Memo

SUBJECT
Mosaic – Pilot Road Project – PG Stack Sampling Results

TO
File

DATE
2025-09-11

PROJECT NUMBER
30281643

COPIES TO
Atusa Amiri – Mosaic
James Dartez – Mosaic
Kim Owen - Mosaic

PREPARED BY
Doug Chambers
John Stolys

The following describes the PG stack sampling results in support for the use of phosphogypsum (PG) in a small-scale pilot road project on Mosaic's property at its New Wales facility in Mulberry, Florida.

PG Sample Collection for Radiological Analysis

Thirty samples of PG were collected on July 15th for analysis from the designed PG area as described above and shown in Figure 1. The 30 samples were collected for radiological analysis at locations distributed across the surface of the PG storage area. At each sample location GPS coordinates were measured and recorded in the field sampling log.

PG samples were collected using a hand shovel from the PG designated for construction. Samples collected for radiological analysis were approximately a quantity of 500 g per sample.

Seven samples additional sample were prepared in the field as blind duplicates for quality assurance (QA). The QA samples are prepared by splitting the field sample at randomly selected locations distributed across the PG sample area. The samples were recorded as duplicates in the field sampling notes but not identified as duplicates on the sample ID or chain of custody documentation for the laboratory.

Collected samples were placed into plastic bags, and double bagged, labelling the inner bag.

Chain of custody documents were prepared at the time of sample collection and maintained with the samples during transport to the laboratory.

The laboratory utilized for radiological analysis was:

Pace Analytical National Center for Testing and Innovation, Mount Juliet, Tennessee

People Advancing Science® - Pace Analytical - Radiochemistry

The radiological analyses completed for the samples included:

- **Radionuclide Analysis:** Analysis was completed by gamma spectroscopy using EPA method 901.1 or equivalent with a 21-day ingrowth period.

Further details of the analysis and laboratory quality assurance are described in the laboratory report provided in Attachment A.

Figure 1 – Location of sequestered PG for sampling

PG Stack Sampling Results Summary

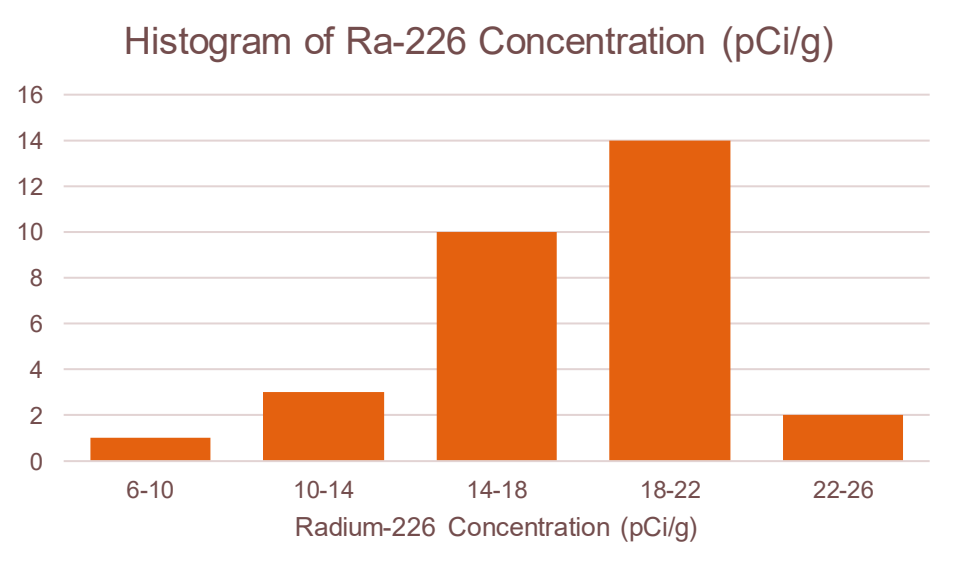
The following provides a summary of the radium-226 results provided in the laboratory results. The radium-226 concentrations were reported based on the measurements of bismuth-214 as is customary for this analysis.

For the 30 samples of PG from the stack the following summary statistics were calculated for radium-226:

Parameter	Value
Arithmetic Mean	17.6 pCi/g
Standard Deviation	3.7
95th Percentile Upper Confidence Limit on Mean*	18.7 pCi/g
Sample Size	30 unique samples

Note: * - 95th Upper Confidence Limit on the Mean was calculated using the formula provided in 40 CFR part 61, *§61.207*

The following chart provides a histogram of the radium-226 concentrations:



The following table provides a summary comparison of the results for the blind duplicate samples:

Sample ID	Ra-226 Concentration (pCi/g)	Blind Duplicate Sample ID	Ra-226 Concentration (pCi/g)
PG-RAD4	24.0	PG-RAD31	19.5
PG-RAD7	24.3	PG-RAD32	18.5
PG-RAD11	17.7	PG-RAD33	17.1
PG-RAD15	6.2	PG-RAD34	7.5
PG-RAD19	18.6	PG-RAD35	17.4
PG-RAD22	18.0	PG-RAD36	17.0
PG-RAD27	17.0	PG-RAD37	16.9

Attachment A – Pace Analytical Report

The attached Pace Analytical report provides further details of the radiological analysis, laboratory quality assurance and raw data.

ANALYTICAL REPORT

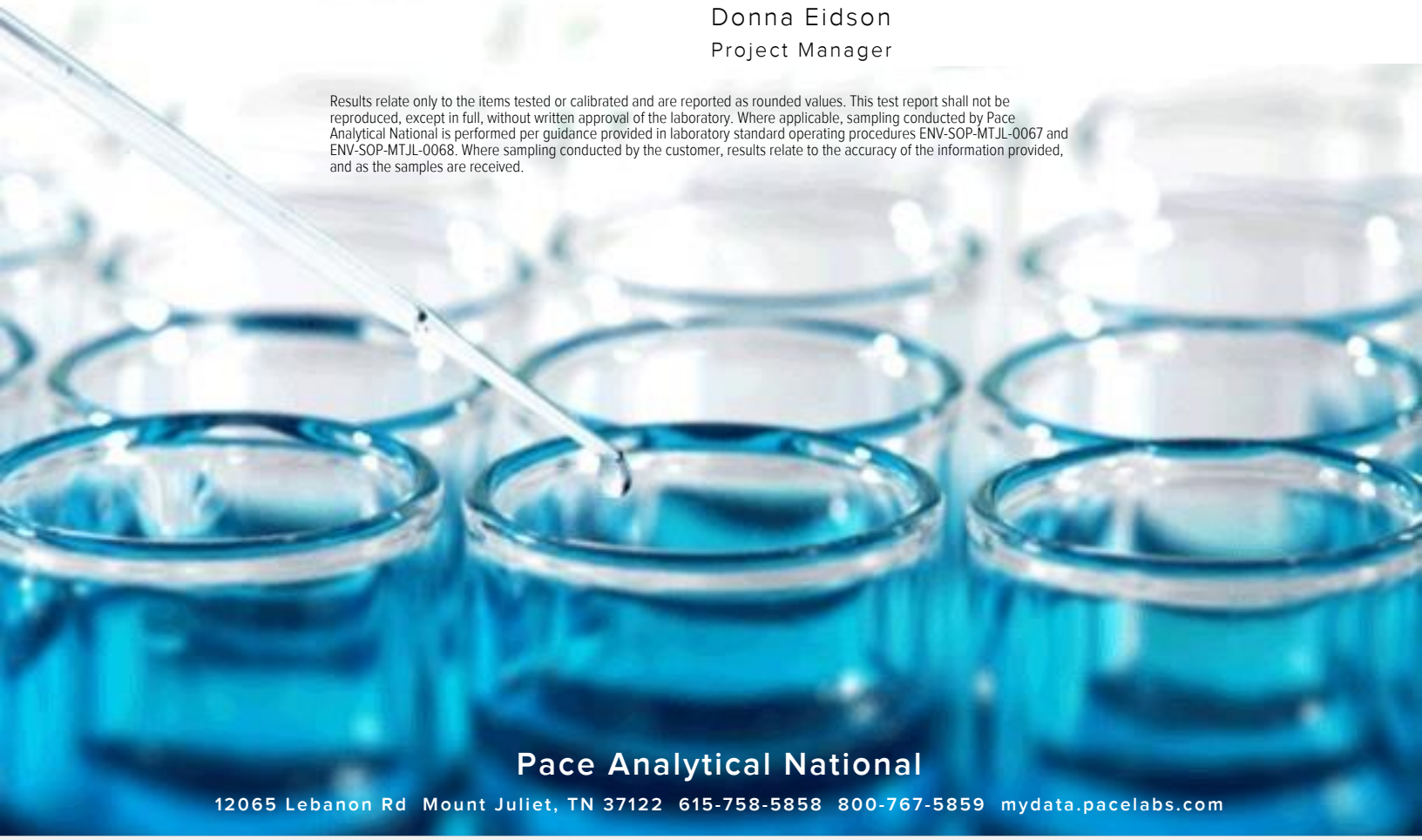
August 18, 2025

ARCADIS US - Paramus, NJ

Sample Delivery Group:	L1879915
Samples Received:	07/18/2025
Project Number:	
Description:	Mosaic-Pilot Road Project
Site:	MOSAIC-NEW WALES-PHASE 2-WEST-
Report To:	Les Skoski

Entire Report Reviewed By:

Donna Eidson
Project Manager



Pace Analytical National
12065 Lebanon Rd Mount Juliet, TN 37122 615-758-5858 800-767-5859 mydata.pacelabs.com

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MOSAIC-07.15.25-PG-RAD1 L1879915-01

Collected by	Collected date/time	Received date/time
	07/15/25 14:02	07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/15/25 21:35	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD2 L1879915-02

Collected by	Collected date/time	Received date/time
	07/15/25 14:07	07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/15/25 21:35	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD3 L1879915-03

Collected by	Collected date/time	Received date/time
	07/15/25 14:11	07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/15/25 22:42	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD4 L1879915-04

Collected by	Collected date/time	Received date/time
	07/15/25 14:14	07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/16/25 14:59	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD5 L1879915-05

Collected by	Collected date/time	Received date/time
	07/15/25 14:20	07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/16/25 15:00	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD6 L1879915-06

Collected by	Collected date/time	Received date/time
	07/15/25 14:23	07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/16/25 15:01	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD7 L1879915-07

Collected by	Collected date/time	Received date/time
	07/15/25 14:25	07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/16/25 15:06	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD8 L1879915-08

Collected by	Collected date/time	Received date/time
	07/15/25 14:31	07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/16/25 15:07	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD9 L1879915-09

Collected by | Collected date/time 07/15/25 14:34 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/16/25 16:11	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD10 L1879915-10

Collected by | Collected date/time 07/15/25 14:37 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/16/25 16:11	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD11 L1879915-11

Collected by | Collected date/time 07/15/25 14:20 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/16/25 16:11	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD12 L1879915-12

Collected by | Collected date/time 07/15/25 14:47 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/16/25 16:12	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD13 L1879915-13

Collected by | Collected date/time 07/15/25 14:49 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/16/25 16:12	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD14 L1879915-14

Collected by | Collected date/time 07/15/25 14:56 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/16/25 17:35	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD15 L1879915-15

Collected by | Collected date/time 07/15/25 14:59 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/17/25 14:06	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD16 L1879915-16

Collected by | Collected date/time 07/15/25 15:23 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/17/25 14:07	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD17 L1879915-17

Collected by	Collected date/time	Received date/time
	07/15/25 15:29	07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/17/25 14:08	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD18 L1879915-18

Collected by	Collected date/time	Received date/time
	07/15/25 15:31	07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/17/25 15:37	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD19 L1879915-19

Collected by	Collected date/time	Received date/time
	07/15/25 15:34	07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/17/25 14:09	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD20 L1879915-20

Collected by	Collected date/time	Received date/time
	07/15/25 15:39	07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566232	1	07/21/25 21:11	08/17/25 14:10	DME	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD21 L1879915-21

Collected by	Collected date/time	Received date/time
	07/15/25 15:42	07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/17/25 15:51	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD22 L1879915-22

Collected by	Collected date/time	Received date/time
	07/15/25 15:44	07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/17/25 15:14	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD23 L1879915-23

Collected by	Collected date/time	Received date/time
	07/15/25 15:47	07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/17/25 15:14	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD24 L1879915-24

Collected by	Collected date/time	Received date/time
	07/15/25 15:48	07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/17/25 15:15	DDD	Mt. Juliet, TN

1 Cp
2 Tc
3 Ss
4 Cn
5 Sr
6 Qc
7 Gl
8 Al
9 Sc

MOSAIC-07.15.25-PG-RAD25 L1879915-25

Collected by | Collected date/time 07/15/25 15:50 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/17/25 15:16	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD26 L1879915-26

Collected by | Collected date/time 07/15/25 15:51 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/17/25 15:23	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD27 L1879915-27

Collected by | Collected date/time 07/15/25 15:52 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/18/25 08:57	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD28 L1879915-28

Collected by | Collected date/time 07/15/25 15:54 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/17/25 15:25	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD29 L1879915-29

Collected by | Collected date/time 07/15/25 15:55 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/18/25 08:57	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD30 L1879915-30

Collected by | Collected date/time 07/15/25 15:57 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/18/25 09:20	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD31 L1879915-31

Collected by | Collected date/time 07/15/25 14:15 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/18/25 09:22	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD32 L1879915-32

Collected by | Collected date/time 07/15/25 14:25 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/18/25 09:54	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD33 L1879915-33

Collected by | Collected date/time 07/15/25 14:40 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/18/25 10:11	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD34 L1879915-34

Collected by | Collected date/time 07/15/25 14:59 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/18/25 09:53	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD35 L1879915-35

Collected by | Collected date/time 07/15/25 15:36 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/18/25 10:12	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD36 L1879915-36

Collected by | Collected date/time 07/15/25 15:46 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/18/25 10:44	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD37 L1879915-37

Collected by | Collected date/time 07/15/25 15:53 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/18/25 10:45	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD38 L1879915-38

Collected by | Collected date/time 07/15/25 13:57 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/18/25 11:18	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD39 L1879915-39

Collected by | Collected date/time 07/15/25 13:54 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/18/25 10:42	DDD	Mt. Juliet, TN

MOSAIC-07.15.25-PG-RAD40 L1879915-40

Collected by | Collected date/time 07/15/25 13:40 | Received date/time 07/18/25 10:00

Method	Batch	Dilution	Preparation date/time	Analysis date/time	Analyst	Location
Radiochemistry by Method DOE Ga-01-R/901.1	WG2566235	1	07/21/25 21:39	08/18/25 10:59	DDD	Mt. Juliet, TN

CASE NARRATIVE

All sample aliquots were received at the correct temperature, in the proper containers, with the appropriate preservatives, and within method specified holding times, unless qualified or notated within the report. Where applicable, all MDL (LOD) and RDL (LOQ) values reported for environmental samples have been corrected for the dilution factor used in the analysis. All radiochemical sample results for solids are reported on a dry weight basis with the exception of tritium, carbon-14 and radon, unless wet weight was requested by the client. All Method and Batch Quality Control are within established criteria except where addressed in this case narrative, a non-conformance form or properly qualified within the sample results. By my digital signature below, I affirm to the best of my knowledge, all problems/anomalies observed by the laboratory as having the potential to affect the quality of the data have been identified by the laboratory, and no information or data have been knowingly withheld that would affect the quality of the data.

