Yucca Mountain Legacy Project Element Analysis Assessment
Compiled by John Hadder 3/11/05

The table below contains all of the elements under consideration for baseline study. There are three rankings: 1 indicates the highest priority, 2 intermediate, and 3 indicates the lowest priority.

Element	Rank	YMP	NTS, 1	NTS, 2	40CFR141	Home Anal.	M, NTS	H, NTS	Ci	EPA (pCi/l)	Solubility	Half life (yr)
Americium-241	1	Y	Y	Y		Y		Y	2.21e+8	1.90e+1	1.00e-3	4.30e+2
Americium-243	1	Y				Y			1.90e+6	1.90e+1	1.00e-3	7.40e+3
Carbon-14	1	Y	Y	Y				Y	1.05e+5	3.20e+3	1.00e+0	5.70e+3
Cesium-137	1	Y	Y	Y	Y	Y		Y	5.43e+9	1.19e+2	1.00e+0	3.00e+1
Curium-244	1					Y			1.21e+8	2.30e+1	1.00e-3	1.80e+1
Europium-154	1		Y			Y			1.20e+8	5.73e+2	1.00e-3	8.60e+0
Hydrogen-3	1		Y	Y	Y	Y	Y		1.60e+7	6.09e+4	1.00e+0	1.23e+1
Iodine-129	1	Y	Y	Y	Y	Y	Y	Y	2.44e+3	2.10e+1	1.00e+0	1.70e+7
Neptunium-237	1	Y	Y	Y		Y	Y	Y	3.06e+4	3.20e+1	1.00e-3	2.10e+6
Plutonium-238	1	Y				Y			2.43e+8	1.50e+1	1.00e-5	8.80e+1
Plutonium-239	1	Y	Y	Y		Y		Y	2.44e+7	1.50e+1	1.00e-3	2.40e+4
Plutonium-240	1	Y	Y			Y		Y	3.63e+7	1.40e+1	1.00e-3	6.50e+3
Plutonium-242	1	Y				Y			1.40e+5	1.50e+1	1.00e-3	3.80e+5
Radium-226	1	Y			Y				na	5.00e+0	2.00e-1	1.60e+3
Radium-228	1				Y				na	2.00e+0	2.00e-1	5.75e+0
Strontium-89	1				Y				na	5.99e+2	1.00e+0	1.38e-1
Strontium-90	1	Y	Y	Y	Y	Y		Y	3.38e+9	4.20e+1	1.00e+0	3.00e+1
Technecium-99	1	Y	Y			Y	Y		1.00e+6	3.79e+3	8.00e-1	2.10e+5
Thorium-229	1	Y							2.89e+1	9.00e+0	2.00e-4	7.90e+3
Uranium-232	1	Y			Y				3.88e+3	2.00e+1	2.00e-3	6.90e+1
Uranium-233	1	Y			Y				1.28e+4	2.00e+1	2.00e-3	1.60e+5
Uranium-234	1	Y	Y		Y			Y	8.95e+4	2.00e+1	2.00e-3	2.50e+5
Uranium-236	1	Y			Y				1.80e+4	2.00e+1	2.00e-3	2.30e+7
Uranium-238	1	Y	Y	Y	Y			Y	2.11e+4	2.00e+1	2.00e-3	4.50e+9
Non-radiological												
Barium-137	1											
Chromium	1				Y							
Gadolinium-154	1											
Lead, and 206, 208	1			Y	Y							
Molybdenum	1											
Zirconium	1											
Zirconium-90	1											

Table Key:

YMP - Y indicates that the element was included in the DOE's analysis for the 2000 TSPA for the Site Recommendation[i]

NTS,1 - Y indicates that the element was a candidate for contamination at the NTS and satisfied one or more criterion; amount *produced*, *mobility* in the groundwater, and *health impacts*.[ii]

NTS,2 - Y indicates elements for final consideration of NTS contamination.[2]

40CFR141 - Y indicates that this element (isotope) is required for compliance with the Safe Drinking Water Standard[iii]

Home Anal. - a simple numerical tally was done combining the top thirty radionuclides in each of three categories; total curies, potential solubility, and EPA MCL's based on effective dose equivalent of 4 mrem/yr for beta and photon emitters, and 15pCi/L for alpha emitters. Any radioisotopes with a tally of three or two was included in the consideration list and is designated with a Y.

M, NTS and H, NTS - indicates mobility and health respectively, and Y designates that the element satisfied that criterion by the peer review panel.[2]

Ci - approximate total curies as determined from the YM FEIS[iv] (commercial spent fuel inventory and significant DOE owned amounts under the "proposed action," and unclassified amounts for 76 underground tests in Areas 19 and 20 below or with 100 meters of the water table.[v]

EPA (pCi/L) - MCL's in picocuries per liter obtained for 4 mrem/yr and 15 pCi/L for beta/photon and alpha emitters respectively with a risk assumption of approximately 1-5 $x10^{-4}$.[vi] ; MCL's for uranium isotopes are based on kidney toxicity, since it is lower than MCL's for cancer

Solubility - potential solubility in considering ingestion of radionuclides[vii]

Half life - mostly from YM FEIS[4], and some from Brechin[6], Martin[7]

