information from the performance assessment simply because a knowledgeable individual had a potential conflict of interest. Therefore, it is important to design the explicit elicitation and use of expert judgment such that the knowledge and reasoning of experts with potential conflicts can be made known to selected specialists in a timely manner. This communication process may include distribution of written publications and analyses, as well as oral presentation.<sup>10</sup>

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DeWispelare, et. al. state:

Motivational biases occur because an expert has a vested interest in an issue and consciously or unconsciously distorts his judgment.<sup>11</sup>

We recommend that DOE incorporate the more conservative concept of independence defined by the NRC in NUREG-1297, Bonano, et. al. in NUREG/CR-5411, and DeWispelare, et. al., and that NRC's guidance regarding independence in the use of expert judgment be at least as rigorous as that established in those same documents.

D. Anonymity.

The importance of independence also manifests itself in the issue of anonymity of individual experts. An individual's compromise of independence can obviously be hidden in anonymity within a group. DeWispelare, et. al. state:

One key issue is whether the judgments should be anonymous or associated with each expert. The elicitation of anonymous judgments has the marked advantage that individual experts can be shielded from strong pressures that may influence their opinion, and are likely to feel more comfortable with openly expressing their true views. . . . However, the use of anonymous judgments has some serious disadvantages. First, . . . the credibility of the elicitation to a large extent depends on the experts used and, therefore, the use of anonymous judgments can be detrimental in this aspect. One way of enhancing the credibility of the elicitation is by associating each judgment with a specific individual. Second, the use of anonymous judgments is inconsistent with the licensing process, in which specific experts may be required to defend their judgments. Third, it hinders the review of the judgments because these are not likely to be associated with a given reasoning process.<sup>12</sup>

DOE's PGFUEJ is silent on this important issue. We recommend that DOE make a clear commitment to attribution of all expert judgments to the specific individuals who make them.

E. Application of Expert Judgment.

Although the PGFUEJ states that it provides the "framework for the formal application of expert judgment," it is not specific about that to which expert judgment will be applied. We

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would ask that DOE be more specific. The PGFUEJ's reference to "the resolution of a technical issue"<sup>13</sup> suggests that formal expert judgment will be used to close further analysis of a technical issue. NRC has, of course, already clearly defined the inherent openness of issues and the freedom of the NRC to consider all issues within a licensing proceeding.<sup>14</sup>

DOE's PGFUEJ states:

. . . the most significant application of formal expert judgment methods by the Project is expected to be in dealing with the technical issues and inherent uncertainties associated with characterizing and predicting the performance of a geologic disposal system for thousands of years into the future. . . . Complex calculations based on sophisticated mathematical models, including quantitative estimates of uncertainty in the calculations, may be performed to evaluate system performance. . . .

The Project intends to make formal use of expert judgment one mechanism for quantifying uncertainty . . .

<sup>15</sup>  
These statements suggest that expert judgment will be used repeatedly and endemically throughout individual, day-to-day decisions related to gathering data, analyzing data, combining data through models, and etc. If this is DOE's intention, and it is certainly DOE's historical method, it will be most difficult to document in the formalized process which DOE now states as its objective.

DeWispelare, et. al. identify scenario development, forecasting, model development, parameter estimation and information gathering as appropriate applications of expert judgment.<sup>16</sup> We concur in the appropriateness of its application in those contexts (with the reservation of the its use to fill data gaps as discussed below). DOE's PGFUEJ does not, however, even specify these particular applications.

We are apprehensive that DOE intends to use expert judgment to fill data gaps, i.e. to posit that certain data exists because experts think that it does. The central issue here is that expert opinion should not be bootstrapped to become equivalent to measured data. Recognizing that probabilities of uncertainty may be attached to either,<sup>17</sup> it goes without saying that the certainty of measured data, particularly if it has been peer reviewed, is superior to the certainty of opinion,

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notwithstanding the expertise of its offeror. "Expert judgment is subjective."<sup>18</sup> Because of the greater certainty of measured data, it should be entitled to greater probative value than should opinion. On this issue, we differ with DeWispelare, et. al., who suggest that opinion is "data" which can be created by expert judgment. Of course, should DeWispelare, et. al. intend to mean only that opinion, like measured data, is information upon which others may rely, and make no conclusion regarding the respective probative values of measured data versus opinion, then we concur in their view.