Donna Eidson
Project Manager

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.344	U	0.332	0.332	0.793	0.368	08/15/2025 21:35	WG2566232
Bismuth-212	0.761	U	1.27	1.27	2.54	1.17	08/15/2025 21:35	WG2566232
Bismuth-214 (Ra-226)	17.0		1.24	1.24	0.387	0.180	08/15/2025 21:35	WG2566232
Lead-212	-0.411	U	0.224	0.224	0.394	0.190	08/15/2025 21:35	WG2566232
Lead-214	18.3		1.35	1.35	0.413	0.196	08/15/2025 21:35	WG2566232
Potassium-40	0.356	U	1.23	1.23	2.45	1.12	08/15/2025 21:35	WG2566232
Thallium-208	0.0432	U	0.112	0.112	0.205	0.0960	08/15/2025 21:35	WG2566232
Thorium-234 (U-238)	3.22	J	1.96	1.96	3.34	1.35	08/15/2025 21:35	WG2566232
Uranium-235	1.50		0.194	0.194	1.11	0.534	08/15/2025 21:35	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.541	J	0.306	0.306	0.639	0.297	08/15/2025 21:35	WG2566232
Bismuth-212	-0.565	U	1.29	1.29	2.61	1.23	08/15/2025 21:35	WG2566232
Bismuth-214 (Ra-226)	19.0		1.35	1.35	0.316	0.148	08/15/2025 21:35	WG2566232
Lead-212	0.101	U	0.184	0.184	0.318	0.154	08/15/2025 21:35	WG2566232
Lead-214	22.2		1.59	1.59	0.377	0.181	08/15/2025 21:35	WG2566232
Potassium-40	0.859	J	1.05	1.05	1.90	0.866	08/15/2025 21:35	WG2566232
Thallium-208	0.0879	J	0.0959	0.0959	0.171	0.0808	08/15/2025 21:35	WG2566232
Thorium-234 (U-238)	-0.809	U	1.20	1.20	2.74	1.12	08/15/2025 21:35	WG2566232
Uranium-235	0.144	U	0.602	0.602	1.02	0.496	08/15/2025 21:35	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.376	U	0.358	0.358	0.843	0.393	08/15/2025 22:42	WG2566232
Bismuth-212	-0.484	U	1.53	1.53	3.17	1.48	08/15/2025 22:42	WG2566232
Bismuth-214 (Ra-226)	19.4		1.40	1.40	0.383	0.179	08/15/2025 22:42	WG2566232
Lead-212	-0.302	U	0.232	0.232	0.406	0.196	08/15/2025 22:42	WG2566232
Lead-214	21.2		1.55	1.55	0.452	0.215	08/15/2025 22:42	WG2566232
Potassium-40	0.269	U	1.30	1.30	2.60	1.19	08/15/2025 22:42	WG2566232
Thallium-208	0.156	J	0.125	0.125	0.217	0.102	08/15/2025 22:42	WG2566232
Thorium-234 (U-238)	2.11	J	1.91	1.91	3.42	1.38	08/15/2025 22:42	WG2566232
Uranium-235	1.61		0.205	0.205	1.20	0.576	08/15/2025 22:42	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.377	U	0.374	0.374	0.868	0.405	08/16/2025 14:59	WG2566232
Bismuth-212	8.07		6.83	6.83	3.04	1.42	08/16/2025 14:59	WG2566232
Bismuth-214 (Ra-226)	24.0		1.71	1.71	0.457	0.216	08/16/2025 14:59	WG2566232
Lead-212	1.42		0.293	0.293	0.454	0.220	08/16/2025 14:59	WG2566232
Lead-214	25.9		1.90	1.90	0.604	0.291	08/16/2025 14:59	WG2566232
Potassium-40	2.14	J	1.32	1.32	2.24	1.01	08/16/2025 14:59	WG2566232
Thallium-208	0.292		0.138	0.138	0.230	0.108	08/16/2025 14:59	WG2566232
Thorium-234 (U-238)	-3.89	U	2.55	2.55	4.40	1.81	08/16/2025 14:59	WG2566232
Uranium-235	0.179	U	0.849	0.849	1.55	0.754	08/16/2025 14:59	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.735	J	0.368	0.368	0.813	0.377	08/16/2025 15:00	WG2566232
Bismuth-212	1.31	J	1.44	1.44	2.73	1.26	08/16/2025 15:00	WG2566232
Bismuth-214 (Ra-226)	20.6		1.48	1.48	0.416	0.195	08/16/2025 15:00	WG2566232
Lead-212	-0.820	U	0.253	0.253	0.449	0.218	08/16/2025 15:00	WG2566232
Lead-214	21.6		1.58	1.58	0.452	0.215	08/16/2025 15:00	WG2566232
Potassium-40	0.457	U	1.32	1.32	2.62	1.20	08/16/2025 15:00	WG2566232
Thallium-208	0.0523	U	0.126	0.126	0.230	0.108	08/16/2025 15:00	WG2566232
Thorium-234 (U-238)	1.69	U	1.82	1.82	3.52	1.42	08/16/2025 15:00	WG2566232
Uranium-235	0.0295	U	0.774	0.774	1.26	0.609	08/16/2025 15:00	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.561	J	0.359	0.359	0.774	0.358	08/16/2025 15:01	WG2566232
Bismuth-212	0.522	U	1.44	1.44	2.83	1.31	08/16/2025 15:01	WG2566232
Bismuth-214 (Ra-226)	21.0		1.52	1.52	0.395	0.185	08/16/2025 15:01	WG2566232
Lead-212	-0.135	U	0.225	0.225	0.384	0.186	08/16/2025 15:01	WG2566232
Lead-214	25.5		1.84	1.84	0.485	0.232	08/16/2025 15:01	WG2566232
Potassium-40	1.26	J	1.34	1.34	2.41	1.09	08/16/2025 15:01	WG2566232
Thallium-208	0.186	J	0.121	0.121	0.209	0.0979	08/16/2025 15:01	WG2566232
Thorium-234 (U-238)	-3.09	U	1.67	1.67	3.32	1.36	08/16/2025 15:01	WG2566232
Uranium-235	1.73		0.204	0.204	1.16	0.562	08/16/2025 15:01	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.451	U	0.495	0.495	1.21	0.556	08/16/2025 15:06	WG2566232
Bismuth-212	-1.12	U	2.27	2.27	4.56	2.11	08/16/2025 15:06	WG2566232
Bismuth-214 (Ra-226)	24.3		1.84	1.84	0.535	0.247	08/16/2025 15:06	WG2566232
Lead-212	-4.11	U	0.474	0.474	0.807	0.394	08/16/2025 15:06	WG2566232
Lead-214	24.9		1.87	1.87	0.660	0.314	08/16/2025 15:06	WG2566232
Potassium-40	1.54	U	1.89	1.89	3.56	1.59	08/16/2025 15:06	WG2566232
Thallium-208	0.159	J	0.170	0.170	0.296	0.137	08/16/2025 15:06	WG2566232
Thorium-234 (U-238)	-0.729	U	1.71	1.71	3.75	1.53	08/16/2025 15:06	WG2566232
Uranium-235	0.341	U	0.840	0.840	1.56	0.758	08/16/2025 15:06	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.438	J	0.252	0.252	0.607	0.283	08/16/2025 15:07	WG2566232
Bismuth-212	0.0207	U	1.00	1.00	2.06	0.962	08/16/2025 15:07	WG2566232
Bismuth-214 (Ra-226)	14.3		1.04	1.04	0.260	0.121	08/16/2025 15:07	WG2566232
Lead-212	-2.26	U	0.248	0.248	0.417	0.204	08/16/2025 15:07	WG2566232
Lead-214	14.7		1.06	1.06	0.289	0.138	08/16/2025 15:07	WG2566232
Potassium-40	0.226	U	0.856	0.856	1.70	0.775	08/16/2025 15:07	WG2566232
Thallium-208	0.208		0.0816	0.0816	0.133	0.0621	08/16/2025 15:07	WG2566232
Thorium-234 (U-238)	-2.32	U	1.45	1.45	2.41	0.989	08/16/2025 15:07	WG2566232
Uranium-235	0.941	J	0.140	0.140	1.06	0.518	08/16/2025 15:07	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.105	U	0.287	0.287	0.695	0.322	08/16/2025 16:11	WG2566232
Bismuth-212	0.755	U	1.21	1.21	2.37	1.10	08/16/2025 16:11	WG2566232
Bismuth-214 (Ra-226)	13.6		1.03	1.03	0.350	0.164	08/16/2025 16:11	WG2566232
Lead-212	0.688		0.204	0.204	0.331	0.160	08/16/2025 16:11	WG2566232
Lead-214	14.1		1.07	1.07	0.437	0.208	08/16/2025 16:11	WG2566232
Potassium-40	1.49	J	1.01	1.01	1.72	0.765	08/16/2025 16:11	WG2566232
Thallium-208	0.0841	J	0.102	0.102	0.184	0.0862	08/16/2025 16:11	WG2566232
Thorium-234 (U-238)	-1.64	U	1.64	1.64	3.30	1.35	08/16/2025 16:11	WG2566232
Uranium-235	0.984	U	0.163	0.163	1.16	0.562	08/16/2025 16:11	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.465	J	0.360	0.360	0.794	0.367	08/16/2025 16:11	WG2566232
Bismuth-212	-0.191	U	1.48	1.48	3.02	1.40	08/16/2025 16:11	WG2566232
Bismuth-214 (Ra-226)	20.6		1.47	1.47	0.381	0.177	08/16/2025 16:11	WG2566232
Lead-212	-0.943	U	0.248	0.248	0.438	0.212	08/16/2025 16:11	WG2566232
Lead-214	21.3		1.55	1.55	0.476	0.227	08/16/2025 16:11	WG2566232
Potassium-40	-0.578	U	1.31	1.31	2.75	1.26	08/16/2025 16:11	WG2566232
Thallium-208	0.107	J	0.123	0.123	0.219	0.103	08/16/2025 16:11	WG2566232
Thorium-234 (U-238)	-0.0784	U	1.67	1.67	3.61	1.46	08/16/2025 16:11	WG2566232
