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Friday, July 12, 2019

Glenn Huber
Stan A. Huber Consultants, Inc.
200 N. Cedar Rd.
New Lenox, IL 60451

RE: ECC McClurg (Soil)

Dear Mr. Huber:

A summary of gamma spectroscopy results for our sample number G190127 is in Table 1. Stan A. Huber Consultants, Inc. identified the sample as ECC McClurg (Soil). The table below lists the concentrations of selected radionuclides. Values with a less-than symbol (" $<$ ") indicate a concentration below RSSI's minimum detectable concentration (MDC). Additional identified radionuclides are in the complete gamma spectroscopy report.

Table 1. High-resolution Gamma Spectroscopy Results [pCi/g]

Radionuclide	Sample
	G190127
	ECC McClurg (Soil)
Pb-214	0.94
Bi-214	0.95
Ra-226 ¹	0.95
Ac-228	27.79
Ra-228 ²	27.79
Th-232 ³	27.79
Tl-208	7.90
K-40	11.38
Pb-212	22.30
Bi-212	28.85
Th-234	$<$ 0.83
Pa-234m	$<$ 2.70
U-238 ⁴	$<$ 1.75

¹ The concentration of Ra-226 is based on the average concentration of Pb-214 and Bi-214.

² The concentration of Ra-228 is based on the surrogate Ac-228.

³ The concentration of Th-232 is based on the surrogate Ac-228.

⁴ The concentration of U-238 is based on the average concentrations of Th-234 and Pa-234m.

Some radionuclides of interest, thorium-232 (Th-232), radium-226 (Ra-226), radium-228 (Ra-228), and uranium-238 (U-238), are difficult to identify and quantify directly at low concentrations with reasonable counting intervals. The concentrations of surrogates with more abundant high energy photons usually represent the concentration of Th-232, Ra-226, Ra-228, and U-238. The successful use of surrogates depends upon the radionuclides in each series being in equilibrium.

Radium-226 (Ra-226), in the uranium series, has only one significant photon at 186.21 keV with a gamma fraction slightly greater than 0.03. Analysis for Ra-226 using this energy is difficult because of the possible presence of uranium-235 (U-235), which has an interfering 185.72 keV photon with a 0.57 gamma fraction, and protactinium-234 (Pa-234) which emits an interfering 186.15 keV photon with a 0.02 gamma fraction. The gamma fraction is the fraction of decays that produce a photon of a given energy. Bismuth-214 (Bi-214) and lead-214 (Pb-214) are used as surrogates for Ra-226.

The equilibrium between Ra-226 and its decay products, including Pb-214 and Bi-214, may be disturbed if radon-222 (Rn-222) is released when samples are collected. Rn-222, a gaseous Ra-226 decay product, has a half-life of 3.8 days. Pb-214 and Bi-214 reestablish equilibrium with Ra-226 in a sample after an in-growth period, typically seven Rn-222 half-lives. As a standard protocol, samples are normally held for 30 days to reestablish equilibrium. This sample was analyzed on receipt and was not held for in-growth. The average of the activities of Pb-214 and Bi-214 is shown as the activity of Ra-226.

Both Th-232 and Ra-228, in the thorium series, emit photons with very low gamma fractions at very low energies. In the thorium series, actinium-228 (Ac-228) is usually in equilibrium with both Th-232 and Ra-228 when collected. Bi-212 has a branching fraction of approximately 0.36 for decays to thallium-208 (Tl-208). Therefore, the activity of Tl-208 is approximately 36% the activity of other radionuclides in the thorium series. The branching fraction is the fraction of decays that proceed through a given decay path.

U-238, in the uranium series, emits photons with very low gamma fractions at low energies. Thorium-234 (Th-234) and protactinium-234m (Pa-234m), both with photons at higher energies and with larger gamma fractions, are usually in

Glenn Huber
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RSSI

equilibrium with U-238. The average of the activities of Th-234 and Pa-234m is shown as the activity of U-238.

The complete spectroscopy analysis results are attached. Please call me at 847-965-1999 if you have any questions.

Sincerely,

A handwritten signature in cursive script that reads "Aaron J. Morris".

