J. Noggle (RI)

From: "Adler, Joseph J." <jadler@entergy.com>
To: <jdn@nrc.gov>
Date: 06/01/2006 10:28:39 AM
Subject: Uranium results and evaluation

Jim,

Attached is a TID that documents our results and evaluation concerning Uranium found in our ground water. I have hard copy lab reports with Uranium data for MWs- 50, 49, 42, and 36. I will fax them to you now and e-mail the pdfs later today

Jay

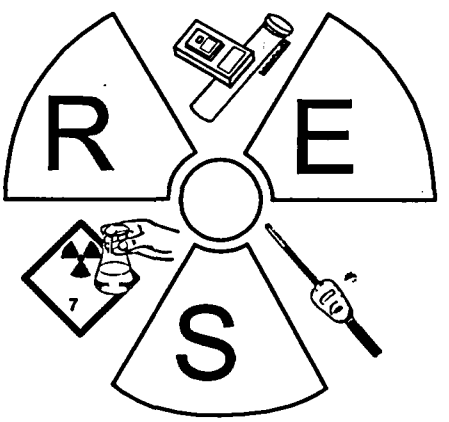
<<TID 06-001, Uranium in Ground Water_Final.DOC>>

C-4

Entergy Nuclear NorthEast
Indian Point Energy Center (IPEC)

TID-2006-001

Evaluation of Uranium Concentrations In Groundwater Samples At IPEC



Prepared By: _____ Date: _____

Reviewed By: _____ Date: _____

Approved By: _____ Date: _____

1. executive summary

Monitoring Well 49 (MW 49) groundwater samples from bedrock fractures exhibited detectable U-234 and U-238 activity by alpha spectroscopy. The U-234/U-238 activity ratio of the samples averaged 2.02. At first glance, the identification of U-234 in disequilibrium with U-238 in the environment around nuclear facilities would appear to be uncommon unless manmade sources are introduced to upset this equilibrium. This assumption is based on U-234, the daughter of U-238 being in secular equilibrium with U-238. Therefore, in an undisturbed, closed system, the U-234 to U-238 ratio would be expected to be unity. Since U-234 is enriched along with U-235 in the nuclear fuel fabrication process (the ratio of U-234/U-238 in a 15 year old, 4.3% enriched spent fuel element is 4.78), this environmental disequilibrium can be interpreted as an indication that material is from a nuclear facility, rather than from naturally occurring uranium.

Numerous studies, published in scientific journal and periodicals indicate that U-234/U-238 disequilibrium in water from bedrock fractures is a common, natural phenomenon with documented ratios of up to 10:1. Since the MW 49 sample also did not indicate the presence of transuranic radionuclides (which make up the bulk of the radioactivity from nuclides with atomic numbers equaling or exceeding uranium in spent fuel), the disequilibrium between U-234 and U-238 found in the MW 49 sample is associated with the documented natural phenomenon as discussed below.

2. EVALUATION

Monitoring well samples were recently analyzed by Teledyne Laboratories using alpha spectroscopy to determine if alpha emitting radionuclides from Indian Point were present in monitoring well samples. The sample results are shown in Table 1.

Table 1 - Uranium 234 and 238 Results Above Detection Limits

TBE L#	IP# ID	Run	U-234 pCi/L	U-238 pCi/L	U-234/ U-238 Ratio
L28182-4	MW-49 25 ft	Original	1.08	0.62	1.74
L28182-4	MW-49 25 ft	Recount	1.14	0.57	2.00
L28182-4	MW-49 25 ft	Rerun	1.09	0.54	2.02
		Average	**1.10**	**0.58**	**1.91**
L28182-3	MW-49 42 ft	Original	2.06	1.02	2.02
L28182-3	MW-49 42 ft	Recount	1.98	0.71	2.79
L28182-3	MW-49 42 ft	Rerun	2.1	0.89	2.36
		Average	**2.05**	**0.87**	**2.34**
L28183-5	MW-36B 52 ft	Original	2.1	1.43	1.47