Uranium-235	1.59		0.211	0.211	1.26	0.607	08/16/2025 16:11	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.286	U	0.292	0.292	0.667	0.309	08/16/2025 16:11	WG2566232
Bismuth-212	-0.685	U	5.41	5.41	2.46	1.15	08/16/2025 16:11	WG2566232
Bismuth-214 (Ra-226)	17.7		1.28	1.28	0.309	0.144	08/16/2025 16:11	WG2566232
Lead-212	-0.391	U	0.187	0.187	0.329	0.160	08/16/2025 16:11	WG2566232
Lead-214	21.0		1.52	1.52	0.384	0.183	08/16/2025 16:11	WG2566232
Potassium-40	-0.482	U	1.08	1.08	2.18	0.993	08/16/2025 16:11	WG2566232
Thallium-208	0.0331	U	0.104	0.104	0.195	0.0918	08/16/2025 16:11	WG2566232
Thorium-234 (U-238)	-1.20	U	1.21	1.21	2.74	1.12	08/16/2025 16:11	WG2566232
Uranium-235	1.42		0.175	0.175	0.991	0.480	08/16/2025 16:11	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.183	U	0.396	0.396	0.954	0.427	08/16/2025 16:12	WG2566232
Bismuth-212	-1.18	U	1.76	1.76	3.76	1.71	08/16/2025 16:12	WG2566232
Bismuth-214 (Ra-226)	19.1		1.50	1.50	0.478	0.218	08/16/2025 16:12	WG2566232
Lead-212	-3.10	U	0.404	0.404	0.721	0.351	08/16/2025 16:12	WG2566232
Lead-214	19.2		1.47	1.47	0.576	0.272	08/16/2025 16:12	WG2566232
Potassium-40	0.867	U	1.58	1.58	3.11	1.36	08/16/2025 16:12	WG2566232
Thallium-208	0.142	J	0.155	0.155	0.270	0.125	08/16/2025 16:12	WG2566232
Thorium-234 (U-238)	-1.87	U	1.72	1.72	3.46	1.41	08/16/2025 16:12	WG2566232
Uranium-235	1.23	U	0.226	0.226	1.50	0.725	08/16/2025 16:12	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.415	J	0.201	0.201	0.453	0.209	08/16/2025 16:12	WG2566232
Bismuth-212	-0.427	U	0.816	0.816	1.77	0.824	08/16/2025 16:12	WG2566232
Bismuth-214 (Ra-226)	10.5		0.777	0.777	0.198	0.0917	08/16/2025 16:12	WG2566232
Lead-212	-1.72	U	0.197	0.197	0.340	0.166	08/16/2025 16:12	WG2566232
Lead-214	10.7		0.780	0.780	0.231	0.110	08/16/2025 16:12	WG2566232
Potassium-40	0.595	U	0.716	0.716	1.35	0.610	08/16/2025 16:12	WG2566232
Thallium-208	0.134		0.0685	0.0685	0.117	0.0545	08/16/2025 16:12	WG2566232
Thorium-234 (U-238)	-0.786	U	0.962	0.962	1.93	0.789	08/16/2025 16:12	WG2566232
Uranium-235	0.796	J	0.115	0.115	0.896	0.437	08/16/2025 16:12	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.559	J	0.311	0.311	0.678	0.309	08/16/2025 17:35	WG2566232
Bismuth-212	-1.13	U	1.27	1.27	2.77	1.28	08/16/2025 17:35	WG2566232
Bismuth-214 (Ra-226)	14.1		1.06	1.06	0.362	0.167	08/16/2025 17:35	WG2566232
Lead-212	-0.546	U	0.202	0.202	0.370	0.178	08/16/2025 17:35	WG2566232
Lead-214	15.4		1.16	1.16	0.411	0.194	08/16/2025 17:35	WG2566232
Potassium-40	0.459	U	1.07	1.07	2.13	0.952	08/16/2025 17:35	WG2566232
Thallium-208	0.0325	U	0.108	0.108	0.199	0.0925	08/16/2025 17:35	WG2566232
Thorium-234 (U-238)	2.63	J	1.80	1.80	2.93	1.18	08/16/2025 17:35	WG2566232
Uranium-235	1.04	J	0.172	0.172	1.05	0.502	08/16/2025 17:35	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.328	J	0.193	0.193	0.427	0.193	08/17/2025 14:06	WG2566232
Bismuth-212	0.156	U	0.826	0.826	1.66	0.760	08/17/2025 14:06	WG2566232
Bismuth-214 (Ra-226)	6.23		0.519	0.519	0.236	0.109	08/17/2025 14:06	WG2566232
Lead-212	0.454		0.140	0.140	0.231	0.111	08/17/2025 14:06	WG2566232
Lead-214	6.30		0.515	0.515	0.300	0.142	08/17/2025 14:06	WG2566232
Potassium-40	0.548	J	0.565	0.565	1.03	0.440	08/17/2025 14:06	WG2566232
Thallium-208	0.0785	J	0.0728	0.0728	0.130	0.0600	08/17/2025 14:06	WG2566232
Thorium-234 (U-238)	0.198	U	0.912	0.912	2.14	0.874	08/17/2025 14:06	WG2566232
Uranium-235	0.493	U	0.102	0.102	0.762	0.368	08/17/2025 14:06	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.432	J	0.254	0.254	0.558	0.262	08/17/2025 14:07	WG2566232
Bismuth-212	-2.76	U	4.05	4.05	2.04	0.956	08/17/2025 14:07	WG2566232
Bismuth-214 (Ra-226)	15.8		1.09	1.09	0.275	0.130	08/17/2025 14:07	WG2566232
Lead-212	0.939		0.197	0.197	0.303	0.147	08/17/2025 14:07	WG2566232
Lead-214	17.9		1.28	1.28	0.356	0.171	08/17/2025 14:07	WG2566232
Potassium-40	1.52		0.879	0.879	1.50	0.688	08/17/2025 14:07	WG2566232
Thallium-208	0.114	J	0.0934	0.0934	0.168	0.0799	08/17/2025 14:07	WG2566232
Thorium-234 (U-238)	-1.29	U	2.05	2.05	4.15	1.70	08/17/2025 14:07	WG2566232
Uranium-235	1.34		0.173	0.173	1.20	0.585	08/17/2025 14:07	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.0659	U	0.408	0.408	0.961	0.449	08/17/2025 14:08	WG2566232
Bismuth-212	1.22	U	1.57	1.57	3.09	1.44	08/17/2025 14:08	WG2566232
Bismuth-214 (Ra-226)	18.4		1.35	1.35	0.476	0.224	08/17/2025 14:08	WG2566232
Lead-212	1.25		0.313	0.313	0.499	0.242	08/17/2025 14:08	WG2566232
Lead-214	20.1		1.48	1.48	0.577	0.277	08/17/2025 14:08	WG2566232
Potassium-40	1.04	U	1.33	1.33	2.49	1.12	08/17/2025 14:08	WG2566232
Thallium-208	0.0801	U	0.139	0.139	0.258	0.122	08/17/2025 14:08	WG2566232
Thorium-234 (U-238)	-1.77	U	2.63	2.63	6.02	2.46	08/17/2025 14:08	WG2566232
Uranium-235	1.47	U	0.252	0.252	1.84	0.897	08/17/2025 14:08	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.459	J	0.289	0.289	0.653	0.309	08/17/2025 15:37	WG2566232
Bismuth-212	0.525	U	1.19	1.19	2.27	1.07	08/17/2025 15:37	WG2566232
Bismuth-214 (Ra-226)	20.8		1.41	1.41	0.316	0.150	08/17/2025 15:37	WG2566232
Lead-212	0.806		0.235	0.235	0.411	0.200	08/17/2025 15:37	WG2566232
Lead-214	22.3		1.58	1.58	0.425	0.205	08/17/2025 15:37	WG2566232
Potassium-40	1.41	J	1.01	1.01	1.76	0.814	08/17/2025 15:37	WG2566232
Thallium-208	0.151	J	0.101	0.101	0.186	0.0888	08/17/2025 15:37	WG2566232
Thorium-234 (U-238)	1.81	U	2.79	2.79	5.51	2.25	08/17/2025 15:37	WG2566232
Uranium-235	1.66		0.216	0.216	1.53	0.745	08/17/2025 15:37	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.270	U	0.367	0.367	0.885	0.412	08/17/2025 14:09	WG2566232
Bismuth-212	2.44	J	5.66	5.66	3.19	1.49	08/17/2025 14:09	WG2566232
Bismuth-214 (Ra-226)	18.6		1.35	1.35	0.407	0.190	08/17/2025 14:09	WG2566232
Lead-212	-0.509	U	0.230	0.230	0.393	0.190	08/17/2025 14:09	WG2566232
Lead-214	19.9		1.47	1.47	0.455	0.216	08/17/2025 14:09	WG2566232
Potassium-40	0.816	U	1.39	1.39	2.70	1.23	08/17/2025 14:09	WG2566232
Thallium-208	0.121	J	0.123	0.123	0.218	0.102	08/17/2025 14:09	WG2566232
Thorium-234 (U-238)	0.590	U	1.62	1.62	3.44	1.39	08/17/2025 14:09	WG2566232
Uranium-235	1.51		0.204	0.204	1.21	0.581	08/17/2025 14:09	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.517	J	0.296	0.296	0.681	0.317	08/17/2025 14:10	WG2566232
Bismuth-212	1.19	J	1.25	1.25	2.33	1.09	08/17/2025 14:10	WG2566232
Bismuth-214 (Ra-226)	17.9		1.28	1.28	0.308	0.144	08/17/2025 14:10	WG2566232
Lead-212	-0.0923	U	0.188	0.188	0.324	0.157	08/17/2025 14:10	WG2566232
Lead-214	20.8		1.50	1.50	0.382	0.183	08/17/2025 14:10	WG2566232
Potassium-40	1.06	J	1.04	1.04	1.85	0.835	08/17/2025 14:10	WG2566232
Thallium-208	0.170		0.0976	0.0976	0.165	0.0774	08/17/2025 14:10	WG2566232
Thorium-234 (U-238)	-2.69	U	1.42	1.42	2.76	1.13	08/17/2025 14:10	WG2566232
Uranium-235	1.37		0.172	0.172	0.997	0.484	08/17/2025 14:10	WG2566232