Several statements of DeWispelare, et. al. leave their thinking on this issue a bit opaque:

The term expert judgment refers to the data or information that is produced through communication with an expert. Expert judgment can be evaluations of theories, models, or experiments or recommendations for further research. Expert judgment may also be numerical data that can be used in PA models or can be analyzed and interpreted. Expert judgments can be either qualitative or quantitative. Expert judgments can also be judgments about uncertain quantities or judgments about value preferences. . . . Value judgments can never be proven true or false.<sup>19</sup>

Expert judgment is used widely to synthesize and interpret other types of data. It provides information when other sources, such as measurements, observations, experimentation, or simulation, are unavailable or prohibitively costly, or when data from these other sources are sparse, questionable, or only indirectly applicable.<sup>20</sup>

Expert judgment can be considered a type of data. . . .

Expert judgment is often considered soft data in comparison to data that has been measured or obtained from observations or instruments.<sup>21</sup>

Expert elicitation is a tool that provides a type of data, expert judgments. . . .<sup>22</sup>

While DeWispelare, et. al. seem to haze the distinction between and relative weight of measured facts and opinion, rather than clarify it, this may perhaps be excused because of their primary attention to "scientific resolution"<sup>23</sup> of factual questions, rather than the regulatory determination of "reasonable assurance"<sup>24</sup> which the NRC will be called upon make.

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Depending on the problem with its attendant constraints, the complexity and criticality of an issue and time and resources available for data collection create a situation in which the other methods of *scientific resolution* are not possible. In these cases, formally derived expert judgments *fill the gaps* in the technical approach and allow the process to continue toward a solution.<sup>25</sup>

We take particular issue with the notion implied by the statement by DeWispelare, et. al. that,

Expert judgment can also be used in certain circumstances to directly synthesize, interpolate, or extrapolate a sparsely populated data set.<sup>26</sup>

and that,

Expert judgment can be used to synthesize existing data with historic and causal bases to extend the data into the future.<sup>27</sup>

These statements fail to segregate measured fact from opinion. Without a clear segregation between measured facts and "synthesized, interpolated or extrapolated" facts, the latter masquerade as the former. The deeper the latter become buried in subsequent reliance scenarios, the more impossible it becomes to quantify the uncertainty of subsequently derived "facts". Particularly where independence is compromised, or overconfidence is permitted to infect judgments, the real state of physical properties represented by measured facts could become subsumed in supposed fact. Such a development would not support reasonable assurance of repository safety.

The reliance upon expert judgment to fill data, i.e. measured data, gaps would not only reinforce a less aggressive research and characterization program, but would permit DOE to ultimately define the data in the manner best suitable for proving repository performance. While we have no objection to reliance on experts to state that "In my opinion the data should be interpreted thus." it is wholly inappropriate to rely on experts to state "In my opinion the data is thus."<sup>28</sup>

We recommend, specifically, that DOE make a clear commitment not to use of expert judgment to fill data gaps, and generally, to state more clearly where it will apply expert judgment.

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F. Aggregation or Combination of Expert Judgments:

1. Aggregation or combination of expert judgment within specific elicitations.

DeWispelare, et. al. describe techniques for quantifying probability judgments.<sup>29</sup> The techniques they describe presume a single elicitation proceeding in which the probabilistic variables of various components of the problem, including the multiple experts involved, are known. We agree that aggregation of uncertain opinion is possible in that context where a properly established record permits review of the individual evaluations of uncertainty (probability) which will later be collectivized or aggregated. At this juncture, we take no position regarding the preference for particular methods of aggregation, each perhaps depending upon the nature of the issue involved in the elicitation. We do, however agree with several specific points raised by DeWispelare, et. al.:

First, where aggregation of the judgment of different experts is needed, and cumulative distribution functions (CDFs) are utilized, decomposition of the problem makes a difference.<sup>30</sup>

Second, biases should be taken into account when aggregation occurs.