Aaron Morris

attachment

Sample description

G190127 Stan A. Huber Consultants, Inc., ECC McClurg (Soil), 544.9 g, v. 2

Spectrum Filename: H:\GammaVision\User\Spectra\G190127 v. 2.An1

***** S U M M A R Y O F N U C L I D E S I N S A M P L E *****

Nuclide	Activity uCi/g	Uncertainty Counting	1 Sigma Total
AC-228	2.7785E-05	1.331E+00%	3.026E+00%
PB-214	9.4453E-07	1.014E+01%	1.134E+01%
BI-214	9.4736E-07	9.540E+00%	1.013E+01%
K-40	1.1381E-05	6.224E+00%	7.210E+00%
Th-234 <	8.2923E-07		
Pa-234m <	2.6797E-06		
Pb-212	2.2295E-05	6.515E-01%	6.452E+00%
Bi-212	2.8824E-05	6.685E+00%	7.388E+00%
Tl-208	7.9015E-06	1.380E+00%	3.757E+00%
Pa-234	6.0948E-07	2.538E+01%	2.568E+01%
U-235 <	2.1285E-07		
Ra-223 <	1.2656E-07		
Th-227 <	1.3431E-07		
Pa-231 C	1.3433E-06	5.097E+01%	5.129E+01%
Ra-224	2.1951E-05	6.576E+00%	9.178E+00%
Th-231	7.1293E-06	1.041E+01%	1.102E+01%
Pb-211 <	4.6543E-07		
Bi-215 C	8.6152E-08	6.219E+01%	6.248E+01%
Rn-219 <	1.6489E-07		
Cs-137 #	8.0250E-08	6.211E+01%	6.220E+01%

- # - All peaks for activity calculation had bad shape.
- * - Activity omitted from total
- & - Activity omitted from total and all peaks had bad shape.
- < - MDA value printed.
- A - Activity printed, but activity < MDA.
- B - Activity < MDA and failed test.
- C - Area < Critical level.
- F - Failed fraction or key line test.
- H - Half-life limit exceeded

----- S U M M A R Y -----
 Total Activity (1009.4 to 1781.5 keV) 1.313E-04 uCi/g
 This section based on library: SAHCI - 2017-07.Lib

Sample description

G190127 Stan A. Huber Consultants, Inc., ECC McClurg (Soil), 544.9 g, v. 2

Spectrum Filename: H:\GammaVision\User\Spectra\G190127 v. 2.An1

***** S U M M A R Y O F L I B R A R Y P E A K U S A G E *****

- Nuclide -		Average	----- Peak -----				
Name	Code	Activity uCi/g	Energy keV	Activity uCi/g	Code	MDA Value uCi/g	COMMENTS
AC-228	N	2.7785E-05	911.20	2.766E-05	(P	9.656E-08 1.33E+00	G
			968.97	2.798E-05	(P	1.609E-07 1.63E+00	G
			338.32	2.478E-05	- P	4.947E-07 2.29E+00	G
			964.77	2.780E-05	(P	6.206E-07 3.50E+00	G
			463.00	2.280E-05	- P	9.819E-07 6.39E+00	G
			93.35	2.513E-05	-	1.430E-06 5.21E+00	XA
							Energy duplication
			89.96	2.779E-05	}	2.592E-06 6.95E+00	XA
PB-214	N	9.4453E-07	351.93	9.522E-07	(P	6.454E-08 9.65E+00	G
			295.22	9.816E-07	(P	1.003E-07 1.27E+01	G
			242.00	8.095E-07	(P	4.960E-07 5.93E+01	G
			258.87	0.000E+00		6.206E-08 0.00E+00	G
			785.96	0.000E+00		8.024E-08 0.00E+00	G
							Energy duplication
			77.11	0.000E+00	P	4.263E-08 0.00E+00	XA
							Energy duplication
			74.82	0.000E+00		1.427E-08 0.00E+00	XA
							Energy duplication
			89.78	0.000E+00		6.419E-08 0.00E+00	XA
BI-214	N	9.4736E-07	609.31	9.474E-07	(P	5.853E-08 8.90E+00	G
			1120.29	1.607E-06	+ P	2.327E-07 1.86E+01	G
			1764.49	1.492E-06	+ P	2.416E-07 1.85E+01	G
			768.36	2.626E-06	+ P	5.490E-07 2.45E+01	G
			1238.11	2.638E-06	& P	5.594E-07 2.85E+01	G
			934.06	0.000E+00	P	1.727E-07 0.00E+00	G
			1377.67	2.443E-06	+ P	6.939E-07 3.25E+01	G
K-40	N	1.1381E-05	1460.82	1.138E-05	(P	3.771E-07 5.03E+00	G
Th-234	N	0.0000E+00	92.38	0.000E+00	%	8.292E-07 1.00E+03	G
			92.80	0.000E+00	&	1.695E-06 1.00E+03	G
			63.29	0.000E+00	&	2.501E-06 1.00E+03	G
Pa-234m	N	0.0000E+00	1001.03	0.000E+00	&	2.680E-06 1.00E+03	G
			98.43	0.000E+00	%	9.289E-06 1.00E+03	XA
Pb-212	N	2.2295E-05	238.63	2.228E-05	(P	7.295E-08 6.51E-01	G
			300.09	2.251E-05	(6.574E-07 3.65E+00	G
			115.18	2.447E-05	+ P	5.192E-06 2.94E+01	G
							Energy duplication
			77.11	2.155E-05	P	5.608E-07 2.25E+00	XA
							Energy duplication
			74.82	2.229E-05	}	9.363E-07 3.43E+00	XA
			87.35	2.229E-05	}	1.415E-06 4.10E+00	XA
			86.83	2.105E-05	}	2.755E-06 1.17E+01	XA