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.476	U	0.404	0.404	0.968	0.440	08/17/2025 15:51	WG2566235
Bismuth-212	-1.27	U	1.79	1.79	3.63	1.66	08/17/2025 15:51	WG2566235
Bismuth-214 (Ra-226)	20.7		1.59	1.59	0.487	0.224	08/17/2025 15:51	WG2566235
Lead-212	-3.06	U	0.401	0.401	0.703	0.343	08/17/2025 15:51	WG2566235
Lead-214	19.9		1.51	1.51	0.563	0.267	08/17/2025 15:51	WG2566235
Potassium-40	1.17	U	1.62	1.62	3.09	1.37	08/17/2025 15:51	WG2566235
Thallium-208	0.161	J	0.154	0.154	0.266	0.123	08/17/2025 15:51	WG2566235
Thorium-234 (U-238)	-0.292	U	1.49	1.49	3.39	1.39	08/17/2025 15:51	WG2566235
Uranium-235	1.73		0.240	0.240	1.42	0.688	08/17/2025 15:51	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.371	U	0.296	0.296	0.681	0.317	08/17/2025 15:14	WG2566235
Bismuth-212	1.24	J	1.33	1.33	2.49	1.16	08/17/2025 15:14	WG2566235
Bismuth-214 (Ra-226)	18.0		1.30	1.30	0.364	0.172	08/17/2025 15:14	WG2566235
Lead-212	1.27		0.239	0.239	0.364	0.177	08/17/2025 15:14	WG2566235
Lead-214	18.1		1.34	1.34	0.524	0.253	08/17/2025 15:14	WG2566235
Potassium-40	0.340	U	0.965	0.965	1.85	0.839	08/17/2025 15:14	WG2566235
Thallium-208	0.185		0.106	0.106	0.180	0.0846	08/17/2025 15:14	WG2566235
Thorium-234 (U-238)	-2.24	U	1.85	1.85	3.53	1.45	08/17/2025 15:14	WG2566235
Uranium-235	1.15	J	0.178	0.178	1.27	0.618	08/17/2025 15:14	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.293	J	0.225	0.225	0.487	0.230	08/17/2025 15:14	WG2566235
Bismuth-212	-2.32	U	4.22	4.22	1.85	0.872	08/17/2025 15:14	WG2566235
Bismuth-214 (Ra-226)	15.5		1.06	1.06	0.267	0.127	08/17/2025 15:14	WG2566235
Lead-212	1.04		0.183	0.183	0.275	0.134	08/17/2025 15:14	WG2566235
Lead-214	16.7		1.19	1.19	0.329	0.159	08/17/2025 15:14	WG2566235
Potassium-40	0.709	J	0.797	0.797	1.46	0.678	08/17/2025 15:14	WG2566235
Thallium-208	0.172		0.0818	0.0818	0.141	0.0671	08/17/2025 15:14	WG2566235
Thorium-234 (U-238)	-1.43	U	1.83	1.83	3.75	1.54	08/17/2025 15:14	WG2566235
Uranium-235	1.16		0.155	0.155	1.14	0.557	08/17/2025 15:14	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.0699	U	0.375	0.375	0.912	0.429	08/17/2025 15:15	WG2566235
Bismuth-212	-0.153	U	1.44	1.44	2.93	1.37	08/17/2025 15:15	WG2566235
Bismuth-214 (Ra-226)	15.5		1.14	1.14	0.429	0.203	08/17/2025 15:15	WG2566235
Lead-212	1.37		0.288	0.288	0.442	0.215	08/17/2025 15:15	WG2566235
Lead-214	17.1		1.26	1.26	0.535	0.257	08/17/2025 15:15	WG2566235
Potassium-40	0.646	U	1.34	1.34	2.55	1.17	08/17/2025 15:15	WG2566235
Thallium-208	0.173	J	0.122	0.122	0.215	0.102	08/17/2025 15:15	WG2566235
Thorium-234 (U-238)	1.64	U	2.43	2.43	5.10	2.08	08/17/2025 15:15	WG2566235
Uranium-235	1.27	U	0.224	0.224	1.62	0.790	08/17/2025 15:15	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.484	J	0.329	0.329	0.709	0.327	08/17/2025 15:16	WG2566235
Bismuth-212	0.274	U	1.46	1.46	2.92	1.36	08/17/2025 15:16	WG2566235
Bismuth-214 (Ra-226)	18.7		1.34	1.34	0.373	0.174	08/17/2025 15:16	WG2566235
Lead-212	-0.432	U	0.217	0.217	0.382	0.185	08/17/2025 15:16	WG2566235
Lead-214	19.0		1.40	1.40	0.446	0.213	08/17/2025 15:16	WG2566235
Potassium-40	1.04	J	1.17	1.17	2.20	0.995	08/17/2025 15:16	WG2566235
Thallium-208	0.142	J	0.120	0.120	0.211	0.0991	08/17/2025 15:16	WG2566235
Thorium-234 (U-238)	1.74	J	1.77	1.77	3.48	1.41	08/17/2025 15:16	WG2566235
Uranium-235	1.49		0.196	0.196	1.16	0.560	08/17/2025 15:16	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.486	J	0.257	0.257	0.565	0.261	08/17/2025 15:23	WG2566235
Bismuth-212	0.245	U	1.07	1.07	2.08	0.969	08/17/2025 15:23	WG2566235
Bismuth-214 (Ra-226)	13.6		0.994	0.994	0.280	0.131	08/17/2025 15:23	WG2566235
Lead-212	-0.00540	U	0.158	0.158	0.269	0.130	08/17/2025 15:23	WG2566235
Lead-214	16.6		1.21	1.21	0.316	0.151	08/17/2025 15:23	WG2566235
Potassium-40	0.535	U	0.845	0.845	1.57	0.704	08/17/2025 15:23	WG2566235
Thallium-208	0.129	J	0.0843	0.0843	0.146	0.0681	08/17/2025 15:23	WG2566235
Thorium-234 (U-238)	-0.239	U	1.01	1.01	2.35	0.958	08/17/2025 15:23	WG2566235
Uranium-235	1.27		0.150	0.150	0.854	0.414	08/17/2025 15:23	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.693		0.315	0.315	0.683	0.318	08/18/2025 08:57	WG2566235
Bismuth-212	-0.341	U	1.29	1.29	2.57	1.20	08/18/2025 08:57	WG2566235
Bismuth-214 (Ra-226)	17.0		1.24	1.24	0.391	0.185	08/18/2025 08:57	WG2566235
Lead-212	1.07		0.228	0.228	0.353	0.171	08/18/2025 08:57	WG2566235
Lead-214	17.8		1.32	1.32	0.503	0.242	08/18/2025 08:57	WG2566235
Potassium-40	0.503	U	1.02	1.02	1.92	0.873	08/18/2025 08:57	WG2566235
Thallium-208	0.205		0.110	0.110	0.186	0.0876	08/18/2025 08:57	WG2566235
Thorium-234 (U-238)	3.20	J	1.78	1.78	3.50	1.44	08/18/2025 08:57	WG2566235
Uranium-235	1.34		0.188	0.188	1.26	0.615	08/18/2025 08:57	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.485	J	0.246	0.246	0.560	0.264	08/17/2025 15:25	WG2566235
Bismuth-212	-0.0252	U	1.00	1.00	2.03	0.960	08/17/2025 15:25	WG2566235
Bismuth-214 (Ra-226)	17.2		1.20	1.20	0.269	0.128	08/17/2025 15:25	WG2566235
Lead-212	-2.76	U	0.265	0.265	0.410	0.201	08/17/2025 15:25	WG2566235
Lead-214	17.9		1.26	1.26	0.283	0.136	08/17/2025 15:25	WG2566235
Potassium-40	0.908	J	0.924	0.924	1.72	0.796	08/17/2025 15:25	WG2566235
Thallium-208	0.259		0.0803	0.0803	0.128	0.0603	08/17/2025 15:25	WG2566235
Thorium-234 (U-238)	-0.683	U	1.13	1.13	2.35	0.967	08/17/2025 15:25	WG2566235
Uranium-235	1.32		0.152	0.152	0.994	0.487	08/17/2025 15:25	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.0735	U	0.428	0.428	1.10	0.520	08/18/2025 08:57	WG2566235
Bismuth-212	0.177	U	1.65	1.65	3.28	1.54	08/18/2025 08:57	WG2566235
Bismuth-214 (Ra-226)	18.4		1.33	1.33	0.440	0.208	08/18/2025 08:57	WG2566235
Lead-212	1.42		0.303	0.303	0.475	0.230	08/18/2025 08:57	WG2566235
Lead-214	20.7		1.51	1.51	0.572	0.275	08/18/2025 08:57	WG2566235
Potassium-40	1.78	J	1.40	1.40	2.49	1.14	08/18/2025 08:57	WG2566235
Thallium-208	0.180	J	0.136	0.136	0.242	0.114	08/18/2025 08:57	WG2566235
Thorium-234 (U-238)	-1.68	U	2.59	2.59	5.85	2.40	08/18/2025 08:57	WG2566235
Uranium-235	1.70	J	0.254	0.254	1.84	0.899	08/18/2025 08:57	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.557	J	0.306	0.306	0.674	0.318	08/18/2025 09:20	WG2566235
Bismuth-212	1.14	J	1.22	1.22	2.28	1.07	08/18/2025 09:20	WG2566235
Bismuth-214 (Ra-226)	21.2		1.44	1.44	0.348	0.165	08/18/2025 09:20	WG2566235
Lead-212	0.473		0.246	0.246	0.448	0.218	08/18/2025 09:20	WG2566235
Lead-214	23.6		1.67	1.67	0.425	0.204	08/18/2025 09:20	WG2566235
Potassium-40	0.286	U	1.01	1.01	1.90	0.883	08/18/2025 09:20	WG2566235
Thallium-208	0.237		0.110	0.110	0.198	0.0946	08/18/2025 09:20	WG2566235
Thorium-234 (U-238)	-1.56	U	2.74	2.74	5.89	2.41	08/18/2025 09:20	WG2566235
Uranium-235	1.57		0.216	0.216	1.55	0.757	08/18/2025 09:20	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.517	J	0.338	0.338	0.744	0.345	08/18/2025 09:22	WG2566235
Bismuth-212	5.58		5.62	5.62	2.79	1.30	08/18/2025 09:22	WG2566235
Bismuth-214 (Ra-226)	19.5		1.39	1.39	0.381	0.178	08/18/2025 09:22	WG2566235
Lead-212	-0.353	U	0.224	0.224	0.386	0.187	08/18/2025 09:22	WG2566235
Lead-214	20.6		1.50	1.50	0.433	0.207	08/18/2025 09:22	WG2566235
Potassium-40	-0.708	U	1.12	1.12	2.41	1.11	08/18/2025 09:22	WG2566235
Thallium-208	0.153	J	0.119	0.119	0.208	0.0977	08/18/2025 09:22	WG2566235
Thorium-234 (U-238)	1.27	U	1.64	1.64	3.35	1.36	08/18/2025 09:22	WG2566235
Uranium-235	0.163	U	0.747	0.747	1.21	0.585	08/18/2025 09:22	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.733		0.305	0.305	0.643	0.300	08/18/2025 09:54	WG2566235
Bismuth-212	1.57	J	1.18	1.18	2.17	1.01	08/18/2025 09:54	WG2566235
Bismuth-214 (Ra-226)	18.5		1.31	1.31	0.311	0.146	08/18/2025 09:54	WG2566235
Lead-212	-0.125	U	0.188	0.188	0.325	0.158	08/18/2025 09:54	WG2566235
Lead-214	21.5		1.54	1.54	0.386	0.186	08/18/2025 09:54	WG2566235
Potassium-40	1.38	J	1.06	1.06	1.84	0.838	08/18/2025 09:54	WG2566235
Thallium-208	0.203		0.0983	0.0983	0.164	0.0776	08/18/2025 09:54	WG2566235
Thorium-234 (U-238)	-1.67	U	1.26	1.26	2.77	1.13	08/18/2025 09:54	WG2566235
Uranium-235	0.276	U	0.594	0.594	1.00	0.487	08/18/2025 09:54	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.306	U	0.305	0.305	0.736	0.343	08/18/2025 10:11	WG2566235
Bismuth-212	0.431	U	1.29	1.29	2.55	1.19	08/18/2025 10:11	WG2566235
Bismuth-214 (Ra-226)	17.1		1.25	1.25	0.356	0.166	08/18/2025 10:11	WG2566235
Lead-212	0.800		0.224	0.224	0.366	0.177	08/18/2025 10:11	WG2566235
Lead-214	17.7		1.32	1.32	0.502	0.241	08/18/2025 10:11	WG2566235
Potassium-40	0.396	U	0.957	0.957	1.84	0.825	08/18/2025 10:11	WG2566235
Thallium-208	0.138	J	0.110	0.110	0.192	0.0902	08/18/2025 10:11	WG2566235
Thorium-234 (U-238)	-2.86	U	1.96	1.96	3.49	1.43	08/18/2025 10:11	WG2566235
Uranium-235	0.0172	U	0.693	0.693	1.27	0.618	08/18/2025 10:11	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.343		0.170	0.170	0.342	0.156	08/18/2025 09:53	WG2566235
Bismuth-212	0.760	J	0.663	0.663	1.26	0.575	08/18/2025 09:53	WG2566235
Bismuth-214 (Ra-226)	7.45		0.559	0.559	0.210	0.0980	08/18/2025 09:53	WG2566235
Lead-212	0.438		0.134	0.134	0.226	0.109	08/18/2025 09:53	WG2566235
Lead-214	8.46		0.633	0.633	0.250	0.119	08/18/2025 09:53	WG2566235
Potassium-40	0.262	U	0.604	0.604	1.16	0.525	08/18/2025 09:53	WG2566235
Thallium-208	0.0810	J	0.0638	0.0638	0.114	0.0534	08/18/2025 09:53	WG2566235
Thorium-234 (U-238)	0.333	U	1.38	1.38	2.95	1.20	08/18/2025 09:53	WG2566235
Uranium-235	0.612	U	0.111	0.111	0.870	0.421	08/18/2025 09:53	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.648	J	0.466	0.466	1.06	0.497	08/18/2025 10:12	WG2566235
Bismuth-212	-1.77	U	1.75	1.75	3.75	1.75	08/18/2025 10:12	WG2566235
Bismuth-214 (Ra-226)	17.4		1.31	1.31	0.506	0.238	08/18/2025 10:12	WG2566235
Lead-212	1.64		0.338	0.338	0.522	0.252	08/18/2025 10:12	WG2566235
Lead-214	18.9		1.41	1.41	0.626	0.300	08/18/2025 10:12	WG2566235
Potassium-40	2.08	J	1.53	1.53	2.70	1.22	08/18/2025 10:12	WG2566235
Thallium-208	0.138	J	0.148	0.148	0.269	0.127	08/18/2025 10:12	WG2566235
Thorium-234 (U-238)	-1.45	U	2.75	2.75	6.34	2.59	08/18/2025 10:12	WG2566235
Uranium-235	1.40	U	0.262	0.262	1.96	0.954	08/18/2025 10:12	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.458	J	0.248	0.248	0.558	0.263	08/18/2025 10:44	WG2566235
Bismuth-212	0.356	U	1.05	1.05	2.02	0.955	08/18/2025 10:44	WG2566235
Bismuth-214 (Ra-226)	17.0		1.16	1.16	0.284	0.135	08/18/2025 10:44	WG2566235
Lead-212	0.393		0.198	0.198	0.357	0.174	08/18/2025 10:44	WG2566235
Lead-214	18.3		1.30	1.30	0.386	0.186	08/18/2025 10:44	WG2566235
Potassium-40	0.458	U	0.830	0.830	1.54	0.713	08/18/2025 10:44	WG2566235
Thallium-208	0.0778	U	0.0864	0.0864	0.165	0.0788	08/18/2025 10:44	WG2566235
Thorium-234 (U-238)	-0.270	U	2.26	2.26	4.92	2.01	08/18/2025 10:44	WG2566235
Uranium-235	1.27	J	0.183	0.183	1.35	0.656	08/18/2025 10:44	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.620	J	0.333	0.333	0.722	0.335	08/18/2025 10:45	WG2566235
Bismuth-212	-0.248	U	1.22	1.22	2.53	1.17	08/18/2025 10:45	WG2566235
Bismuth-214 (Ra-226)	16.9		1.22	1.22	0.349	0.163	08/18/2025 10:45	WG2566235
Lead-212	-0.218	U	0.209	0.209	0.362	0.175	08/18/2025 10:45	WG2566235
Lead-214	17.9		1.31	1.31	0.402	0.191	08/18/2025 10:45	WG2566235
Potassium-40	0.171	U	1.09	1.09	2.19	0.998	08/18/2025 10:45	WG2566235
Thallium-208	0.0382	U	0.113	0.113	0.209	0.0983	08/18/2025 10:45	WG2566235
Thorium-234 (U-238)	4.68		2.29	2.29	3.24	1.31	08/18/2025 10:45	WG2566235
Uranium-235	1.46		0.188	0.188	1.11	0.536	08/18/2025 10:45	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.618	J	0.294	0.294	0.653	0.305	08/18/2025 11:18	WG2566235
Bismuth-212	2.15		4.36	4.36	2.12	0.985	08/18/2025 11:18	WG2566235
Bismuth-214 (Ra-226)	17.2		1.22	1.22	0.304	0.143	08/18/2025 11:18	WG2566235
Lead-212	0.350		0.186	0.186	0.297	0.144	08/18/2025 11:18	WG2566235
Lead-214	19.8		1.43	1.43	0.359	0.172	08/18/2025 11:18	WG2566235
Potassium-40	0.617	U	1.04	1.04	1.91	0.876	08/18/2025 11:18	WG2566235
Thallium-208	0.220		0.0954	0.0954	0.157	0.0737	08/18/2025 11:18	WG2566235
Thorium-234 (U-238)	-0.172	U	1.16	1.16	2.63	1.08	08/18/2025 11:18	WG2566235
Uranium-235	0.211	U	0.582	0.582	0.982	0.478	08/18/2025 11:18	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.491	J	0.260	0.260	0.554	0.260	08/18/2025 10:42	WG2566235
Bismuth-212	-0.0231	U	0.983	0.983	1.98	0.929	08/18/2025 10:42	WG2566235
Bismuth-214 (Ra-226)	15.7		1.08	1.08	0.288	0.136	08/18/2025 10:42	WG2566235
Lead-212	1.05		0.199	0.199	0.302	0.147	08/18/2025 10:42	WG2566235
Lead-214	17.8		1.27	1.27	0.355	0.171	08/18/2025 10:42	WG2566235
Potassium-40	0.592	U	0.822	0.822	1.53	0.704	08/18/2025 10:42	WG2566235
Thallium-208	0.0951	J	0.0893	0.0893	0.161	0.0764	08/18/2025 10:42	WG2566235
Thorium-234 (U-238)	-0.699	U	1.98	1.98	4.10	1.68	08/18/2025 10:42	WG2566235
Uranium-235	1.32		0.171	0.171	1.22	0.594	08/18/2025 10:42	WG2566235