[A]ggregation [of expert judgments] needs to consider not only the biases and possible dependencies among the experts, but also should account for the different ways in which the different experts or groups of experts view and analyze the problem.<sup>31</sup>

Third, the particular approach to various uncertainty issues is situational.

If expert judgments are sought on the distribution of the numerical value of X, the question posed could be "given the available information about the value of X, what is the probability density function (PDF) that best represents the uncertainty about its value?" If expert information about the uncertain parameter X is desired, the question posed could be "what information and experience do the experts have that is directly relevant to the estimation of the value of X?"<sup>32</sup>

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2. Aggregation or combination of and among various expert judgments in multiple elicitations.

DeWispelare, et. al. do not adequately discuss the techniques which might be used to aggregate the results of multiple elicitations or the individual component parts of various elicitations. The NRC will be called upon in licensing a high level radioactive waste repository to make a determination based on just such a collectivized body of measured data and expert opinion. DeWispelare, et. al. observe:

The incompleteness of the information base makes forecasting such performance [of a radioactive waste disposal system] an underdetermined problem; that is, there will be multiple interpretations that are consistent with the available information. In addition to the scientific and technical difficulties, the management and disposal of radioactive waste has considerable economic and social implications that also need to be factored into the solution to the problem.<sup>33</sup>

The extent of uncertainty in underlying opinion-based information is, of course, relevant to the extent of uncertainty in a later collectivized judgment. Greater knowledge about underlying opinion-based information, including knowledge that and where it occurs within the underlying information base and knowledge of the quantified subjective probability inherent in each opinion-based datum, permits greater certainty in later collectivized judgment and overall probabilistic risk assessment. Therefore, we advocate the establishment of an expert judgment marker system by which any later reviewer may discover the existence and whereabouts of an expert judgment, and that a probability assessment be contemporaneously attached to each marker.

Even with such a system in place, however, Nevada is apprehensive of overreliance upon pervasive expert judgment in a licensing proceeding<sup>34</sup> and will seek every opportunity to advocate rejection of opinion-based information in favor of better evidence. "The use of expert judgments should not be considered a substitute for the collection of data or the conduct of other scientific and technical analyses. The use of expert judgments should, in principle, be restricted to those situations when the collection of so-called 'hard' data or other information is not practically possible."<sup>35</sup>

Inasmuch as it is evident even now that the Department of Energy will seek to justify reliance upon expert opinion on the

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basis of lack of fiscal resources to ascertain measured data, even though DOE has already spent millions on wasteful administrative programs, Nevada is justifiably concerned that the NRC not be presented with a total licensing information base which is largely subjective in nature. Nevada will surely assert in that instance that the NRC cannot determine with reasonable assurance that a repository can be operated without unreasonable risk to the health and safety of the public.

G. Formalities Within the Elicitation Process:

DOE's PGFUEJ does not formally commit to a formal elicitation process involving all of the elements described by DeWispelare, et. al.: (i) selection and decomposition of the problem, (ii) selection of experts, (iii) training and debiasing, (iv) formal elicitation sessions, (v) complete and comprehensive formal documentation.<sup>36</sup>

The important issue in formalization of the application of expert judgment is whether the formalization is sufficient to notify reviewers, including a later NRC High Level Nuclear Waste Repository Licensing Board and the parties appearing before it in a licensing proceeding, of the nature and extent of the judgments elicited such that they may reasonably rely on those judgments or otherwise repeat<sup>37</sup> or examine them. DOE's PGFUEJ does not, in our opinion, require the requisite notice to subsequent reviewers.

The PGFUEJ states:

In conducting an elicitation [of expert judgment] or peer review, the DOE will ensure that:

The form of documentation is adequate to provide objective evidence that these guidelines have been addressed and that the record is complete enough to permit an independent assessment of the results by external parties. The documentation and the controls applied will satisfy the appropriate quality assurance requirements.<sup>38</sup>

This is a worthy objective, but no details are established with which to assure that the objective will be reached.