L28183-5	MW-36B 52 ft	Recount	2.21	1.33	1.66
L28183-5	MW-36B 52 ft	Rerun	2.32	1.4	1.66
		Average	**2.21**	**1.39**	**1.59**
L28182-5	MW-49 65 ft	Original	2.21	0.94	2.35
L28182-5	MW-49 65 ft	Recount	2.34	1.15	2.03
L28182-5	MW-49 65 ft	Rerun	2.04	0.87	2.34
		Average	**2.20**	**0.99**	**2.23**
	Overall Average		1.89	0.96	2.02

Concerns were raised by staff personnel reviewing the results, and by Teledyne, due to the U-234 to U-238 ratio exceeding 1. In the natural uranium decay chain U-234 and U-238 are in secular equilibrium. U-234 has a half-life of 247,000 years and is a daughter of U-238 which has a half-life of 4,510,000,000 years. In an undisturbed, closed system, the activities of the parent U-238 and the daughter U-234 are equal and the U-234/U-238 ratio is approximately unity. As seen in Table 1, the U-234 activities of the samples in question were significantly higher than the U-238 activities.

If the Urnium observed in the sample is from Indian Point, it would originate from spent fuel. The enrichment process used to make commercial nuclear fuel increases the relative abundance of U-234 as well as U-235. Since new fuel is not stored for prolonged periods on site and has rigorous storage requirements to ensure it is not degraded prior to placement in the core, it is unlikely that new fuel could be the source of potential Uranium contamination in the groundwater. Spent fuel is stored in Spent Fuel Pools. There are indications that Unit 1 and Unit 2 Spent Fuel Pool water are the major sources of groundwater contamination. However, Uranium comprises a small percentage of the total heavy element activity in spent fuel (e.g., elements with atomic numbers equal to or higher than Uranium). Ikenberry[4,3] provides the radionuclide activities in spent nuclear fuel with 4.3% enrichment and a 15-year decay time in Table A-12 of the document. The uranium and transuranic activities from Ikenberry are shown in the 2nd and 3rd columns of Table 2. This indicates that the U-234/U-238 activity ratio of spent fuel is 4.78.

Table 2 - Spent Fuel Transuranic and Uranium Activities

Radionuclide	Ikenberry Quantity Curies	Ikenberry Quantity mCi	Percent Uranium and Trans
U234	6.600E-06	6.600E-03	0.00114%
U236	1.870E-06	1.870E-03	0.00032%
U238	1.380E-06	1.380E-03	0.00024%
Np237	2.500E-06	2.500E-03	0.00043%
Pu238	2.560E-02	2.560E+01	4.41%
Pu239	1.775E-03	1.775E+00	0.30572%
Pu240	3.100E-03	3.100E+00	0.53393%
Pu241	3.850E-01	3.850E+02	66.31%
Pu242	1.500E-05	1.500E-02	0.00258%
Am241	1.470E-01	1.470E+02	25.32%
Am242m	7.100E-05	7.100E-02	0.01223%

Am243	2.000E-04	2.000E-01	0.03445%
Cm243	1.280E-04	1.280E-01	0.02205%
Cm244	1.770E-02	1.770E+01	3.05%
Cm245	2.900E-06	2.900E-03	0.00050%
Cm246	9.000E-07	9.000E-04	0.00016%
Total U and Transuranics		5.806E+02	
U-234/U-238 Ratio		4.78	

It can also be seen from the table that U-234 and U-238 make up a very small percentage of the total Uranium and transuranics activity in spent fuel. The "Percent Uranium and Transuranics" column shows each individual nuclides percentage of the total activity shown at the bottom of the table (e.g., 5.806E+2 mCi) The uranium nuclides comprise thousandths of a percent of the total activity for heavy nuclides in spent fuel. Most of the source term is Pu-241 (principally a beta emitter), Am-241, and Cm-244.