Radiochemistry by Method DOE Ga-01-R/901.1

Analyte	Result pCi/g	Qualifier	2 sigma CE + / -	TPU + / -	MDA pCi/g	Lc pCi/g	Analysis Date date / time	Batch
Actinium-228 (Ra-228)	0.344	U	0.413	0.413	0.951	0.446	08/18/2025 10:59	WG2566235
Bismuth-212	0.798	U	1.68	1.68	3.31	1.55	08/18/2025 10:59	WG2566235
Bismuth-214 (Ra-226)	18.5		1.35	1.35	0.467	0.220	08/18/2025 10:59	WG2566235
Lead-212	1.45		0.313	0.313	0.491	0.238	08/18/2025 10:59	WG2566235
Lead-214	20.3		1.49	1.49	0.600	0.288	08/18/2025 10:59	WG2566235
Potassium-40	0.0737	U	1.36	1.36	2.69	1.23	08/18/2025 10:59	WG2566235
Thallium-208	0.238	J	0.137	0.137	0.238	0.112	08/18/2025 10:59	WG2566235
Thorium-234 (U-238)	-1.98	U	2.65	2.65	5.90	2.41	08/18/2025 10:59	WG2566235
Uranium-235	1.33	U	0.248	0.248	1.82	0.884	08/18/2025 10:59	WG2566235

Method Blank (MB)

(MB) R4260001-3 08/16/25 00:01

Analyte	MB Result pCi/g	MB Qualifier	MB 2 sigma CE + / -	MB MDA pCi/g	MB Lc pCi/g
Actinium-228 (Ra-228)	-0.0144	U	0.0773	0.188	0.0816
Americium-241	0.0131	U	0.168	0.303	0.138
Bismuth-212	0.0260	U	0.345	0.739	0.325
Bismuth-214 (Ra-226)	0.0321	U	0.0550	0.108	0.0484
Cesium-137	0.0412	J	0.0331	0.0599	0.0267
Cobalt-60	-0.0164	U	0.0201	0.0708	0.0306
Lead-212	0.00958	U	0.0358	0.0704	0.0324
Lead-214	0.00346	U	0.0415	0.0941	0.0426
Potassium-40	0.0794	U	0.253	0.552	0.228
Thallium-208	-0.0190	U	0.0262	0.0569	0.0255
Thorium-234 (U-238)	0.775	J	0.508	0.849	0.334
Uranium-235	0.0792		0.0303	0.0507	0.0235

L1879915-01 Original Sample (OS) • Duplicate (DUP)

(OS) L1879915-01 08/15/25 21:35 • (DUP) R4260001-1 08/15/25 22:42

Analyte	Original Result pCi/g	Original 2 sigma CE + / -	Original MDA pCi/g	Original Lc pCi/g	DUP Result pCi/g	DUP 2 sigma CE + / -	DUP MDA pCi/g	DUP Lc pCi/g	DUP RPD %	DUP RER	DUP Qualifier	DUP RPD Limits %	DUP RER Limit
Actinium-228 (Ra-228)	0.344	0.332	0.793	0.368	0.395	0.304	0.669	0.310	13.9	0.114	J	20	3
Bismuth-212	0.761	1.27	2.54	1.17	0.126	1.24	2.45	1.14	143	0.358	U	20	3
Bismuth-214 (Ra-226)	17.0	1.24	0.387	0.180	18.2	1.31	0.331	0.155	6.76	0.660		20	3
Lead-212	-0.411	0.224	0.394	0.190	0.364	0.187	0.311	0.150	200	2.65		20	3
Lead-214	18.3	1.35	0.413	0.196	21.4	1.55	0.397	0.190	15.6	1.51		20	3
Potassium-40	0.356	1.23	2.45	1.12	0.926	1.03	1.85	0.834	89.1	0.356	J	20	3
Thallium-208	0.0432	0.112	0.205	0.0960	0.143	0.105	0.184	0.0867	107	0.652	J	20	3
Thorium-234 (U-238)	3.22	1.96	3.34	1.35	1.25	1.49	2.71	1.11	88.0	0.799	J	20	3
Uranium-235	1.50	0.194	1.11	0.534	1.57	0.181	1.00	0.487	4.50	0.260		20	3

Laboratory Control Sample (LCS) • Laboratory Control Sample Duplicate (LCSD)

(LCS) R4260001-2 08/15/25 23:43 • (LCSD) R4260001-4 08/16/25 00:35

Analyte	Spike Amount pCi/g	LCS Result pCi/g	LCSD Result pCi/g	LCS Rec. %	LCSD Rec. %	Rec. Limits %	LCS Qualifier	LCSD Qualifier	RPD %	RPD Limits %
Americium-241	36.9	34.8	35.9	94.3	97.2	80.0-120			3.06	20
Cesium-137	53.8	58.7	58.4	109	109	80.0-120			0.410	20
Cobalt-60	62.9	67.6	63.7	108	101	80.0-120			5.95	20

Method Blank (MB)

(MB) R4260211-2 08/17/25 14:20

Analyte	MB Result pCi/g	MB Qualifier	MB 2 sigma CE + / -	MB MDA pCi/g	MB Lc pCi/g
Actinium-228 (Ra-228)	-0.0522	U	0.105	0.291	0.119
Americium-241	-0.0822	U	0.141	0.271	0.126
Bismuth-212	-0.0808	U	0.491	1.18	0.493
Bismuth-214 (Ra-226)	0.0129	U	0.0624	0.134	0.0554
Cesium-137	0.0219	U	0.0419	0.0850	0.0358
Cobalt-60	0.00492	U	0.0289	0.107	0.0427
Lead-212	-0.0119	U	0.0617	0.116	0.0529
Lead-214	-0.0309	U	0.0584	0.147	0.0650
Potassium-40	0.196	U	0.448	1.04	0.413
Thallium-208	0.0109	U	0.0302	0.0646	0.0264
Thorium-234 (U-238)	1.08	J	0.684	1.14	0.446
Uranium-235	0.0281	U	0.0509	0.0946	0.0438

L1879915-21 Original Sample (OS) • Duplicate (DUP)

(OS) L1879915-21 08/17/25 15:51 • (DUP) R4260211-4 08/18/25 08:37

Analyte	Original Result pCi/g	Original 2 sigma CE + / -	Original MDA pCi/g	Original Lc pCi/g	DUP Result pCi/g	DUP 2 sigma CE + / -	DUP MDA pCi/g	DUP Lc pCi/g	DUP RPD %	DUP RER	DUP Qualifier	DUP RPD Limits %	DUP RER Limit
Actinium-228 (Ra-228)	0.476	0.404	0.968	0.440	0.608	0.252	0.546	0.258	24.4	0.278		20	3
Bismuth-212	-1.27	1.79	3.63	1.66	0.144	0.964	1.86	0.879	200	0.697	U	20	3
Bismuth-214 (Ra-226)	20.7	1.59	0.487	0.224	18.7	1.26	0.298	0.142	10.5	1.02		20	3
Lead-214	19.9	1.51	0.563	0.267	20.0	1.41	0.343	0.165	0.752	0.0725		20	3
Potassium-40	1.17	1.62	3.09	1.37	0.202	0.784	1.47	0.683	141	0.536	U	20	3
Thallium-208	0.161	0.154	0.266	0.123	0.233	0.0895	0.151	0.0719	36.5	0.403		20	3
Thorium-234 (U-238)	-0.292	1.49	3.39	1.39	5.73	2.67	3.68	1.51	200	1.97		20	3
Uranium-235	1.73	0.240	1.42	0.688	1.44	0.178	1.24	0.607	18.4	0.975		20	3

Laboratory Control Sample (LCS) • Laboratory Control Sample Duplicate (LCSD)

(LCS) R4260211-1 08/17/25 12:02 • (LCSD) R4260211-3 08/17/25 15:18

Analyte	Spike Amount pCi/g	LCS Result pCi/g	LCSD Result pCi/g	LCS Rec. %	LCSD Rec. %	Rec. Limits %	LCS Qualifier	LCSD Qualifier	RPD %	RPD Limits %
Americium-241	36.9	33.1	32.9	89.7	89.3	80.0-120			0.485	20
Cesium-137	53.8	53.4	55.5	99.2	103	80.0-120			3.86	20
Cobalt-60	62.9	63.3	65.7	101	104	80.0-120			3.64	20

GLOSSARY OF TERMS

Guide to Reading and Understanding Your Laboratory Report

The information below is designed to better explain the various terms used in your report of analytical results from the Laboratory. This is not intended as a comprehensive explanation, and if you have additional questions please contact your project representative.

Results Disclaimer - Information that may be provided by the customer, and contained within this report, include Permit Limits, Project Name, Sample ID, Sample Matrix, Sample Preservation, Field Blanks, Field Spikes, Field Duplicates, On-Site Data, Sampling Collection Dates/Times, and Sampling Location. Results relate to the accuracy of this information provided, and as the samples are received.

Abbreviations and Definitions

MDA	Minimum Detectable Activity.
Rec.	Recovery.
RER	Replicate Error Ratio.
TPU	Total Propagated Uncertainty reported at 2 sigma (counting error plus all measurable variables).
Lc	Decision Level or Critical Level. DOE required Detection limit at a 68% confidence level.
RPD	Relative Percent Difference.
SDG	Sample Delivery Group.
Analyte	The name of the particular compound or analysis performed. Some Analyses and Methods will have multiple analytes reported.
Limits	These are the target % recovery ranges or % difference value that the laboratory has historically determined as normal for the method and analyte being reported. Successful QC Sample analysis will target all analytes recovered or duplicated within these ranges.
Original Sample	The non-spiked sample in the prep batch used to determine the Relative Percent Difference (RPD) from a quality control sample. The Original Sample may not be included within the reported SDG.
Qualifier	This column provides a letter and/or number designation that corresponds to additional information concerning the result reported. If a Qualifier is present, a definition per Qualifier is provided within the Glossary and Definitions page and potentially a discussion of possible implications of the Qualifier in the Case Narrative if applicable.
Result	The actual analytical final result (corrected for any sample specific characteristics) reported for your sample. If there was no measurable result returned for a specific analyte, the result in this column may state “ND” (Not Detected) or “BDL” (Below Detectable Levels). The information in the results column should always be accompanied by either an MDL (Method Detection Limit) or RDL (Reporting Detection Limit) that defines the lowest value that the laboratory could detect or report for this analyte.
Uncertainty (Radiochemistry)	Confidence level of 2 sigma.
U (Radiochemistry)	Result + Error < MDA.
J (Radiochemistry)	Result < MDA; Result + Error > MDA.
Case Narrative (Cn)	A brief discussion about the included sample results, including a discussion of any non-conformances to protocol observed either at sample receipt by the laboratory from the field or during the analytical process. If present, there will be a section in the Case Narrative to discuss the meaning of any data qualifiers used in the report.
Quality Control Summary (Qc)	This section of the report includes the results of the laboratory quality control analyses required by procedure or analytical methods to assist in evaluating the validity of the results reported for your samples. These analyses are not being performed on your samples typically, but on laboratory generated material.
Sample Chain of Custody (Sc)	This is the document created in the field when your samples were initially collected. This is used to verify the time and date of collection, the person collecting the samples, and the analyses that the laboratory is requested to perform. This chain of custody also documents all persons (excluding commercial shippers) that have had control or possession of the samples from the time of collection until delivery to the laboratory for analysis.
Sample Results (Sr)	This section of your report will provide the results of all testing performed on your samples. These results are provided by sample ID and are separated by the analyses performed on each sample. The header line of each analysis section for each sample will provide the name and method number for the analysis reported.
Sample Summary (Ss)	This section of the Analytical Report defines the specific analyses performed for each sample ID, including the dates and times of preparation and/or analysis.

Qualifier	Description
J	The identification of the analyte is acceptable; the reported value is an estimate.
U	Below Detectable Limits: Indicates that the analyte was not detected.