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In particular DOE's PGFUEJ should require:

1. Formalization of selection of substantive and normative experts and the process of elicitation to ensure debiasing of judgments.<sup>39</sup>
2. Formalization of a process which requires the discussion by experts within open meetings and which attributes opinion to particular experts.
3. Formalization of the quantities that will be elicited and statement of all assumptions that may influence the judgments.<sup>40</sup>
4. Formal decomposition of the problem with assessment of the complexity of the components or parts of the problem, the reasoning process used to decompose the problem and the interdependencies between the different components<sup>41</sup> and the creation of formal methods to avoid decoupling of critical couplings between interdependent components.<sup>42</sup>
5. Formalization of a methodology with which to elicit the biases of participants in judgment elicitation proceedings and a requirement that those biases be published in the formal report of proceedings.
6. Formalization of a methodology for providing the proper amount and quality of information to experts in order to avoid the possible improper influence upon experts through cognitive bias (availability, anchoring, representativeness, ignoring base rates, nonregressive predictions, overconfidence and confirmation).<sup>43</sup>
7. Formalization of a methodology for eliciting responses from experts in order to avoid possible inadvertent misrepresentation or other inadvertent motivational bias.<sup>44</sup>
8. Formalization of a methodology to ensure that experts have properly considered disconfirming information.<sup>45</sup>
9. Formalization of a methodology for aggregation of judgments that considers the biases and possible dependencies among the experts.<sup>46</sup>

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10. Creation of a reference identifier (marker) to be attached to each expert judgment (whether explicit or implicit)<sup>47</sup> to indicate whether each is a belief, opinion or value judgment.<sup>48</sup>

11. Creation of a reference identifier (marker) to be attached to each expert judgment (whether explicit or implicit) to indicate whether each is a quantitative or qualitative.<sup>49</sup>

12. Creation of a reference identifier (marker) to be attached to each belief, opinion or value judgment contained within the data, analyses, models or performance assessments, so as to a) identify the individual expert making the judgment,<sup>50</sup> b) distinguish each from known facts (measured physical conditions) similarly contained, c) quantify the overall reliance on expert judgment versus known facts, and d) evaluate the effects of aggregation and compounding of expert judgment.<sup>51</sup> The reference identifier should permit a traceable avenue to the formal record of the elicitation process. The reference identifier should be "findable" through electronic search review of the data, analysis, models and performance assessments upon which DOE relies to prove reasonable assurance of repository safety.

13. Formalization of a methodology with which to assign a quantitative probability<sup>52</sup> coefficient for each belief, opinion or value judgment contained within the data, analyses, models or performance assessments, so as to a) permit identification of the selected form of expressing the associated uncertainty in quantitative judgments representing subjective uncertainties,<sup>53</sup> and b) permit quantification and aggregation of the overall probability of the collectivized judgments upon which reliance is sought.

14. Formalization of a methodology with which to verify that later discovered information is integrated into prior expert opinion and that improper reliance has not been placed on prior opinions which have not been consequently updated.<sup>54</sup>

#### H. Conclusion.

In the complex technological arena of formally evaluating the prospective performance of a high level nuclear waste

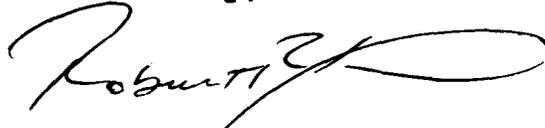
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repository, rigorous standards for reliance upon expert judgment in lieu of known facts are essential. The length of time involved suggests the potential lapse of memory and loss of evidence, creating additional uncertainty.

Notwithstanding the need in some instances to rely upon expert judgment, Nevada opposes DOE's and NRC's overreliance upon pervasive expert judgment in a licensing proceeding. Nevada will consequently seek every opportunity to advocate rejection of opinion-based information in favor of better evidence. Nevada is justifiably concerned that the NRC not license a repository on an information base which is largely subjective in nature. The NRC's assurance that a repository can be operated without unreasonable risk to the health and safety of the public would not be reasonable under those circumstances.

