Revised March 6, 1995

Memorandum to: Dr. Martin J. Steindler, Chairman, ACNW

From: L. Deering, Senior Staff Scientist

Subject: Impressions and Conclusions of the ACNW Working Group Meeting on Use of Isotopic Methods to Date Groundwater at the Proposed Yucca Mountain Site.

Dr. Hinze asked me to put together the attached summary report (Attachment 1) of the subject meeting to transmit the four consultant's reports provided to the Committee. Please note that recommendations made in this report are not sanctioned by the Committee, and are not intended as advice for the DOE. Rather, they serve as a collection of suggestions on data needs noted by the ACNW consultants, for the benefit of the ACNW, and possibly the NRC staff, should staff find them useful in their interactions with DOE.

A list of the key issues identified for the Working Group is included in Attachment 2. The consultants' reports are included in Attachments 3-6. Consultants were also asked to comment on two specific questions posed by Dr. Hinze following the meeting; their responses are contained in Attachments 7-9. Finally, Attachment 10 contains a copy of a note from the USGS on clarification of what is meant by the term "residence time." If you have questions, recommendations, or would like to discuss this information, please contact me or Dr. Hinze.

Attachments: As Stated

cc: ACNW staff
J. Larkins
R. Savio

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DRAFT 2

SUMMARY AND CONCLUSIONS: GROUNDWATER AGE DATING WORKING GROUP MEETING, OCTOBER 21, 1994, LAS VEGAS, NEVADA

Groundwater is the most likely pathway for radionuclide escape at the proposed Yucca Mountain HLW site, hence characterization of subsurface hydrology and hydrochemistry are among the most critical activities underway in the Yucca Mountain site characterization program. Large uncertainties exist in characterizing the unsaturated zone hydrology and hydrochemistry due to complex site conditions and limitations in existing methodologies. The NRC must be prepared to provide appropriate guidance to the DOE on licensing concerns and how the NRC will apply the regulatory framework for complying with the subsystem GWTT criterion and overall performance objective.

Current results from isotopic dating reveal evidence for rapid flow via fractures, which may have important implications to GWTT and overall site performance. While there is much uncertainty associated with isotopic dating, results of these methods are of critical value to site characterization because they provide one of the only relatively direct indications of system performance. Thus DOE will need to factor the isotopic evidence for rapid flow paths into its demonstration of compliance with the GWTT requirement and explain plausible conceptual models that are compatible with the existing isotope data.

Because of the importance and timeliness of this subject in supporting GWTT and performance assessment evaluations, the ACNW convened the October 21, 1994 Working Group meeting held in Las Vegas, NV. The purpose of the Working Group was to look at results of isotopic methods being used at Yucca Mountain to estimate patterns and rates of groundwater movement, and the reliability of the isotopic dating methods for groundwater.

Key issues identified for consideration by the Working Group members and participants are listed in Attachment 2, along with a list of two additional questions posed to the consultants for comment following the meeting.

Based on the key issues and questions identified, and the reports submitted by the consultants, a synthesis of the overall impressions and conclusions from the meeting are listed below:

1. Isotopic results cannot be used to estimate a unique or absolute age of groundwater or groundwater travel time due to uncertainties associated with each of the specific dating methods, and the fact that the flow path itself must be known in order to infer an actual travel time. By themselves, isotopic methods can only be used to estimate residence time of groundwater, or the time that has elapsed since a sampled volume of water has entered the underground system, rather than an actual travel time.

2. Despite limitations, results from isotopic dating are of critical importance because they provide the only relatively direct indication of system performance. To date they have provided the most valuable information on the GWTT issue of fastest path of likely radionuclide travel. Isotopic results are invaluable when used as an independent line of evidence to evaluate the appropriateness of conceptual models of groundwater flow and bound potential minimum GWTTs (all).

3. Various dating methods are best used in combination with other dating methods and hydrologic data to constrain possible interpretations from use of a single method. Results should be compared for consistency to develop credible defensible conceptual models of the system (all).