ACCREDITATIONS & LOCATIONS

Pace Analytical National 12065 Lebanon Rd Mount Juliet, TN 37122

Alabama	40660	Nebraska	NE-OS-15-05
Alaska	17-026	Nevada	TN000032021-1
Arizona	AZ0612	New Hampshire	2975
Arkansas	88-0469	New Jersey–NELAP	TN002
California	2932	New Mexico [1]	TN00003
Colorado	TN00003	New York	11742
Connecticut	PH-0197	North Carolina	Env375
Florida	E87487	North Carolina [1]	DW21704
Georgia	NELAP	North Carolina [3]	41
Georgia [1]	923	North Dakota	R-140
Idaho	TN00003	Ohio–VAP	CL0069
Illinois	200008	Oklahoma	9915
Indiana	C-TN-01	Oregon	TN200002
Iowa	364	Pennsylvania	68-02979
Kansas	E-10277	Rhode Island	LAO000356
Kentucky [1 6]	KY90010	South Carolina	84004002
Kentucky [2]	16	South Dakota	n/a
Louisiana	AI30792	Tennessee [1 4]	2006
Louisiana	LA018	Texas	T104704245-20-18
Maine	TN00003	Texas [5]	LAB0152
Maryland	324	Utah	TN000032021-11
Massachusetts	M-TN003	Vermont	VT2006
Michigan	9958	Virginia	110033
Minnesota	047-999-395	Washington	C847
Mississippi	TN00003	West Virginia	233
Missouri	340	Wisconsin	998093910
Montana	CERT0086	Wyoming	A2LA
A2LA – ISO 17025	1461.01	AIHA-LAP,LLC EMLAP	100789
A2LA – ISO 17025 [5]	1461.02	DOD	1461.01
Canada	1461.01	USDA	P330-15-00234
EPA–Crypto	TN00003		

[1] Drinking Water [2] Underground Storage Tanks [3] Aquatic Toxicity [4] Chemical/Microbiological [5] Mold [6] Wastewater n/a Accreditation not applicable

* Not all certifications held by the laboratory are applicable to the results reported in the attached report.

* Accreditation is only applicable to the test methods specified on each scope of accreditation held by Pace Analytical.

Pace® Location Requested (City/State): **Mt. Juliet TN**

CHAIN-OF-CUSTODY Analytical Request Document

Chain-of-Custody is a LEGAL DOCUMENT - Complete all relevant fields

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Scan QR Code for instructions

L1879915

Company Name: Mosaic	Contact/Report To: Les.Skoski@arcadis.com
Street Address: Mosaic New Wales 3095 Country Road 640, Mulberry, FL 33860	Phone #: +1 201 398-4377
	E-Mail: Les.Skoski@arcadis.com
	Cc E-Mail: Robert.C.White@arcadis.com
Customer Project #: 30281643	Invoice to: Les Skoski
Project Name: Mosaic - Pilot Road Project	Invoice E-mail: Les.Skoski@arcadis.com
Site Collection Info/Facility ID (as applicable): Mosaic-New Wales-Phase 2-West-South	Purchase Order # (if applicable): 30281643
	Quote #:
Time Zone Collected: [ ] AK [ ] PT [ ] MT [ ] CT [X] ET	County / State origin of sample(s): United States
Data Deliverables: [ ] Level II [ ] Level III [ ] Level IV [ ] EQUIS [ ] Other	Regulatory Program (DW, RCRA, etc.) as applicable: Reportable [ ] Yes [ ] No
	Rush (Pre-approval required): [ ] Same Day [ ] 1 Day [ ] 2 Day [ ] 3 Day Other _____ Date Results Requested:
	DW PWSID # or WW Permit # as applicable: Field Filtered (If applicable): [ ] Yes [X] No Analysis:

* Matrix Codes (Insert in Matrix box below): Drinking Water (DW), Ground Water (GW), Wastewater (WW), Product (P), Soil/Solid (SS), Oil (OL), Wipe (WP), Tissue (TS), Bioassay (B), Vapor (V), Surface Water (SW),Sediment (SED), Sludge (SL), Caulk (CK), Leachate (LL), Biosolid (BS), Other (OT)

Customer Sample ID	Matrix *	Comp / Grab	Composite Start Date	Composite Start Time	Collected or Composite End Date	Collected or Composite End Time	# Cont.	Residual Chlorine Result	Residual Chlorine Units	EPA method 901.1	Sample Comment
Mosaic-07.15.25-PG-Rad1	ss	c			07/15/25	2:02 pm	1			X	01
Mosaic-07.15.25-PG-Rad2	ss	c			07/15/25	2:07 pm	1			X	02
Mosaic-07.15.25-PG-Rad3	ss	c			07/15/25	2:11 pm	1			X	03
Mosaic-07.15.25-PG-Rad4	ss	c			07/15/25	2:14 pm	1			X	04
Mosaic-07.15.25-PG-Rad5	ss	c			07/15/25	2:20 pm	1			X	05
Mosaic-07.15.25-PG-Rad6	ss	c			07/15/25	2:23 pm	1			X	06
Mosaic-07.15.25-PG-Rad7	ss	c			07/15/25	2:25 pm	1			X	07
Mosaic-07.15.25-PG-Rad8	ss	c			07/15/25	2:31 pm	1			X	08
Mosaic-07.15.25-PG-Rad9	ss	c			07/15/25	2:34 pm	1			X	09
Mosaic-07.15.25-PG-Rad10	ss	c			07/15/25	2:37 pm	1			X	10

Specify Container Size **

Identify Container Preservative Type***

Analysis Requested

**Container Size: (1) 1L, (2) 500mL, (3) 250mL, (4) 125mL, (5) 100mL, (6) 40mL vial, (7) EnCore, (8) TerraCore, (9) 90mL, (10) Other

*** Preservative Types: (1) None, (2) HNO3, (3) H2SO4, (4) HCl, (5) NaOH, (6) Zn Acetate, (7) NaHSO4, (8) Sod. Thiosulfate, (9) Ascorbic Acid, (10) MeOH, (11) Other

Lab Use Only

Proj. Mgr:

AcctNum / Client ID: F130

Profile / Template:

Prelog / Bottle Ord. ID:

Preservation non-cor... for sa...

Additional Instructions from Pace®:
All peaks reported. Method 901.1 with 21 day in-growth.

Collected By:
Printed Name
Signature

Customer Remarks / Special Conditions / Possible Hazards:
Samples are Phosphogypsum handle with caution.

# Coolers:	Thermometer ID:	Correction Factor (°C):	Obs. Temp. (°C):	Corrected Temp. (°C):	[ ] On Ice

Relinquished by/Company: (Signature)	Date/Time:	Received by/Company: (Signature)	Date/Time:	Tracking Number:
Billy White Arcadis	07/15/25 11:02 PM			
Relinquished by/Company: (Signature)	Date/Time:	Received by/Company: (Signature)	Date/Time:	Delivered by: [ ] In- Person [ ] Courier
Relinquished by/Company: (Signature)	Date/Time:	Received by/Company: (Signature) CHROENO	Date/Time: 07.18.25 1000	[ ] FedEx [ ] UPS [ ] Other
		Received by/Company: (Signature)	Date/Time:	Page: 1 of 4

Sample Receipt Checklist

COC Seal Present/Intact: [Y] N NP — If Applicable
COC Signed/Accurate: [Y] N — VOA Zero Headspace: [Y] N
Bottles arrive intact: [Y] N — Pres. Correct/Check: [Y] N
Correct bottles used: [Y] N
Sufficient volume sent: [Y] N — Condition: NCF [OK]
RA Screen <0.5 mR/hr: [Y] N

Conditions found at https://info.pacelabs.com/hubfs/pas-standard-terms.pdf.

Pace® Location Requested (City/State): **Mt. Juliet TN**

CHAIN-OF-CUSTODY Analytical Request Document

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L1574015

Company Name: Mosaic	Contact/Report To: Les Skoski
Street Address: Mosaic New Wales 3095 Country Road 640, Mulberry, FL 33860	Phone #: 1 201 398-4377
	E-Mail: Les.Skoski@arcadis.com
	Cc E-Mail: Robert.C.White@arcadis.com
Customer Project #: 30281643	Invoice to: Les Skoski
Project Name: Mosaic - Pilot Road Project	Invoice E-mail: Les.Skoski@arcadis.com
Site Collection Info/Facility ID (as applicable): Mosaic-New Wales-Phase 2-West-South	Purchase Order # (if applicable): 30281643
	Quote #:
Time Zone Collected: [ ] AK [ ] PT [ ] MT [ ] CT [ ] ET	County / State origin of sample(s):
Data Deliverables: [ ] Level II [ ] Level III [ ] Level IV [ ] EQUIS [ ] Other_____	Regulatory Program (DW, RCRA, etc.) as applicable: Reportable [ ] Yes [ ] No
	Rush (Pre-approval required): [ ] Same Day [ ] 1 Day [ ] 2 Day [ ] 3 Day Other _____ Date Results Requested:
	DW PWSID # or WW Permit # as applicable: Field Filtered (if applicable): [ ] Yes [ ] No Analysis:

Specify Container Size **

Identify Container Preservative Type***

Analysis Requested

**Container Size: (1) 1L, (2) 500mL, (3) 250mL, (4) 125mL, (5) 100mL, (6) 40mL vial, (7) EnCore, (8) TerraCore, (9) 90mL, (10) Other

*** Preservative Types: (1) None, (2) HNO3, (3) H2SO4, (4) HCl, (5) NaOH, (6) Zn Acetate, (7) NaHSO4, (8) Sod. Thiosulfate, (9) Ascorbic Acid, (10) MeOH, (11) Other

Lab Use Only: Proj. Mgr: / AcctNum / Client ID: / Table #: / Profile / Template: / Prelog / Bottle Ord. ID:

* Matrix Codes (Insert in Matrix box below): Drinking Water (DW), Ground Water (GW), Wastewater (WW), Product (P), Soil/Solid (SS), Oil (OL), Wipe (WP), Tissue (TS), Bioassay (B), Vapor (V), Surface Water (SW), Sediment (SED), Sludge (SL), Caulk (CK), Leachate (LL), Biosolid (BS), Other (OT)

Customer Sample ID	Matrix *	Comp / Grab	Composite Start Date	Composite Start Time	Collected or Composite End Date	Collected or Composite End Time	# Cont.	Residual Chlorine Result	Residual Chlorine Units	EPA method 901.1	Sample Comment	Preservation non-conformance identified for sample.
Mosaic-07.15.25-PG-Rad11	ss				07/15/25	2:40 pm	1			X	11	
Mosaic-07.15.25-PG-Rad12	ss				07/15/25	2:47 pm	1			X	12	
Mosaic-07.15.25-PG-Rad13	ss				07/15/25	2:49 pm	1			X	13	
Mosaic-07.15.25-PG-Rad14	ss				07/15/25	2:56 pm	1			X	14	
Mosaic-07.15.25-PG-Rad15	ss				07/15/25	2:59 pm	1			X	15	
Mosaic-07.15.25-PG-Rad16	ss				07/15/25	3:23 pm	1			X	16	
Mosaic-07.15.25-PG-Rad17	ss				07/15/25	3:29 pm	1			X	17	
Mosaic-07.15.25-PG-Rad18	ss				07/15/25	3:31 pm	1			X	18	
Mosaic-07.15.25-PG-Rad19	ss				07/15/25	3:34 pm	1			X	19	
Mosaic-07.15.25-PG-Rad20	ss				07/15/25	3:39 pm	1			X	20	

Additional Instructions from Pace®:
All peaks reported. Method 901.1 with 21 day in-growth.

Collected By:
Printed Name
Signature

Customer Remarks / Special Conditions / Possible Hazards:

# Coolers:	Thermometer ID:	Correction Factor (°C):	Obs. Temp. (°C):	Corrected Temp. (°C):	[ ] On Ice

Relinquished by/Company: (Signature)	Date/Time:	Received by/Company: (Signature)	Date/Time:	Tracking Number:
Pilot Wht Arcadis	07/15/25 11:02PM			
Relinquished by/Company: (Signature)	Date/Time:	Received by/Company: (Signature)	Date/Time:	Delivered by: [ ] In- Person [ ] Courier
Relinquished by/Company: (Signature)	Date/Time:	Received by/Company: (Signature) CRobend	Date/Time: 07/18/25 1000	[ ] FedEX [ ] UPS [ ] Other
Relinquished by/Company: (Signature)	Date/Time:	Received by/Company: (Signature)	Date/Time:	Page: 2 of 4

Pace® Location Requested (City/State): **Mt. Juliet TN**

CHAIN-OF-CUSTODY Analytical Request Document

Chain-of-Custody is a LEGAL DOCUMENT - Complete all relevant fields

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Scan QR Code for instructions

L1879915

Company Name: Mosaic	Contact/Report To: Les Skoski
Street Address: Mosaic New Wales, 3095 Country Road 640, Mulberry, FL 33860	Phone #: 1 201 398-4377
	E-Mail: Les.Skoski@arcadis.com
	Cc E-Mail: Robert.C.White@arcadis.com
Customer Project #: 30281643	Invoice to: Les Skoski
Project Name: Mosaic - Pilot Road Project	Invoice E-mail: Les.Skoski@arcadis.com
Site Collection Info/Facility ID (as applicable): Mosaic-New Wales-Phase 2-West-South	Purchase Order # (if applicable): 30281643
	Quote #:
Time Zone Collected: [ ] AK [ ] PT [ ] MT [ ] CT [ ] ET	County / State origin of sample(s):
Data Deliverables: [ ] Level II [ ] Level III [ ] Level IV [ ] EQUIS [ ] Other	Regulatory Program (DW, RCRA, etc.) as applicable: Reportable [ ] Yes [ ] No
	Rush (Pre-approval required): [ ] Same Day [ ] 1 Day [ ] 2 Day [ ] 3 Day Other _____ Date Results Requested:
	DW PWSID # or WW Permit # as applicable: Field Filtered (if applicable): [ ] Yes [ ] No Analysis:

**Containter Size: (1) 1L, (2) 500mL, (3) 250mL, (4) 125mL, (5) 100mL, (6) 40mL vial, (7) EnCore, (8) TerraCore, (9) 90mL, (10) Other

*** Preservative Types: (1) None, (2) HNO3, (3) H2SO4, (4) HCl, (5) NaOH, (6) Zn Acetate, (7) NaHSO4, (8) Sod. Thiosulfate, (9) Ascorbic Acid, (10) MeOH, (11) Other

* Matrix Codes (Insert in Matrix box below): Drinking Water (DW), Ground Water (GW), Wastewater (WW), Product (P), Soil/Solid (SS), Oil (OL), Wipe (WP), Tissue (TS), Bioassay (B), Vapor (V), Surface Water (SW),Sediment (SED), Sludge (SL), Caulk (CK), Leachate (LL), Biosolid (BS), Other (OT)

Customer Sample ID	Matrix *	Comp / Grab	Composite Start Date	Composite Start Time	Collected or Composite End Date	Collected or Composite End Time	# Cont.	Residual Chlorine Result	Residual Chlorine Units	Specify Container Size **	Identify Container Preservative Type***	Analysis Requested: EPA method 901.1	Sample Comment
Mosaic-07.15.25-PG-Rad21	ss	c			07/15/25	3:42 pm	1					X	21
Mosaic-07.15.25-PG-Rad22	ss	c			07/15/25	3:44 pm	1					X	22
Mosaic-07.15.25-PG-Rad23	ss	c			07/15/25	3:47 pm	1					X	23
Mosaic-07.15.25-PG-Rad24	ss	c			07/15/25	3:48 pm	1					X	24
Mosaic-07.15.25-PG-Rad25	ss	c			07/15/25	3:50 pm	1					X	25
Mosaic-07.15.25-PG-Rad26	ss	c			07/15/25	3:51 pm	1					X	26
Mosaic-07.15.25-PG-Rad27	ss	c			07/15/25	3:52 pm	1					X	27
Mosaic-07.15.25-PG-Rad28	ss	c			07/15/25	3:54 pm	1					X	28
Mosaic-07.15.25-PG-Rad29	ss	c			07/15/25	3:55 pm	1					X	29
Mosaic-07.15.25-PG-Rad30	ss	c			07/15/25	3:57 pm	1					X	30

Lab Use Only: Proj. Mgr: | AcctNum / Client ID: | Table #: | Profile / Template: | Prelog / Bottle Ord. ID:

Preservation non-conformance identified for sample.

Additional Instructions from Pace® :
All peaks reported. Method 901.1 with 21 day in-growth.

Collected By:
Printed Name
Signature

Customer Remarks / Special Conditions / Possible Hazards:

Coolers: | Thermometer ID: | Correction Factor (°C): | Obs. Temp. (°C): | Corrected Temp. (°C): | [ ] On Ice

Relinquished by/Company: (Signature)	Date/Time:	Received by/Company: (Signature)	Date/Time:	Tracking Number:
Riley White Arcadis	07/15/25 11:02 PM			
Relinquished by/Company: (Signature)	Date/Time:	Received by/Company: (Signature)	Date/Time:	Delivered by: [ ] In- Person [ ] Courier [ ] FedEx [ ] UPS [ ] Other
Relinquished by/Company: (Signature)	Date/Time:	Received by/Company: (Signature) CRoberts	Date/Time: 07/18/25 1000	
Relinquished by/Company: (Signature)	Date/Time:	Received by/Company: (Signature)	Date/Time:	Page: 3 of 4

Pace® Location Requested (City/State): **Mt. Juliet TN**

CHAIN-OF-CUSTODY Analytical Request Document

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Scan QR Code for instructions

L1879915

Company Name: Mosaic	Contact/Report To: Les Skoski
Street Address: Mosaic New Wales 3095 Country Road 640, Mulberry, FL 33860	Phone #: 1 201 398-4377
	E-Mail: Les.Skoski@arcadis.com
	Cc E-Mail: Robert.C.White@arcadis.com
Customer Project #: 30281643	Invoice to: Les Skoski
Project Name: Mosaic - Pilot Road Project	Invoice E-mail: Les.Skoski@arcadis.com
Site Collection Info/Facility ID (as applicable): Mosaic-New Wales-Phase 2-West-South	Purchase Order # (if applicable): 30281643
	Quote #:
Time Zone Collected: [ ] AK [ ] PT [ ] MT [ ] CT [ ] ET	County / State origin of sample(s):
Data Deliverables: [ ] Level II [ ] Level III [ ] Level IV [ ] EQUIS [ ] Other	Regulatory Program (DW, RCRA, etc.) as applicable: Reportable [ ] Yes [ ] No
Rush (Pre-approval required): [ ] Same Day [ ] 1 Day [ ] 2 Day [ ] 3 Day Other Date Results Requested:	DW PWSID # or WW Permit # as applicable: Field Filtered (if applicable): [ ] Yes [X] No Analysis:

Specify Container Size **

Identify Container Preservative Type***

Analysis Requested

**Container Size: (1) 1L, (2) 500mL, (3) 250mL, (4) 125mL, (5) 100mL, (6) 40mL vial, (7) EnCore, (8) TerraCore, (9) 90mL, (10) Other

*** Preservative Types: (1) None, (2) HNO3, (3) H2SO4, (4) HCl, (5) NaOH, (6) Zn Acetate, (7) NaHSO4, (8) Sod. Thiosulfate, (9) Ascorbic Acid, (10) MeOH, (11) Other

Lab Use Only: Proj. Mgr: / AcctNum / Client ID: / Table #: / Profile / Template: / Prelog / Bottle Ord. ID:

Preservation non-conformance identified for sample.

* Matrix Codes (Insert in Matrix box below): Drinking Water (DW), Ground Water (GW), Wastewater (WW), Product (P), Soil/Solid (SS), Oil (OL), Wipe (WP), Tissue (TS), Bioassay (B), Vapor (V), Surface Water (SW), Sediment (SED), Sludge (SL), Caulk (CK), Leachate (LL), Biosolid (BS), Other (OT)

Customer Sample ID	Matrix *	Comp / Grab	Composite Start Date	Composite Start Time	Collected or Composite End Date	Collected or Composite End Time	# Cont.	Residual Chlorine Result	Residual Chlorine Units	EPA method 901.1	Sample Comment
Mosaic-07.15.25-PG-Rad31	ss	c			07/15/25	2:15 pm	1			X	31
Mosaic-07.15.25-PG-Rad32	ss	c			07/15/25	2:25 pm	1			X	32
Mosaic-07.15.25-PG-Rad33	ss	c			07/15/25	2:40 pm	1			X	33
Mosaic-07.15.25-PG-Rad34	ss	c			07/15/25	2:59 pm	1			X	34
Mosaic-07.15.25-PG-Rad35	ss	c			07/15/25	3:36 pm	1			X	35
Mosaic-07.15.25-PG-Rad36	ss	c			07/15/25	3:46 pm	1			X	36
Mosaic-07.15.25-PG-Rad37	ss	c			07/15/25	3:53 pm	1			X	37
Mosaic-07.15.25-PG-Rad38	ss	c			07/15/25	1:57 pm	1			X	38
Mosaic-07.15.25-PG-Rad39	ss	c			07/15/25	1:54 pm	1			X	39
Mosaic-07.15.25-PG-Rad40	ss	c			07/15/25	1:40 pm	1			X	40

Additional Instructions from Pace®:
All peaks reported. Method 901.1 with 21 day in-growth.

Collected By:
Printed Name
Signature

Customer Remarks / Special Conditions / Possible Hazards:

# Coolers:	Thermometer ID:	Correction Factor (°C):	Obs. Temp. (°C):	Corrected Temp. (°C):	[ ] On Ice

Relinquished by/Company: (Signature)	Date/Time:	Received by/Company: (Signature)	Date/Time:	Tracking Number:
Robert White Arcadis	07/15/25 1102 PM			
Relinquished by/Company: (Signature)	Date/Time:	Received by/Company: (Signature)	Date/Time:	Delivered by: [ ] In-Person [ ] Courier [ ] FedEx [ ] UPS [ ] Other
Relinquished by/Company: (Signature)	Date/Time:	Received by/Company: (Signature) CRobert	Date/Time: 07.18.25 1000	
Relinquished by/Company: (Signature)	Date/Time:	Received by/Company: (Signature)	Date/Time:	Page: 4 of 4

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Multiple Parcel Form

L#_____

Parcel Tracking Number	Infrared Thermometer ID	Temperature Reading (°C)	Correction Factor (°C)	Corrected Temperature (°C)	Custody Seal Intact
UPS				Amb	~~Yes~~ / No / Not Present
UPS				Amb	~~Yes~~ / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present
					Yes / No / Not Present

CRoberts
Name

07.18.25
Date

Attachment B - 40 CFR part 61, Appendix B

Method 114—Test Methods for Measuring Radionuclide Emissions from Stationary Sources

1. *Purpose and Background*

This method provides the requirements for: (1) Stack monitoring and sample collection methods appropriate for radionuclides; (2) radiochemical methods which are used in determining the amounts of radionuclides collected by the stack sampling and; (3) quality assurance methods which are conducted in conjunction with these measurements. These methods are appropriate for emissions for stationary sources. A list of references is provided.

Many different types of facilities release radionuclides into air. These radionuclides differ in the chemical and physical forms, half-lives and type of radiation emitted. The appropriate combination of sample extraction, collection and analysis for an individual radionuclide is dependent upon many interrelated factors including the mixture of other radionuclides present. Because of this wide range of conditions, no single method for monitoring or sample collection and analysis of a radionuclide is applicable to all types of facilities. Therefore, a series of methods based on “principles of measurement” are described for monitoring and sample collection and analysis which are applicable to the measurement of radionuclides found in effluent streams at stationary sources. This approach provides the user with the flexibility to choose the most appropriate combination of monitoring and sample collection and analysis methods which are applicable to the effluent stream to be measured.

2. *Stack Monitoring and Sample Collection Methods*

Monitoring and sample collection methods are described based on “principles of monitoring and sample collection” which are applicable to the measurement of radionuclides from effluent streams at stationary sources. Radionuclides of most elements will be in the particulate form in these effluent streams and can be readily collected using a suitable filter media. Radionuclides of hydrogen, oxygen, carbon, nitrogen, the noble gases and in some circumstances iodine will be in the gaseous form. Radionuclides of these elements will require either the use of an in-line or off-line monitor to directly measure the radionuclides, or suitable sorbers, condensers or bubblers to collect the radionuclides.

2.1 Radionuclides as Particulates. The extracted effluent stream is passed through a filter media to remove the particulates. The filter must have a high efficiency for removal of sub-micron particles. The guidance in ANSI/HPS N13.1-1999 (section 6.6.2 Filter media) shall be followed in using filter media to collect particulates (incorporated by reference—see § 61.18 of this part).

2.2 Radionuclides as Gases.

2.2.1 The Radionuclide Tritium (H-3). Tritium in the form of water vapor is collected from the extracted effluent sample by sorption, condensation or dissolution techniques. Appropriate collectors may include silica gel, molecular sieves, and ethylene glycol or water bubblers.

Tritium in the gaseous form may be measured directly in the sample stream using Method B-1, collected as a gas sample or may be oxidized using a metal catalyst to tritiated water and collected as described above.

2.2.2 Radionuclides of Iodine. Iodine is collected from an extracted sample by sorption or dissolution techniques. Appropriate collectors may include charcoal, impregnated charcoal, metal zeolite and caustic solutions.

2.2.3 Radionuclides of Argon, Krypton and Xenon. Radionuclides of these elements are either measured directly by an in-line or off-line monitor, or are collected from the extracted sample by low temperature sorption techniques, Appropriate sorbers may include charcoal or metal zeolite.

2.2.4 Radionuclides of Oxygen, Carbon, Nitrogen and Radon. Radionuclides of these elements are measured directly using an in-line or off-line monitor. Radionuclides of carbon in the form of carbon dioxide may be collected by dissolution in caustic solutions.

2.3 Definition of Terms

In-line monitor means a continuous measurement system in which the detector is placed directly in or adjacent to the effluent stream. This may involve either gross radioactivity measurements or specific radionuclide measurements. Gross measurements shall be made in conformance with the conditions specified in Methods A-4, B-2 and G-4.

Off-line monitor means a measurement system in which the detector is used to continuously measure an extracted sample of the effluent stream. This may involve either gross radioactivity measurements or specific radionuclide measurements. Gross measurements shall be made in conformance with the conditions specified in Methods A-4, B-2 and G-4.

Sample collection means a procedure in which the radionuclides are removed from an extracted sample of the effluent using a collection media. These collection media include filters, absorbers, bubblers and condensers. The collected sample is analyzed using the methods described in Section 3.

3. *Radionuclide Analysis Methods*

A series of methods based on “principles of measurement” are described which are applicable to the analysis of radionuclides collected from airborne effluent streams at stationary sources. These methods are applicable only under the conditions stated and within the limitations described. Some methods specify that only a single radionuclide be present in the sample or the chemically separated sample. This condition should be interpreted to mean that no other radionuclides are present in quantities which would interfere with the measurement.

