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July 7, 1988

009/1.5/WWL.010
RS-NMS-85-009
Communication No. 268

U.S. Nuclear Regulatory Commission
Division of High-Level Waste Management
Technical Review Branch
OWFN - 4H3
Washington, DC 20555

Attention: **Mr. Jeff Pohle, Project Officer**
Technical Assistance in Hydrogeology - Project B (RS-NMS-85-009)

Re: **Documentation of Response to Questions from L. Lehamn (for State of Nevada) Concerning WWL Technical Report No. 3 "Estimates of Cumulative Radioactive Flux at Yucca Mountain Nevada"**

Dear Mr. Pohle:

Attached please find a letter report from Mr. Tom Sniff of Water, Waste and Land concerning certain clarifications to Technical Report # 3. The background and need for such a letter is addressed below.

On June 20, 1988, I received a series of telephone calls from Dr. Linda Lehamn, technical consultant to the State of Nevada, concerning what she considered to be an error in the formulation of the equation that WWL presented to calculate the curie load of a radionuclide that might be released to the accessible environment over 10,000 years. Dr. Lehman informed me that she had discussed the matter at some length with Mr. N. Coleman (HLTR), who had directed her to contact NWC directly. Dr. Lehamn's concern was that, when she tried to reproduce the sample calculation using Np-239 instead of Am-241, she got a non-sensical result.

After discussing the Np example with her, I, too, was inclined to believe that a factor was missing from the key equation. I reviewed the paper and then contacted WWL for clarification. Mssrs. Lyle Davis and Tom Sniff at WWL identified the misunderstanding that Dr. Lehman and I (and apparently Mr. Coleman, as well) had concerning the paper. The equation is correct as presented in Technical Report #3. However, the value of t that is used depends on the radionuclide of concern, as is pointed out very clearly on page 9 of the WWL report. This is the error initially made by Dr. Lehman and me: we used 10,000 years along with the rest of the Np data without considering the limitation on t.

D1021/
WM-11/
NH14/

Mr. Sniff's letter report rather elegantly clarifies the computational process that was implicit in Technical Report #3. Table 1 of the letter report presents the results of intermediate calculations that were used by WWL to develop the graphs of the technical report. When the correct time interval is used, the calculations are seen to be internally consistent. After additional quality assurance review by NWC (the original report had already received a Level 1 review by NWC and Daniel B. Stephens and Associates), we are confident that the analysis, the results and the conclusions are correct <u>within the limits described in the text</u> (see Section 3.3 of Technical Report #3).

I relayed the WWL technical explanation to Dr. Lehman on June 22, 1988, and told her that I would recommend to you that she be provided with a copy of this letter and the attached WWL clarifications. Since the matter addresses material that is already in the public domain and because no fundamental revisions to the analysis or conclusions are involved, I have included Dr. Lehman on direct distribution for this letter, including the attachment from WWL.

If you have questions about this letter, WWL's attachment, or my discussions with Dr. Lehman, please contact me.

Respectfully submitted,
NUCLEAR WASTE CONSULTANTS, INC.

Mark J. Logsdon

Mark J. Logsdon, Project Manager

cc: US NRC - Director, NMSS (ATTN PSB)
HLWM (ATTN Division Director)
Edna Knox, Contract Administrator
HLTR (ATTN Branch Chief)
D. Chery, HLTR
Dr. Linda Lehamn, Lehman and Associates, Burnsville, MN

J. Minier, DBS

bc: L.Davis, WWL
M. Galloway, TTI

Water, Waste & Land, Inc.
CONSULTING ENGINEERS & SCIENTISTS

RECEIVED
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June 24, 1988

Mr. Mark Logsdon
Nuclear Waste Consultants
155 South Madison Street, Suite 302
Denver, Colorado 80209

Dear Mark,

This letter is in response to questions which have been brought forth pertaining to Mini-Report #3 - Estimates of Cumulative Radioactive Flux at Yucca Mountain, Nevada. In particular the questions seem to focus around the parameters used in the equation on page 9 of the report. A review of those parameters and a presentation of the results of the equation in much more detail to clear up any questions which may have arisen are given below.