4. Isotopic results to date indicate a highly heterogeneous flow system with multiple flow paths, some of which are quite rapid along fractures or faults, with fracture flow and lateral flow being the dominant flow system. Further, the existence of bomb-pulse tritium (H-3) and Cl-36 at depth is very difficult to explain using the current DOE conceptual model, hence it appears that these results invalidate the current DOE conceptual model of matrix dominated flow, which may grossly overestimate GWTT (Davis, Foland).

5. Results from various isotopic dating methods vary widely, over several orders of magnitude, due in part to mixing and in part to the contributions of moisture from both fracture and matrix flow at various points. Results to date have been difficult to interpret. Furthermore, many of the holes used were not originally intended for isotope studies, thus in many cases results reflect contamination and may not yield the information desired. To make matters worse, various isotope methods, including C-14, H-3, and Cl-36, have been used on samples collected from different locations and/or intervals and compared, again making inconsistencies in results difficult to interpret.

   Discrepancies in dating methods observed at Yucca Mountain could therefore be due to 1) mixing of water of different ages, yielding an overall younger or older apparent age, 2) sampling water originating from different pathways (fractures or matrix), 3) comparing results from different spatial locations, or 4) uncertainties in dating methods, such as in-situ production of isotopes as well as other sources that must be accounted for.

   DOE has proposed a mixing model to explain age discrepancies and show that a small percentage of young water mixed with older matrix water results in a much younger apparent age for C-14 and Cl-36. However, another equally plausible conceptual model may be that the majority of water moves via discrete fractures, with some or little mixing with older matrix water, causing the apparent age of the sample to be older than it really is. Multiple conceptual models must be considered and tested (Conrad).

6. It is not clear how DOE intends to use the isotope information to guide additional data collection, or to support GWTT and PA analyses. DOE needs to develop a strategy for demonstrating compliance, and specifically, how the isotope data will be used to support this demonstration. In this way additional isotopic data needs can be determined and prioritized. Failure to prioritize data needs may result in incomplete information in 1998 to determine site suitability, and hence submittal of an incomplete License Application (Conrad,Davis).

   Because DOE has not outlined a strategy for use of existing and future isotope results, it is difficult to speculate on the usefulness of isotopic data in the future. Future isotopic data could be used potentially to resolve some of the following key issues: 1) the distribution of flux between matrix and fractures that should be assumed in performance assessment (this one is tough), 2) minimum GWTTs, 3) role of climate change in understanding existing and future states of system and 4) conceptual model uncertainty (Davis).

7. The occurrence of H-3 and Cl-36 at depth indicates that recent water has entered the system. However, it is not known along what pathways (fractures) water has entered, their extent, or, most important, from what pathways it is discharging. How water leaves the system is a critical question which must be answered before site suitability can be determined. Mass balance, i.e., equilibrium between recharge and discharge must be considered in assessing how water enters and exits the system. While DOE has suggested matrix flow below the perched zones, it is reasonable to assume water escapes from the system via fractures, in the same manner it entered the system. To answer this, subsurface data are needed on actual pathways below the repository horizon (Leap, Conrad).

8. Hydrology and geochemistry data and expertise must be integrated to come up with a consistent interpretation of the total data set. Integration appears to be being carried out at the investigator level, but not necessarily at the program level from top down (all, Conrad).

9. In summary, while the methods should improve over time, it is not likely that dramatic improvement in the near future will occur that will enhance the reliability of methods. Nonetheless, in lieu of measurements of true GWTT, isotope methods seem to provide the most direct and credible estimates of what GWTT could be. DOE will need to reconcile current results indicative of fast fracture flow with its existing conceptual model, and develop a strategy for how it will use future measurements in its overall strategy to get to compliance to ensure collection and integration of the data needed for licensing.

Recommendations

- USGS has proposed the idea that water may flow intermittently via fractures to a certain depth, reach an impediment and become ponded, then slowly imbibe into the matrix. However, considering the concept of mass balance of a steady-state system, an alternative model that must be tested is periodic drainage of the perched zones via fractures when pressure becomes sufficient to induce fracture flow, equal in amount to the flow entering the system via fracture flow. DOE needs to collect isotopic samples below the perched zones to determine if fracture flow also predominates below these zones (Conrad), and if possible, collect samples form fractures and perched zones fed by fractures (in addition to just the matrix). In addition, it should correlate sample locations with respect to lithology and fracture zones, and plot the results. DOE should also monitor observed water table rise in the perched zones and attempt to correlate fluctuations to precipitation (Conrad).