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				Energy duplication	
		89.78	2.098E-05	}	3.493E-06 1.47E+01 XA
Bi-212	N	2.8824E-05			
		727.33	2.882E-05	(P	5.670E-07 6.67E+00 G
		785.37	1.757E-05	-	3.182E-06 2.57E+01 G
		288.20	3.551E-05	+	6.158E-06 2.15E+01 G
		1620.50	5.417E-05	+	4.075E-06 8.58E+00 G
Tl-208	N	7.9015E-06			
		583.19	7.901E-06	(P	4.363E-08 1.38E+00 G
		277.35	8.703E-06	+ P	4.665E-07 7.71E+00 G
		860.56	1.000E-05	+ P	4.384E-07 3.89E+00 G
					Energy duplication
		74.97	7.901E-06	}	2.816E-06 2.33E+01 XA
		72.81	2.054E-05	+	4.007E-06 1.90E+01 XA
Pa-234	N	6.0948E-07			
		131.30	5.628E-07	(1.590E-07 2.86E+01 G
		152.72	0.000E+00	%	3.827E-07 2.35E+02 G
		227.25	0.000E+00		5.139E-09 0.00E+00 G
		226.50	1.409E-06	&	5.205E-07 4.72E+01 G
		946.00	6.721E-07	&(1.570E-07 4.19E+01 G
		98.43	9.963E-07	&	1.485E-07 1.90E+01 XA
		94.65	4.436E-07		2.989E-07 6.66E+01 XA
U-235	N	0.0000E+00			
		143.76	0.000E+00	&	2.129E-07 1.00E+03 G
		163.36	0.000E+00	&	4.759E-07 1.00E+03 G
		205.31	0.000E+00	&	3.823E-07 1.00E+03 G
		93.35	0.000E+00	%	4.294E-07 1.00E+03 XA
		89.96	0.000E+00	%	8.093E-07 1.00E+03 XA
Ra-223	N	0.0000E+00			
		269.46	0.000E+00	%	1.266E-07 1.00E+03 G
		154.21	0.000E+00	%	5.339E-07 1.00E+03 G
		144.23	0.000E+00	%	3.326E-07 1.00E+03 G
		323.87	0.000E+00	%	3.796E-07 1.00E+03 G
		83.79	0.000E+00	%	2.164E-07 1.00E+03 XA
		81.07	0.000E+00	%	2.140E-07 1.00E+03 XA
Th-227	N	0.0000E+00			
		235.97	0.000E+00	%	1.343E-07 1.00E+03 G
		256.25	0.000E+00	&	2.270E-07 1.00E+03 G
		329.85	0.000E+00	%	4.258E-07 1.00E+03 G
		300.00	0.000E+00	%	1.532E-06 1.00E+03 G
		286.12	0.000E+00	%	9.874E-07 1.00E+03 G
Pa-231	N	1.3433E-06			
		302.65	1.106E-06	(8.233E-07 7.46E+01 G
		300.07	0.000E+00		1.481E-08 0.00E+00 G
		283.69	1.745E-06	&(1.031E-06 6.95E+01 G
		330.06	0.000E+00	%	1.892E-06 1.30E+02 G
Ra-224	N	2.1951E-05			
		240.99	2.195E-05	(1.389E-06 6.58E+00 G
Th-231	N	7.1293E-06			
		84.22	7.129E-06	(P	7.091E-07 1.04E+01 G

