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Dr. Mal Knapp
Chief of Geotechnical Branch
Division of Waste Management
U.S. Nuclear Regulatory Commission
Washington, D.C. 20241

Dear Dr. Knapp:

This letter constitutes an opinion on a working paper entitled "Examples for Discussion NRC/DOE Meeting on Performance Allocation, September 1985." The purpose of this working paper, as stated on the cover sheet is as follows:

> (The examples in this paper are intended only to illustrate the concepts of performance allocation and to facilitate discussion. These examples should not be interpreted as specifications by the NRC staff of specific values to be used in a performance allocation for any particular site, nor should the example approaches be construed as being the only approaches that might be used. The applicant must allocate performance for each site based on the individual features of the site and on the applicant's allocation of the resources to be devoted to site characterization.)

Need for performance allocation:

Part 60 sets out performance objectives for three of the major barriers of a repository system, but leaves to the applicant's discretion the proposed means by which compliance with the performance objectives is to be demonstrated. For example, the engineered barrier system release rate specified in Part 60 can potentially be achieved by a low groundwater flux coupled with low solubilities, by a low waste form leach rate, or by reliance on other engineered barriers such as bentonite backfill materials. Part 60 also leaves open (i.e., to the applicant's discretion) the means by which compliance with the EPA standards will be demonstrated. Two general approaches are available: a) better than required performance from one or more of the barriers addressed in Part 60 (provided that a multiple barrier approach is retained), or b) reliance on another characteristic of the disposal system, such as the site geochemistry.

Both DOE's site characterization plans and NRC's reviews of those plans will be significantly affected by the specific approach selected by DOE. In order to determine if the kind and

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> amount of testing and investigation is sufficient -- "how much is enough" -- DOE should specify as early as possible the barriers to be relied on and the level of performance sought from each barrier.

I agree with these introductory statements. It is advisable to try to delineate the protection from radionuclide releases that is to be assigned to the different portions of the sequence of protective devices that are inherent in the concept of a waste repository. On a broad scale these protective mechanisms can be allocated to the waste package, to the hydrogeologic characteristics of the ground water flow system, and to the geochemcial characteristics of the hydrogeologic medium that constitutes the structural framework that houses the ground water flow system. The characteristics of the waste package can be viewed (broadly) as all of the man-made characteristics of the repository including any coating on the spent fuel rods, the containers of the spent fuel rods and the backfill materials of the repository itself. Conceptually it would be advisable to delineate up front the role to be played by each of these "hurdles" to radionuclide migration from any repository site. Beyond that point quantification of the man-made and natural barrier systems becomes difficult, and elusive. More specifically, the assignment of a confidence interval or a level of confidence to each component that comprises the various hurdles in the engineered and natural barrier system in my opinion would be difficult.

My experience with field oriented determinations of hydrogeologic properties of various types of porous media suggest that the "confidence interval" assigned to values of the variables that describe the natural barrier system ultimately will be delineated on the basis of professional judgement. These judgements will address whether or not the testing procedures implemented to delineate the values of the variables can be defended as state-of-the-art procedures. This conclusion is a consequence not only of my observations of field procedures but also of my interpretation of the procedures used commonly by geostatisticians in the assignment of confidence interval or level of confidence over any variable that must take on a finite value for analytical or numerical purposes. Some limited assessment of the uncertainty in an end product such as travel time is possible but such assessment will not evaluate the uncertainty of the validity of the data base itself.

This concept is difficult at best to describe verbally; consequently I request that you view the following remarks in that context.

The concept of error analysis as related to any data base is based primarily on the data base that happens to exist. A student T test can deal with no data other than the data that are incorporated into the student T test. For example, if all the boreholes producing data on hydraulic conductivity that are incorporated into a student T test suffer from uncorrected partial penetration of the aquifer then the level of confidence derived from the test would not reflect the error produced by partial penetration effects. Consequently the confidence interval derived for the test data would not reflect the error caused by partial penetration effects. Other more sophisticated examples could be cited using more sophisticated types of tests. For reasons of this type I suggest that the critical issue with respect to assignment of retardation responsibility to different portions of the engineered and natural barrier system should be based primarily on whether or not the testing procedures utilized for that portion of the barrier system are state-of-the-art testing procedures. Assessments of uncertainty in end products such as travel time can be useful but such assessments will not reflect the uncertainty inherent in acquiring different portions of the data base that are required for the calculations.