It is essential that the NRC issue guidance on the use of expert judgment in the process of characterizing and licensing a high level radioactive waste repository. Please advise us of the process and timing by which the NRC intends to issue such guidance. Thank you.

Sincerely,



Robert R. Loux  
Executive Director

RRL/JHD/wp

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1. DeWispelare, A.R., L.T. Herren, E.J. Bonano, R.T. Clemen, 1994 *Background Report on the Use and Elicitation of Expert Judgment*, Center for Nuclear Waste Regulatory Analyses, CNWRA 94-019, p. 1-2.
2. "Because of DOE's pervasive effort in the waste management area, the lack or unavailability of other technical expertise in certain areas, and the possibility of reducing the technical qualifications of the reviewers in order that total independence is maintained, it may not be possible to exclude all DOE or DOE contractor personnel from participating in a peer review." U.S. NRC, 1988, *Peer Review for High-Level Waste Repositories*, "General Technical Position, NUREG-1297, p. 4.
3. *Supra.* note 1, p. 2-9.
4. U.S. DOE, *Principles and Guidelines for Formal Use of Expert Judgment by the Yucca Mountain Site Characterization Project Office*, May 22, 1995, Revision 0, p. 5.
5. *Id.*, p. 9.
6. *Id.*, p. 10.
7. *Supra.* note 2, p. 4. We recognize that the processes of peer review and expert elicitation differ, particularly in the degree to which they involve extensive documentation of the expert's judgments and whether or not they involve interaction among the participants. Nevertheless, the independence issue is similar and the importance of independence of experts is more pronounced in the elicitation of expert judgment. See, DeWispelare, et. al., *supra.* note 1, p. 1-4.
8. *Supra.* note 2, p. 22.
9. See, Bonano, E.J., S.C. Hora, R. L. Keeney, D. von Winterfeldt, 1990, *Elicitation and Use of Expert Judgment in Performance Assessment for High-Level Waste Repositories*, NUREG/CR-5411, p. 7.
10. *Id.*, pp. 14, 15.
11. *Supra.* note 1, p. 2-15.
12. *Supra.* note 1, p. 2-13.
13. *Supra.* note 4, pp. i, ii.

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14. As recognized in your May 4, 1995 presentation at the NRC/DOE Technical Exchange on Licensing in Las Vegas. See, Holonich, *Overview of the U.S. Nuclear Regulatory Commission*, p. 10, "Issue Resolution."

15. *Supra.* note 4, p. 1.

16. *Supra.* note 1, pp. 1-9 -- 1-11.

17. "All data are imperfect representations of reality. . . . So-called 'hard' data, such as data taken from instruments, cannot be considered to be perfect because of problems such as random noise, equipment malfunction, operator interference, data selection, or data interpretation. The validity of all data varies."

DeWispelare, *Supra.* note 1, p. 1-12.

18. *Id.*, p. 1-4.

19. *Id.*, p. 1-2.

20. *Id.*, p. 1-5.

21. *Id.*, p. 1-11.

22. *Id.*, p. 5-26.

23. *Id.*, p. 1-5.

24. 10 C.F.R. 60.31.

25. *Supra.*, note 1, pp. 1-5, 1-6.

26. *Id.*, p. 1-8.

27. *Id.*, p. 1-9.

28. With this in mind, we take particular exception to the example presented by DeWispelare, *et. al.*, referring to Kaplan, S., 1992, *Expert Information Versus Expert Opinions: Another Approach to the Problem of Eliciting/Combining/Using Expert Knowledge in PRA. Journal of Reliability Engineering and System Safety* 35: 51-72:

The approach advocated by Kaplan (1992) is the use of experts to generate the necessary information relevant to the value of the parameter of interest, which he refers to as the elicitation of expert information and Goodwin and Wright

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(1991) call the elicitation of expert knowledge. In other words, if one is interested in the probability distribution of a parameter, expert judgments can be used to construct that distribution based on sufficient available information. If the information is not initially available, experts would be used in that case to generate the information. As such, the elicitation of expert information is a precursor to the elicitation of expert judgments in those cases for which the information cannot be obtained by other scientifically or technically acceptable means.