Sample description

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Spectrum Filename: H:\GammaVision\User\Spectra\G190127 v. 2.An1

Pb-211 N 0.0000E+00
404.85 0.000E+00 & 4.654E-07 1.00E+03 G
832.01 0.000E+00 % 2.993E-07 1.00E+03 G
427.09 0.000E+00 & 1.238E-06 1.00E+03 G
766.51 0.000E+00 % 1.678E-06 1.00E+03 G

Bi-215 N 8.6152E-08
271.23 8.615E-08 (5.339E-08 6.22E+01 G
517.63 0.000E+00 3.091E-09 0.00E+00 G
401.81 0.000E+00 % 1.659E-07 1.01E+02 G
563.70 0.000E+00 % 2.324E-07 1.14E+02 G

Rn-219 N 0.0000E+00
271.23 0.000E+00 % 1.649E-07 1.00E+03 G
401.81 0.000E+00 % 2.604E-07 1.00E+03 G

Cs-137 I 8.0250E-08
661.66 8.025E-08 ?(P 3.433E-08 5.55E+01 G
(- This peak used in the nuclide activity average.

- * - Peak is too wide, but only one peak in library.
- ! - Peak is part of a multiplet and this area went negative during deconvolution.
- ? - Peak is too narrow.
- @ - Peak is too wide at FW25M, but ok at FWHM.
- % - Peak fails sensitivity test.
- \$ - Peak identified, but first peak of this nuclide failed one or more qualification tests.
- + - Peak activity higher than counting uncertainty range.
- - Peak activity lower than counting uncertainty range.
- = - Peak outside analysis energy range.
- & - Calculated peak centroid is not close enough to the library energy centroid for positive identification.
- P - Peakbackground subtraction
- } - Peak is too close to another for the activity to be found directly.

Nuclide Codes:	Peak Codes:
T - Thermal Neutron Activation	G - Gamma Ray
F - Fast Neutron Activation	X - X-Ray
I - Fission Product	P - Positron Decay
N - Naturally Occurring Isotope	S - Single-Escape
P - Photon Reaction	D - Double-Escape
C - Charged Particle Reaction	K - Key Line
M - No MDA Calculation	A - Not in Average
R - Coincidence Corrected	C - Coincidence Peak
H - Half-life limit exceeded	

This section based on library: SAHCI - 2017-07.Lib

Sample description

G190127 Stan A. Huber Consultants, Inc., ECC McClurg (Soil), 544.9 g, v. 2

Spectrum Filename: H:\GammaVision\User\Spectra\G190127 v. 2.An1

***** U N I D E N T I F I E D P E A K S U M M A R Y *****

Channel	Peak Centroid Energy	Background Counts	Net Area Counts	Intensity Cts/Sec	Uncert 1 Sigma %	FWHM keV	Suspected Nuclide
118.65	24.82	7970.	6328.	1.758	2.97	1.114	s
138.80	29.22	8892.	486.	0.135	36.62	0.521	s
157.83	33.39	7296.	804.	0.223	21.54	1.414	s
185.22	39.38	4431.	1114.	0.309	12.08	1.006	s
347.98	74.98	6142.	153.	0.043	72.83	1.077	sc
406.94	87.87	5757.	183.	0.051	58.95	1.091	D
595.92	129.16	4943.	1702.	0.473	6.32	1.134	D
709.55	153.95	4163.	503.	0.140	18.69	1.159	D
962.73	209.44	3786.	2922.	0.812	3.51	1.217	D
974.26	211.97	3239.	122.	0.034	66.39	1.219	c
1237.27	269.51	2790.	112.	0.031	67.09	1.278	c
1241.24	270.44	2204.	1963.	0.545	4.07	1.279	D
1505.06	328.06	1687.	1613.	0.448	4.38	1.337	D
1668.48	363.85	676.	114.	0.032	37.12	0.445	s
1876.82	409.44	1373.	864.	0.240	8.61	1.433	-
2262.33	493.79	522.	112.	0.031	36.03	0.282	sM
2340.29	510.85	1532.	3479.	0.966	3.55	1.758	sM
2554.78	557.78	348.	54.	0.015	60.11	0.509	sM
2575.57	562.36	866.	351.	0.098	12.99	1.568	D
2635.39	575.42	178.	62.	0.017	36.32	0.614	s
2884.43	629.92	438.	86.	0.024	42.43	0.625	s
3120.44	681.57	428.	86.	0.024	71.33	0.274	s
3458.51	755.56	647.	338.	0.094	17.28	1.401	s
3638.66	794.99	521.	1406.	0.391	4.65	1.569	-
3694.19	807.15	243.	111.	0.031	30.84	0.393	s
3823.79	835.51	396.	475.	0.132	9.89	1.062	s
4618.62	1009.50	65.	49.	0.014	33.54	0.358	s
5703.56	1247.03	200.	258.	0.072	17.58	1.481	s
7265.29	1589.04	153.	897.	0.249	5.40	2.183	-
7455.69	1630.74	70.	346.	0.096	8.30	1.351	s