These observations in large part are a consequence of the fact that the analysis of complex hydrogeological systems is in fact an art as well as a science. The aforementioned error caused by partial penetration would not be reflected uniquely by well founded scientific pumping test data. The effects of partial penetration are not obvious from standard hydraulic property test data and identical effects can be produced by other phenomena. Such effects must be identified by an experienced professional hydrogeologist who has observed the effects previously and who is able to use other types of data to produce a quality judgement regarding this effect.

Given that I was assigned the responsibility for defending a program that would assign responsibility for retardation of radionuclides to specified portions of the retardation circuit I would adopt the following procedure.

1. I would identify the state-of-the-art procedures for designing and constructing waste packaging materials. I use waste packaging in the broad sense of the meaning of the word. The broad sense of the meaning of the word includes all treatments that can be applied to the spent fuel rods, all protective mechanisms that can be incorporated into the containers, and all aspects of the backfill of the repository itself.

2. I would identify the state-of-the-art procedures that should be applied to the delineation of the conceptual model of the natural barrier system. This mdoel in essence is a hydrogeologic conceptual model. This step constitutes the most difficult and risky step in the process. If the criteria that are utilized to delineate the conceptual hydrogeologic model at a specific site are inappropriate then the characterization of the entire natural barrier system will be fallacious. This error cannot be quantified by geostatistical methodologies that currently are available. The delineation of the conceptual model that characterizes the natural barrier system is a matter of professional judgement. It is the portion of the site characterization procedure that constitutes an art as well as a science. The criteria used to delineate the conceptual model must include all the geologic and hydrogeologic data that can be obtained for the site. Geophysical data and core data are most useful in this regard. Borehole flow survey logs, for example, are particularly useful in differentiating heterogeneous conceptual models from homogeneous conceptual models. State-of-the-art testing procedure constitutes a very important

aspect of the delineation of a defensible conceptual model to be utilized at a given site.

3. Once a defensible conceptual model is developed, based on defensible state-of-the-art procedures and good judgement, it is necessary to develop a defensible state-of-the-art testing scheme or strategy for that conceptual model. We have performed this step for the BWIP site in the form of Staff Technical Position 1.1. We have not performed this step for any of the other sites. A defensible state-of-the-art testing procedure is necessary for any site. It must be derived from the defensible conceptual model described above. It probably will not be possible to assign a meaningful confidence interval to the variables that result from the state-of-the-art testing procedure that is developed for the adopted conceptual model. The testing procedure probably will be defensible only in the context of whether or not it is state-of-the-art. Factors that are incorporated into the concept of state-of-the-art include interval separation by packers, installation of piezometers, measurement of fluid potential downhole versus uphole, multiple well testing versus single well testing, and methodology used to select the interval to be tested. The selection of the most defensible state-of-the-art testing scheme is one of the most important parts of the defensibility of the characterization of any site. It is for this reason that the NRC staff devoted so much time and energy to the creation of STP 1.1. The defensibility of all the subsequent aspects of the natural barrier system rests on the defensibility of the selection of a defensible state-of-the-art testing scheme for the conceptual model developed for a given site. In the case of STP 1.1 the conceptual model reflected by the testing strategy consists of a layered aquifer case with the possibility of relatively permeable discontinuities and/or hydrogeologic barriers in combination with the possibility of leakage through aquitards along flow pathways that do not constitute discontinuities in the normal sense of the word. All these factors are judgemental in nature. It is difficult, if not impossible, to assign a confidence interval to any of the variables that are operative in the procedure. The assignment of a confidence interval would, in my opinion, consist in large part of a quantitative assessment of the testing procedure itself, not of the natural barrier system or of the conceptual model.