An average U-234/U-238 ratio of approximately 2 was observed in the Indian Point well water samples. This is higher than the natural uranium equilibrium ratio of 1 and lower than the spent fuel activity ratio of 4.78. Numerous references are available in the literature documenting disequilibrium between U-234 and U-238 in groundwater and especially in water sequestered in bedrock in an oxidizing environment.

Suksi[4.1] cites the following mechanisms as contributing to U-234/U-238 disequilibrium. "*The following mechanisms have been recognised as responsible for disequilibration of natural radioactive decay chains: (1) dissolution/precipitation, (2) diffusion, (3) α-recoil and (4) recoil-induced vulnerability to leaching (see review in Osmond and Ivanovich 1992). Selective leaching by groundwater when it percolates past mineral grains is a common disequilibration mechanism in the bedrock environment. The susceptibility of U to groundwater leaching and, consequently, disequilibration of its decay chains depends on the location and binding of U in the rock matrix (cf. section 2.2).*"

Nimz[4.4] states "*It has long been observed that the two uranium isotopes are seldom in secular equilibrium in natural waters (Cherdyntsev et al., 1955). The activity ratio of 234U to 238U is generally greater than one, often substantially greater.*" He also describes work in which the variations in U-234/U-238 ratios between bodies of water were used as a natural tracer and describes ratios higher than those observed in the Indian Point monitoring well samples being evaluated. "*Variations in flow rates have also been observed using U isotopic compositions. Kronfeld and Rosenthal (1981) collected water samples from Bet Shean and Harod valleys in Israel, which comprise a single large drainage basin. The samples showed very small variations in U concentrations (~1-4 mg/L), but large variations in 234U/238U activity ratios (<1.5 to >3.0).*"

Paces[4.5] states the following with regard to characterization of water in the bedrock at Yucca Mountain, "*234U/238U and -230Th/238U ratios determined by TIMS in both water and volcanic rocks vary throughout the >500-m-thick unsaturated zone (UZ) at Yucca Mountain. Infiltration, with 234U/238U activity ratios (AR) of about 1.5 to 1.8, is*

modified as it percolates downward by addition of 234U via a-recoil and preferential leaching from pore walls and fracture surfaces. Water in shallower parts of the UZ commonly has 234U/238U AR of 2 to 4, whereas values of 7 to 10 are common at greater depths. Water perched in welded tuffs near the base of the UZ also has large 234U/238U AR (7 to 8), as does ground water in the upper parts of the saturated zone." There are an ample number of other scientific papers and dissertations which document natural U-234/U-238 disequilibrium in bedrock aquifers.

3. CONCLUSION

Based upon the following considerations, the sample results are indicative of naturally occurring uranium in groundwater.

- Disequilibrium between U-234 and U-238 in groundwater is a well documented phenomenon.
- The absence of the more abundant spent fuel related alpha emitting transuranics in the samples.

Naturally occurring Uranium isotopes in ground water samples are expected background radionuclides and do warrant further evaluation.

4. References

4.1. ISSN 0358-7746, Juhani Suksi, *"Natural Uranium As A Tracer In Radionuclide,"* Academic Dissertation, University of Helsinki, Faculty of Science Department of Chemistry Laboratory of Radiochemistry Finland.

4.2. GEOSPHERE TRANSPORT STUDIES

4.3. DIRS 156919-Ikenberry (2001, all), *"Inventory and Characteristics of Spent Nuclear Fuel, High-Level Radioactive Waste, and Other Materials."*

4.4. UCRL-JC-131027- Gregory J. Nimz, June 1998, "The Isotope Hydrology of Catchment Basins: Lithogenic and Cosmogenic Isotopic Systems."

4.5. Geological Society of America 2002 Denver Annual Meeting, Paper No. 137-3, James B. Paces, "U-Series Isotopes Water/Rock Interaction, And Evidence Of Unsaturated-Zone Flow At Yucca Mountain, Nevada."

5. Attachments

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