- s - Peak fails shape tests.
- D - Peak area deconvoluted.
- L - Peak written from unknown list.
- C - Area < Critical level.
- M - Peak is close to a library peak.

 This section based on library: SAHCI - 2017-07.Lib

Sample description

G190127 Stan A. Huber Consultants, Inc., ECC McClurg (Soil), 544.9 g, v. 2

Spectrum Filename: H:\GammaVision\User\Spectra\G190127 v. 2.An1

Acquisition information

Start time: 12-Jul-2019 15:19:08
Live time: 3600
Real time: 3630
Dead time: 0.82 %
Detector ID: 3

Detector system

CLTCOMP MCB 9

Calibration

Filename: G190127 v. 2.An1
2016-08-17 30% GEM-30185-P Calibration

Energy Calibration

Created: 12-Jul-2019 17:28:11
Zero offset: -1.135 keV
Gain: 0.219 keV/channel
Quadratic: 2.092E-08 keV/channel²

Efficiency Calibration

Created: 25-Jun-2018 17:23:35
Type: Polynomial
Uncertainty: 0.636 %
Coefficients: -0.517219 -4.334817 0.560084
-0.067363 0.002781 -0.000051

Library Files

Main analysis library: SAHCI - 2017-07.Lib
Library Match Width: 0.500
Peak stripping: Library based

Analysis parameters

Analysis engine: Env32 G53W4.22
Start channel: 20 (3.24keV)
Stop channel: 8144 (1781.51keV)
Peak rejection level: 100.000%
Peak search sensitivity: 3
Sample Size: 5.4490E+02
Activity scaling factor: 1.0000E+00/(1.0000E+00* 5.4490E+02) =
1.8352E-03
Detection limit method: Traditional ORTEC method
Random error: 1.0000000E+00
Systematic error: 1.0000000E+00
Fraction Limit: 0.000%
Background width: best method (based on spectrum).
Half lives decay limit: 12.000
Activity range factor: 2.000
Min. step backg. energy: 0.000
Multiplet shift channel: 2.000

Corrections

	Status	Comments
Decay correct to date:	NO	
Decay during acquisition:	NO	
Decay during collection:	NO	
True coincidence correction:	NO	
Peaked background correction:	YES	2017-02-06 GEM-30185-P Background 06-Feb-2017 11:25:12
Absorption (Internal):	NO	
Geometry correction:	NO	
Random summing:	NO	

total peaks alloc. 62 cutoff 20.00000 %
Energy Calibration
Normalized diff: 0.1236



*6312 Oakton Street
Morton Grove, IL 60053-2723
847-965-1999
Fax 847-965-1991*

The analytical results above relate only to the sample(s) provided to RSSI by the client. The condition of the sample(s) as provided to the laboratory, unless otherwise specified, is the condition of the sample(s) during analysis. Unless otherwise specified, analysis was performed at RSSI.

Analysis authorized by license No. IL-01429-01. Analysis approved by the Canadian Nuclear Safety Commission, meeting the criteria and requirements of R-116.

The identification of the sample(s) and/or sample material(s) is based on information as provided by the client.

This report shall not be reproduced except in its entirety without the approval of RSSI.

-- End Report --