- DOE needs to show why the rapid travel times above the repository horizon based on isotopic results are not the same as those below the horizon. Isotopic samples need to be collected from below the repository horizon to asses whether bomb-pulse isotopes have reached greater depths. It is critical to have data below the repository horizon, considering credit is likely to be taken for the presumed unfractured tuffs below (Davis).

- DOE needs to use multiple isotope techniques on the same samples and intervals so that results can be compared. Current results were apparently collected from different locations and intervals and then compared. In addition, work on Br/Cl ratios should be continued to resolve whether this method can be used to correct age estimates using Cl-36 due to in-situ production of Cl (Foland, Hinze).

- DOE must consider more than one conceptual model of flow and transport at the proposed site in numerical models. The current approach is to let a single model based on equivalent porous media drive additional data collection, which presupposes that this is the correct conceptual model (Conrad, Davis). DOE needs to use isotopic results to test the appropriateness of this and other conceptual models for unsaturated flow and transport. For example, current models should be tested as to whether they can be used to simulate rapid movement of modern water to the depths observed.

- DOE needs to develop an overall roadmap outlining DOE's strategy for demonstrating compliance, and specifically, how the isotope data will be used to support this demonstration. In this way additional data needs can be prioritized (Conrad).

Summary and Follow-up

The Working Group addressed many but not all of the key issues listed in Attachment 2. The group identified the primary methods for dating groundwater, discussed their appropriate use at Yucca Mountain, and the limitations and difficulties associated with each method. Discussed to a lesser extent or not discussed include how DOE has changed its conceptual model to explain the isotope results and accommodate evidence for a fracture flow dominated system, how DOE has modified its site characterization activities in response to this data, consistency with isotopic results and modeling, and implications of isotopic results on GWTT.

The results of this meeting will be used to formulate advice to the Commission on GWTT. In follow-up to this meeting, the ACNW is planning to conduct a Working Group meeting on groundwater modeling in June, 1995, including how modeling is being used by the DOE to support its compliance demonstration with 10 CFR 60, with emphasis on conceptual models and integration of modeling efforts and site characterization. The result of the follow on meeting will be used to advise the Commission on the status of modeling activities and integration of modeling and site characterization.

ATTACHMENT 2

Key Issues Provided to Working Group

- What are the primary isotopic methods to date groundwater and limitations of each method?

- Which isotopic dating methods are best suited for use at Yucca Mountain to discern the nature and rate of groundwater and or gaseous movement through the unsaturated zone and are they being utilized?

- What difficulties exist in using isotopic methods for unsaturated studies and how much emphasis should be placed on results?

- What is DOE doing in response to new information on fracture flow from isotopic dating? Is DOE placing enough emphasis on understanding fracture flow and fault pathways in its studies?

- What is the current status of results from groundwater age dating studies? Has DOE changed its conceptual model of flow through the unsaturated zone to explain the isotopic results and if so, how? How has DOE modified ongoing testing and studies of the unsaturated zone in response to these results?

- What are the results of recent modeling of groundwater travel time? Are the results of unsaturated zone flow modeling consistent with the results of isotopic dating?

- What are the implications of isotopic results on travel time requirements for DOE's 10 CFR 960 and 10 CFR 60?

- Is it possible that the H-3 detected in the Calico Hills unit was transported as a gas? Does the fact that it moves as a gas or liquid render the method unsuitable for tracing groundwater movement?

- How do the age estimates using various methods compare to each other and how do estimates in the unsaturated zone compare to the saturated zone?

- Two additional questions posed to the consultants following the meeting include:

1. Is it likely that isotopic methods of dating groundwater will be sufficiently credible that they will provide believable information on GWTT at Yucca Mountain by 1995, 1996, and 1997?

2. If isotopic methods are not going to be available are there alternative credible methods for ascertaining GWTT, and if so, what data are required?

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