Element	Rank	YMP	NTS, 1	NTS, 2	40CFR141	Home Anal.	M, NTS	H, NTS	Ci	EPA (pCi/l)	Solubility	half life (yr)
Actinium-227	2	y							1.01e+2	1.00e+0	1.00e-3	2.20e+0
Americium-242/242m	2	y				Y			1.60e+6	1.09e+3	1.00e-3	1.40e+2
Antimony-125	2		Y			Y	Y		3.60e+6	1.94e+3	1.00e-2	2.80e+0
Cesium-134	2		Y			Y		Y	5.89e+6	8.10e+1	1.00e+0	2.10e+0
Chorine-36	2		Y						1.13e+3	1.85e+3	1.00e+0	3.00e+5
Cobalt-60	2		Y			Y	Y		2.73e+7	2.18e+2	5.00e-2	5.30e+0
Europium-152	2		Y						4.33e+2	8.41e+2	1.00e-3	1.35e+1
Europium-155	2		Y			Y			2.20e+7	3.59e+3	1.00e-3	4.80e+0
Krypton-85	2		Y				Y		1.52e+8	na	na	1.07e+1
Lead-210	2	y							na	1.00e+0	2.00e-1	2.26e+1
Protactium-231	2	y							2.10e+1	8.00e+0	1.00e-3	3.30e+4
Ruthenium-106	2		Y			Y	Y		1.04e+5	2.03e+2	5.00e-2	1.00e+0
Samarium-151	2		y						3.17e+7	1.41e+4	na	9.00e+1
Thorium-230	2	Y							1.85e+1	2.10e+1	2.00e-4	7.50e+4
Cadmium-113m	3					Y			1.50e+6	5.24e+4	5.00e-2	1.40e+1
Curium-242	3					Y			1.30e+6	5.10e+1	1.00e-3	4.50e-1
Curium-243	3					Y			1.30e+6	2.10e+1	1.00e-3	2.90e+1
Iron-55	3					Y			4.20e+5	9.25e+3	1.00e-1	2.70e+0
Nickel-59	3					Y			1.61e+5	2.70e+4	5.00e-2	7.60e+4
Nickel-63	3					Y			2.20e+7	9.91e+3	5.00e-2	1.00e+2
Plutonium-241	3					Y			3.20e+9	1.50e+1	1.00e-3	1.40e+1
Zirconium-93	3					Y			1.94e+5	5.09e+3	2.00e-3	1.50e+6
Non-radiological												
Cadmium	2				Y							

Nickel	2				Y							
Titanium	2											
Vanadium	2											

Explanation of ranking:

Any element that is required for the Safe Drinking Standard, and/or was included in the YMP, NTS,1 and Home Analysis was ranked 1. Some YMP selections were included like Thorium-229 as it is a significant intermediate daughter product from Plutonium-240, 239, & 238, Uranium-232 & 233, Americium-241, Neptumium-237, decay with a fairly large half life (order of thousands of years).

Lead-210 is also a daughter intermediate product from the Uranium-238 decay chain; however a relatively short lived (21 years) half life. Other lead isotopes are probably better to focus on like Lead-206 and 208, which are the end products of uranium and plutonium decay.

Actinium-227 was on the DOE list, which was mostly likely included because of the potential disruptive and human intrusion scenarios[viii], as the inventory is not large and mobility could also be rather small; however, this isotope is very toxic, so it could be significant under those situations. On the other hand, it may not be relevant to the baseline assessment.

Technecium-99, Neptunium-237, and Americium-241, 243 are all good indicators of repository and NTS contamination. NTS underground testing resulted in very small amounts of Americium-243, so this isotope could differentiate the two sources. If it is of interest Calcium-41 could be used as a NTS tracer, as it has a relatively long half life; although it is likely not to be very mobile in the water system.

Europium-154 contributes much of the short term radioactivity, and may not reach water supplies or will have decayed between exposure and illness realization, so Gadolinium-154 the stable daughter product, is worth analysis. Gadolinium-154 could also serve as a YMP/NTS tracer. The same could apply to Strontium-90 and Cesium-137, which have comparable lifetimes, but exist in very large mass amounts as well as curies. Thus, it is prudent to analyze for Barium-137, and Zirconium-90 the stable daughter products of Cesium-137 and Strontium-90.

Chromium, Molybdenum, and Zirconium are included due to potential heavy metal toxicity derived from spent fuel assembly corrosion and disposal cask degradation.[ix] Chromium toxicity is well known as specifically considered in the EPA Safe Drinking Water Standard. The communication from Paz cites many references within that reveal a need to assess concentrations of a number of heavy metal elements that have or are suspected to have intrinsic toxicity, and which could exacerbate radiotoxic effects.

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[i] U.S. DOE, OCRWM, Yucca Mountain Science and Engineering Report, DOE/RW-0539, May 2001.

[ii] The American Society of Engineers, *Strategy for Remediating of Groundwater Contamination at the Nevada Test Site,* Technical Peer Review Report (Report of the Review Panel, CRTD-Vol. 62, 2001.

[iii] U.S. EPA, Title 40 Code of Federal Regulations Part 141, National Primary Drinking Water Regulations

[iv] U.S. DOE, *Final Environmental Impact Statement for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High Level Radioactive Waste at Yucca Mountain, Nye County , Nevada, Vol. II,* DOE/EIS-0250F, February 2002.

[v]. Brechin, Vernon, private communication, Mountain View, California.

[vi] U.S. EPA , Radionuclides Notice of Data Availability Technical Support Document, Targeting and Analysis Branch Standards and Risk Management Division Office of Ground Water and Drinking Water United States Environmental Protection Agency, March 2000.

[vii] Martin, James E. and Chul Lee, *Principles of Radiological Health and Safety*, Table 9-9, pp 306-310, John Wiley Sons, Inc., Hoboken, New Jersey, 2003.

[viii] TRW Environmental Safety Systems Inc. , Waste Form Degradation Process Model Report, TDR-WIS-MD-000001 REV 00 ICN 01, 1180 Town Center Drive Las Vegas, Nevada 89144-6363, July 2000.

[ix] Paz, Jacob D, William G. Culbreth, and Delbert Barth, A Review of Health Risks due to Complex Mixtures and Canister Corrosion at Yucca Mountain, private communication, publication in process