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Dear Al:

I was glad to have met you finally at the groundwater travel time workshop in Albuquerque last June. Thank you for reviewing my AGU presentation on using artificial data in evaluating site characterization strategies, and for sending along reprints of your recent papers on the assessment of data worth. I would like to respond to your comments on the AGU paper:

(1) The effective thickness of 1/10 cm used in the calculation is in line with the single measurement of effective porosity at the BWIP site of about 0.0001 and a unit thickness of about 10 meters measured by L. Gelhar in a two-well tracer test. This value seems incredibly small to me too. The Department of Energy's analysis of groundwater travel time at BWIP performed by Peter Clifton uses a significantly larger value of n_e. Typical values of porosity for basalt flow tops seem to be in the range of a few percent.

(2) The study was supposed to be generic and simple, but representative of a real site. I am not sure I accomplished this. I had some misgivings about using the BWIP data for my model study because these data are for the most part from single well slug tests, and probably have very small support. One of the assumptions in the model study was that the data were characteristic of a REV, but I have no way of knowing from the present data if this is so. Even if the data are supported by the REV, I use them on the scale of the finite difference grid which is 365 meters on a side. The 3000 meter correlation length I used was not supported by the data. I was not able to deduce a meaningful variogram from the data and must conclude that they are spatially uncorrelated at the scale of the measurements. I am not sure that the Vanmarke equations to adjust the variance would be useful in this case because I do not have a worthwhile correlation scale from which to work. If the data from BWIP do not represent the REV of a volume smaller than the grid blocks, it would appear that the variance I used in the simulation is too great. Our consultant Roy Williams suggests that all tests at BWIP should be conducted at the largest scales possible, and advocates the use of large-scale pumping. While data collected from a large-scale test would have smaller variance than the slug test data, I am not convinced that this is the correct approach either. The pumping tests may not represent the tranmissivities important to the flow under natural gradient conditions.

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(3) You are correct that the distribution of groundwater travel times illustrated in the example is caused by the distributed nature of the source. I was trying to illustrate the great degree to which the travel time was dependent on the point of release, but you are correct in stating that it is unclear what constitutes the fastest path. A possible definition of a "path" would be a macroscopic entity which includes all water crossing the boundary of the disturbed zone, rather than the travel time from a single point along the perimeter. In the example, most of the flow moves in the well-defined channel so the fastest travel time is reasonably close to the flux-weighted mean travel time. I doubt that we would ever have enough data to be able to discern anything but a gross measure of groundwater travel time. I agree that the Monte Carlo approach where there is homogeneous but uncertain T along the flow path is too simplistic. I do not endorse this approach; my intention was to demonstrate that it did not work very well.

I found the papers you sent to be very interesting and germane to the discussion of groundwater travel time. It might be difficult to apply most of the principles to the U.S. high level program however, because it is hard to define a payoff function for the site. The only penalty which I can think of is that DOE would be forced to reclaim the buried waste if environmental monitoring after site closure indicated that unacceptable levels of release were occurring. This seems to me to be very unlikely. I would be very interested in your views on how and if the risk-based approach could be applied to the U.S. program, given that we are dealing with performance criteria which cannot be measured readily.

Thank you again for your interest. I hope to see you at the DOE/AECL meeting in San Francisco this September and possibly at future DOE panel meetings.

Sincerely,

ORIGINAL SIGNED BY

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SUBJECT: GROUNDWATER TRAVEL TIME WORKSHOP

DATE:

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