4. The last step in the procedure consists of mathematically modeling the natural system. Modeling can be stochastic, deterministic or a combination thereof. The BWIP EA contained an example of the latter. In addition to the variables addressed above, the mathematical model must incorporate boundaries that may be regional in nature. The boundaries must be assigned a location and a hydraulic conductivity to a considerable extent on the basis of qualitative professional judgements. The best and most defensible judgement probably will be derived from individuals who have a large amount of experience with such boundaries. Such judgements probably are the only mechanism by which such boundaries can even be identified, much less quantified. The normal procedure that is implemented in modeling to minimize the effect of error in such analyses is to assume that such

boundaries are located sufficiently distant from a center of activity that the effect of the boundary on the activity is minimal. However, if a boundary in fact exists within a short distance of a center of activity such as a repository site its effect on retardation by the natural system will not be minimal. Consequently qualitative judgements cannot be avoided. Consequently it is essential that the mathematical modeling process incorporate qualitative judgements with respect to location and hydraulic characteristics of boundaries. Their assumed presence or absence can make or break a site. Hydraulic testing procedures as described above can in some cases identify boundaries. But in most cases qualitative judgements based on geology alone cannot be avoided. Consequently it is essential that mathematical modeling personnel recognize that the quality of the output of mathematical models is qualitative to a considerable extent. It is difficult to assign a confidence interval to the qualitative output from such models, even though that output appears in a quantitative format.

In summary, the above discussion suggests that the quantification of the role to be played by each portion of the man-made and natural barrier system is difficult. The most probable scenario for the characterization of the role of each portion of the barrier system is that the criteria on which each portion of the barrier system is evaluated will be based on judgements made by experienced professionals who will identify defensible state-of-the-art procedures for characterization of that portion of the system. If quantification procedures are used exclusively, impossible hurdles will be established that will impede the progress of the national waste disposal program. This statement is a consequence of the fact that it simply is not possible to quantify all the partitions in the engineered and natural barrier systems. Qualitative judgements are unavoidable. Some assessment of travel time uncertainty can be achieved through models such as those presented in the BWIP EA. But it is important to remember that such models do not assess the error in the delineation of the appropriate or inappropriate conceptual model which is the basis for testing strategy design.

In my opinion, allocation of resources for program planning should be based on the following prioritization scheme.

1. The procedures for the delineation of state-of-the-art evaluation and testing for the waste packaging scheme should be delineated. Although my experience in this area is very limited, it seems to me that this portion of the delineation of the state-of-the-art procedure should be relatively straightforward. The procedures basically are engineering procedures that should be reasonably well understood.

2. The state-of-the-art procedures for creating a defensible conceptual model of the natural system at any given site should be delineated. These procedures are not straightforward and they require a considerable amount of qualitative judgement. Experienced field personnel are required for this step. Geology is the controlling factor in this step. This step

requires the transformation of geologic data into engineering data. At this point in the evaluation process the hydrogeologist and the engineer must agree on the portions of the hydrogeologic environment that can be partitioned for purposes of engineering calculations.

3. A testing scheme prioritization procedure must be implemented that will facilitate the characterization of the aforementioned hydrogeologic segments into quantifiable entities. This procedure is qualitative in nature. The qualitative nature of this step cannot be avoided; the results are quantitative, but the procedure itself is qualitative. The end result is a document comparable to STP 1.1. The engineer and the hydrogeologist must agree on the testing procedure to be implemented at this stage.

4. The last step in the process is the development of the mathematical model as described above. The engineer and the hydrogeologist must evaluate the results of the mathematical modeling step on a continuing basis (an iterative procedure) in the context which requires that the hydrogeologic characteristics of the simulations be changed repeatedly in order to produce compatibility of mathematical model output with real data.

This completes my comments on the aforementioned discussion paper. It also provides insight into the format that I think should be utilized to allocate resources among the various portions of the program that ultimately must characterize retardation characteristics of the man-made and natural barrier system. If you have questions regarding this issue, please call.

Sincerely,

Roy E. Williams
Ph.D. Hydrogeology
Registered in Idaho

REW:sl

cc: Hub Miller
Jeff Pohle
Mike Weber
Fred Ross