The equation as presented on page 9 of the report was as follows

$$R = S * F * W * t * E * f * A$$

where

R is the total radioactivity released to the environment at 10,000 years (Ci)
S is the solubility of the isotope (grams/liter)
F is the unit flux (liters/MTHM * yr)
W is the total waste present (MTHM)
t is time (years)
E is the element activity (Ci/g)
f is the fraction of flow in the fractures, and
A is the fraction of the repository underlain by the CHnz unit

The three parameters which appear to need further definition are t, F, and W. The two terms F and W, when multiplied together are equivalent to a yearly flow rate through the entire repository (liters per year), henceforth designated as Q. Substitution of this variable into the equation yields

$$R = S * Q * t * E * f * A$$

As stated in the report on page 9

"Time, t, depends on the amount of element present at 1,000 years, and the element dissolution rate and has a maximum value of 9,000 years. If an element is completely dissolved from the waste in less than 9,000 years, then t becomes the total time it takes to dissolve that element."

This time t is the time it takes to completely dissolve all of a particular isotope from the repository. This time is a function of each isotope's mass, solubility, and the flux rate and can be calculated by dividing the total mass of the isotope present in the repository by the yearly flow rate and the solubility. If m represents the total mass of an isotope in the repository waste, the time, t, required for the equation can be calculated by:

$$t = m / (Q * S)$$

The denominator (Q * S) is the dissolution rate for the particular isotope.

As an example, the time required to completely solubilize the Neptunium isotope Np 237 is demonstrated below. From Table 2 of the report (page 8), the following information is obtained

Element	Solubility moles/liter	MW g/mole	Inventory g/MTHM	Mass g
Np 237	2.10E-04	237	3.83E+02	2.68E+07

The total mass present in the repository at 1060 years for the isotope was calculated by multiplying the inventory value by the design limit of 70,000 MTHM. Applying the equation for the time, where Q is equal to 6.15E+06 (1mm/yr flux) liters per year, the following time was calculated for the complete dissolution of the Neptunium isotopes:

$$t = m / (Q * S)$$
$$t = 2.68E+07 / (6.15+06 * 2.10E-04 * 237)$$
$$t = 88 \text{ years}$$

The time required to dissolve each isotope present in the repository waste given a flux of 1 mm/yr is shown in Table 1.

These same values could be calculated using a unit flux F and W, the total waste present. Since the regulations require the cumulative release at 10,000 years, those radionuclides which are completely solubilized in less than 9,000 years (~1060 years + 9000 years is the 10,000 years for the regulations) are assumed to be completely available for transport from the repository horizon.

The percentage of the isotopes transported to the accessible environment is ultimately dependent upon the percentage of the flux being transported as fracture flow. The isotopes completely dissolved in less than 9,000 years are transported, therefore, as a percentage equivalent to the flow occurring in fractures.

For those isotopes which are not completely dissolved at the end of 9,000 years, the appropriate time to consider for the environmental loading is the 9,000 years. This time gives the cumulative loading on the environment for each of those particular isotopes.

Simply put, the total load to the environment is the total amount of each isotope that is soluble in 9000 years (which may or may not be the total amount of each isotope stored) multiplied by the fraction of flow that occurs as fracture flow. The time, t, used in the equation should be 9000 years or the value given in the table above, which ever is smaller.

The graphs in the report use the total Curies released for each isotope at the end of the 10,000 year period based on the above analysis. I hope that this additional description provides the necessary detail to answer any questions. If I can be of any further assistance, please do not hesitate to call.

Sincerely,

Thomas Lyle Sniff
Senior Engineer

Table 1

Element	Solubility moles/liter	MW g/mole	Inventory g/MTHM	Years to Dissolve
Am243	1.00E-08	243	7.03E+01	329285
Am242	1.00E-08	242	3.19E-03	15
Am241	1.00E-08	241	5.25E-02	248
Pu242	1.80E-06	242	4.10E+02	10713
Pu241	1.80E-06	241	1.52E-03	0
Pu240	1.80E-06	240	1.81E+03	47689
Pu239	1.80E-06	239	4.57E+03	120912
Pu238	1.80E-06	238	1.83E-03	0
Np239	2.10E-04	239	5.58E-05	0
Np237	2.10E-04	237	3.83E+02	88
U238	2.10E-04	238	9.61E+05	218852
U236	2.10E-04	236	3.63E+03	834
U235	2.10E-04	235	7.48E+03	1725
U234	2.10E-04	234	1.21E+01	3
U233	2.10E-04	233	1.37E-01	0
Ra226	1.00E-07	226	6.78E-04	0
Ra225	1.00E-07	225	1.71E-10	0
Cs137	2.10E-04	137	2.53E-08	0
Cs135	2.10E-04	135	3.06E+02	123
Sn126	1.00E-09	126	1.69E+01	1526649
Tc99	2.10E-04	99	7.65E+02	419
Sr90	2.10E-04	90	4.74E-09	0
C14	2.10E-04	14	2.70E-02	0