DeWispelare, et. al., *supra*, note 1, p. 5-6.

29. *Id.*, pp. 3-2 -- 3-15.

30. *Id.*, p. 2-8; see, Hora, S.C., and R.L. Iman. 1989, Expert Opinion in Risk Analysis: The NUREG-1150 Methodology, *Nuclear Science and Engineering* 102: 323-331.

31. *Id.*, p. 2-11; see, Hora, S.C., D. von Winterfeldt, and K.M. Trauth. 1991. *Expert Judgment on Inadvertent Human Intrusion into the Waste Isolation Pilot Plant*, SAND90-3063. Albuquerque, NM: Sandia National Laboratories.

32. *Id.*, p. 1-8.

33. *Id.*, p. 2-5.

34. Technical work in the HLW repository program will use expert elicitation derived judgments to support a number of areas in the program. The use of expert judgment by the DOE is possible in: (i) the preparation of the P[erformance] A[ssessment] calculations and other technical analyses that will support the license application (LA), and (ii) the analyses and deliberations to interpret the results obtained. The containment requirements previously stipulated in the EPA regulation for HLW disposal dictate that a PA be conducted to determine the ability of the disposal system to isolate the wastes over 10,000 years following closure of the repository. PA calculations aimed at supporting the demonstration of compliance with these requirements must include a prediction of the future states that the disposal system could attain over that period and expert judgments are pervasive in determining the possible future states of the system.

DeWispelare, et. al., *supra*, note 1 p. 5-3 (emphasis supplied).

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35. *Id.*, p. 5-4, see, Park, J.R., N.A. Eisenberg, J.T. Buckley, R.G. Baca, and E.J. Bonano. 1994. *The Nuclear Regulatory Commission Strategic Plan for Postclosure Performance Assessment Activities for the High-Level Waste Geologic Repository, Draft Report*, Washington D.C., Nuclear Regulatory Commission, in preparation.

36. *Id.*, p. 1-3.

37. "[G]iven the same information, each expert should be able to reproduce his/her judgments, and related judgments should be consistent with each other. Expert judgments should be updated with new information becomes available, but the update should be effected carefully to ensure consistency; for example, when updating the probability of occurrence of a given event due to new information, internal consistency means that the expert needs to simultaneously update the complement of the event. Formal expert elicitation increases the likelihood of internal consistency by identifying and forcing the resolution of potential inconsistencies.

". . . . Thus, even when presented with identical data, different experts may reach different conclusions. This does not necessarily invalidate the process; it simply provides a range of possible responses based on the expertise existing in the field as a whole."

DeWispelare, et. al., *supra.*, note 1, pp. 1-11, 1-12.

38. *Supra.* note 4, p. 9.

39. *Supra.*, note 1, pp. 2-9, 2-14 (re: motivational bias).

40. *Id.*, p. 2-7.

41. *Id.*, p. 2-8.

42. *Id.*, p. 2-9.

43. *Id.*, pp. 2-11, 2-14, 2-16 -- 2-18.

44. *Id.*, p. 2-16.

45. *Id.*, pp. 2-12, 2-20.

46. *Id.*, p. 2-11.

47. *Supra.* note 9, p. 10.

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48. *Supra.* note 9, p. 9.
49. *Supra.* note 1, p. 2-12.
50. *Id.*, pp. 2-9, 2-13.
51. *Id.*, pp. 3-2 -- 3-15.
52. *Supra.* note 9, p. 10; DeWispelare, et. al., *supra.*, note 1, pp. 3-2 -- 3-15.
53. DeWispelare, et. al., *supra.*, note 1, p. 2-13.
54. *Id.*, pp. 3-16 -- 3-18.