Also identified (Table 1) are methods for a selected list of radionuclides. The listed radionuclides are those which are most commonly used and which have the greatest potential for causing dose to members of the public. Use of methods based on principles of measurement other than those described in this section must be approved in advance of use by the Administrator. For radionuclides not listed in Table 1, any of the described methods may be used provided the user can demonstrate that the applicability conditions of the method have been met.

The type of method applicable to the analysis of a radionuclide is dependent upon the type of radiation emitted, i.e., alpha, beta or gamma. Therefore, the methods described below are grouped according to principles of measurements for the analysis of alpha, beta and gamma emitting radionuclides.

3.1 Methods for Alpha Emitting Radionuclides

3.1.1 Method A-1, Radiochemistry-Alpha Spectrometry.

Principle: The element of interest is separated from other elements, and from the sample matrix using radiochemical techniques. The procedure may involve precipitation, ion exchange, or solvent extraction. Carriers (elements chemically similar to the element of interest) may be used. The element is deposited on a planchet in a very thin film by electrodeposition or by coprecipitation on a very small amount of carrier, such as lanthanum fluoride. The deposited element is then counted with an alpha spectrometer. The activity of the nuclide of interest is measured by the number of alpha counts in the appropriate energy region. A correction for chemical yield and counting efficiency is made using a standardized radioactive nuclide (tracer) of the same element. If a radioactive tracer is not available for the element of interest, a predetermined chemical yield factor may be used.

Applicability: This method is applicable for determining the activity of any alpha-emitting radionuclide, regardless of what other radionuclides are present in the sample provided the chemical separation step produces a very thin

sample and removes all other radionuclides which could interfere in the spectral region of interest. APHA-605(2), ASTM-D-3972(13).

3.1.2 Method A-2, Radiochemistry-Alpha Counting.

Principle: The element of interest is separated from other elements, and from the sample matrix using radiochemistry. The procedure may involve precipitation, ion exchange, or solvent extraction. Carriers (elements chemically similar to the element of interest) may be used. The element is deposited on a planchet in a thin film and counted with an alpha counter. A correction for chemical yield (if necessary) is made. The alpha count rate measures the total activity of all emitting radionuclides of the separated element.

Applicability: This method is applicable for the measurement of any alpha-emitting radionuclide, provided no other alpha emitting radionuclide is present in the separated sample. It may also be applicable for determining compliance, when other radionuclides of the separated element are present, provided that the calculated emission rate is assigned to the radionuclide which could be present in the sample that has the highest dose conversion factor. IDO-12096(18).

3.1.3 Method A-3, Direct Alpha Spectrometry.

Principle: The sample, collected on a suitable filter, is counted directly on an alpha spectrometer. The sample must be thin enough and collected on the surface of the filter so that any absorption of alpha particle energy in the sample or the filter, which would degrade the spectrum, is minimal.

Applicability: This method is applicable to simple mixtures of alpha emitting radionuclides and only when the amount of particulates collected on the filter paper are relatively small and the alpha spectra is adequately resolved. Resolutions should be 50 keV (FWHM) or better, ASTM-D-3084(16).

3.1.4 Method A-4, Direct Alpha Counting (Gross alpha determination).

Principle: The sample, collected on a suitable filter, is counted with an alpha counter. The sample must be thin enough so that self-absorption is not significant and the filter must be of such a nature that the particles are retained on the surface.

Applicability: Gross alpha determinations may be used to measure emissions of specific radionuclides only

(1) when it is known that the sample contains only a single radionuclide, or the identity and isotopic ratio of the radionuclides in the sample are well-known, and

(2) measurements using either Method A-1, A-2 or A-5 have shown that this method provides a reasonably accurate measurement of the emission rate. Gross alpha measurements are applicable to unidentified mixtures of radionuclides only for the purposes and under the conditions described in section 3.7. APHA-601(3), ASTM-D-1943(10).

3.1.5 Method A-5, Chemical Determination of Uranium.

Principle: Uranium may be measured chemically by either colorimetry or fluorometry. In both procedures, the sample is dissolved, the uranium is oxidized to the hexavalent form and extracted into a suitable solvent. Impurities are removed from the solvent layer. For colorimetry, dibenzoylmethane is added, and the uranium is measured by the absorbance in a colorimeter. For fluorometry, a portion of the solution is fused with a sodium fluoride-lithium fluoride flux and the uranium is determined by the ultraviolet activated fluorescence of the fused disk in a fluorometer.

Applicability: This method is applicable to the measurements of emission rates of uranium when the isotopic ratio of the uranium radionuclides is well known. ASTM-E-318(15), ASTM-D-2907(14).

3.1.6 Method A-6, Radon-222—Continuous Gas Monitor.

Principle: Radon-222 is measured directly in a continuously extracted sample stream by passing the air stream through a calibrated scintillation cell. Prior to the scintillation cell, the air stream is treated to remove particulates and excess moisture. The alpha particles from radon-222 and its decay products strike a zinc sulfide coating on the inside of the scintillation cell producing light pulses. The light pulses are detected by a photomultiplier tube which generates electrical pulses. These pulses are processed by the system electronics and the read out is in pCi/l of radon-222.

Applicability: This method is applicable to the measurement of radon-222 in effluent streams which do not contain significant quantities of radon-220. Users of this method should calibrate the monitor in a radon calibration chamber at least twice per year. The background of the monitor should also be checked periodically by operating the instrument in a low radon environment. EPA 520/1-89-009(24).

3.1.7 Method A-7, Radon-222-Alpha Track Detectors

Principle: Radon-222 is measured directly in the effluent stream using alpha track detectors (ATD). The alpha particles emitted by radon-222 and its decay products strike a small plastic strip and produce submicron damage tracks. The plastic strip is placed in a caustic solution that accentuates the damage tracks which are counted using a microscope or automatic counting system. The number of tracks per unit area is correlated to the radon concentration in air using a conversion factor derived from data generated in a radon calibration facility.

Applicability: Prior approval from EPA is required for use of this method. This method is only applicable to effluent streams which do not contain significant quantities of radon-220, unless special detectors are used to discriminate against radon-220. This method may be used only when ATDs have been demonstrated to produce data comparable to data obtained with Method A-6. Such data should be submitted to EPA when requesting approval for the use of this method. EPA 520/1-89-009(24).

3.2 Methods for Gaseous Beta Emitting Radionuclides.

3.2.1 Method B-1, Direct Counting in Flow-Through Ionization Chambers.

Principle: An ionization chamber containing a specific volume of gas which flows at a given flow rate through the chamber is used. The sample (effluent stream sample) acts as the counting gas for the chamber. The activity of the radionuclide is determined from the current measured in the ionization chamber.

Applicability: This method is applicable for measuring the activity of a gaseous beta-emitting radionuclide in an effluent stream that is suitable as a counting gas, when no other beta-emitting nuclides are present. DOE/EP-0096(17), NCRP-58(23).

3.2.2 Method B-2, Direct Counting With In-line or Off-line Beta Detectors.

Principle: The beta detector is placed directly in the effluent stream (in-line) or an extracted sample of the effluent stream is passed through a chamber containing a beta detector (off-line). The activities of the radionuclides present in the effluent stream are determined from the beta count rate, and a knowledge of the radionuclides present and the relationship of the gross beta count rate and the specific radionuclide concentration.

Applicability: This method is applicable only to radionuclides with maximum beta particle energies greater then 0.2 MeV. This method may be used to measure emissions of specific radionuclides only when it is known that the sample contains only a single radionuclide or the identity and isotopic ratio of the radionuclides in the effluent stream are well known. Specific radionuclide analysis of periodic grab samples may be used to identify the types and quantities of radionuclides present and to establish the relationship between specific radionuclide analyses and gross beta count rates.

This method is applicable to unidentified mixtures of gaseous radionuclides only for the purposes and under the conditions described in section 3.7.

3.3 Methods for Non-Gaseous Beta Emitting Radionuclides.

3.3.1 Method B-3, Radiochemistry-Beta Counting.

Principle: The element of interest is separated from other elements, and from the sample matrix by radiochemistry. This may involve precipitation, distillation, ion exchange, or solvent extraction. Carriers (elements chemically similar to the element of interest) may be used. The element is deposited on a planchet, and counted with a beta counter. Corrections for chemical yield, and decay (if necessary) are made. The beta count rate determines the total activity of all radionuclides of the separated element. This method may also involve the radiochemical separation and counting of a daughter element, after a suitable period of ingrowth, in which case it is specific for the parent nuclide.

Applicability: This method is applicable for measuring the activity of any beta-emitting radionuclide, with a maximum energy greater than 0.2 MeV, provided no other radionuclide is present in the separated sample. APHA-608(5).

3.3.2 Method B-4, Direct Beta Counting (Gross beta determination).

Principle: The sample, collected on a suitable filter, is counted with a beta counter. The sample must be thin enough so that self-absorption corrections can be made.

Applicability: Gross beta measurements are applicable only to radionuclides with maximum beta particle energies greater than 0.2 MeV. Gross beta measurements may be used to measure emissions of specific radionuclides only

(1) when it is known that the sample contains only a single radionuclide, and

(2) measurements made using Method B-3 show reasonable agreement with the gross beta measurement. Gross beta measurements are applicable to mixtures of radionuclides only for the purposes and under the conditions described in section 3.7. APHA-602(4), ASTM-D-1890(11).

3.3.3 Method B-5, Liquid Scintillation Spectrometry.

Principle: An aliquot of a collected sample or the result of some other chemical separation or processing technique is added to a liquid scintillation “cocktail” which is viewed by photomultiplier tubes in a liquid scintillation spectrometer. The spectrometer is adjusted to establish a channel or “window” for the pulse energy appropriate to the nuclide of interest. The activity of the nuclide of interest is measured by the counting rate in the appropriate energy channel. Corrections are made for chemical yield where separations are made.

Applicability: This method is applicable to any beta-emitting nuclide when no other radionuclide is present in the sample or the separated sample provided that it can be incorporated in the scintillation cocktail. This method is also applicable for samples which contain more than one radionuclide but only when the energies of the beta particles are sufficiently separated so that they can be resolved by the spectrometer. This method is most applicable to the measurement of low-energy beta emitters such as tritium and carbon-14. APHA-609(6), EML-LV-539-17(19).

3.4 Gamma Emitting Radionuclides

3.4.1 Method G-1, High Resolution Gamma Spectrometry.

Principle: The sample is counted with a high resolution gamma detector, usually either a Ge(Li) or a high purity Ge detector, connected to a multichannel analyzer or computer. The gamma emitting radionuclides in the sample are measured from the gamma count rates in the energy regions characteristic of the individual radionuclide. Corrections are made for counts contributed by other radionuclides to the spectral regions of the radionuclides of interest. Radiochemical separations may be made prior to counting but are usually not necessary.

Applicability: This method is applicable to the measurement of any gamma emitting radionuclide with gamma energies greater than 20 keV. It can be applied to complex mixtures of radionuclides. The samples counted may be in the form of particulate filters, absorbers, liquids or gases. The method may also be applied to the analysis of gaseous gamma emitting radionuclides directly in an effluent stream by passing the stream through a chamber or cell containing the detector. ASTM-3649(9), IDO-12096(18).

3.4.2 Method G-2, Low Resolution Gamma Spectrometry.

Principle: The sample is counted with a low resolution gamma detector, a thallium activated sodium iodide crystal. The detector is coupled to a photomultiplier tube and connected to a multichannel analyzer. The gamma emitting radionuclides in the sample are measured from the gamma count rates in the energy regions characteristic of the individual radionuclides. Corrections are made for counts contributed by other radionuclides to the spectral regions of the radionuclides of interest. Radiochemical separation may be used prior to counting to obtain less complex gamma spectra if needed.

Applicability: This method is applicable to the measurement of gamma emitting radionuclides with energies greater than 100 keV. It can be applied only to relatively simple mixtures of gamma emitting radionuclides. The samples counted may be in the form of particulate filters, absorbers, liquids or gas. The method can be applied to the analysis of gaseous radionuclides directly in an effluent stream by passing the gas stream through a chamber or cell containing the detector. ASTM-D-2459(12), EMSL-LV-0539-17(19).

3.4.3 Method G-3, Single Channel Gamma Spectrometry.

Principle: The sample is counted with a thallium activated sodium iodide crystal. The detector is coupled to a photomultiplier tube connected to a single channel analyzer. The activity of a gamma emitting radionuclide is determined from the gamma counts in the energy range for which the counter is set.

Applicability: This method is applicable to the measurement of a single gamma emitting radionuclide. It is not applicable to mixtures of radionuclides. The samples counted may be in the form of particulate filters, absorbers, liquids or gas. The method can be applied to the analysis of gaseous radionuclides directly in an effluent stream by passing the gas stream through a chamber or cell containing the detector.

3.4.4 Method G-4, Gross Gamma Counting.

Principle: The sample is counted with a gamma detector usually a thallium activated sodium iodine crystal. The detector is coupled to a photomultiplier tube and gamma rays above a specific threshold energy level are counted.

Applicability: Gross gamma measurements may be used to measure emissions of specific radionuclides only when it is known that the sample contains a single radionuclide or the identity and isotopic ratio of the radionuclides in the effluent stream are well known. When gross gamma measurements are used to determine emissions of specific radionuclides periodic measurements using Methods G-1 or G-2 should be made to demonstrate that the gross gamma measurements provide reliable emission data. This method may be applied to analysis of gaseous radionuclides directly in an effluent stream by placing the detector directly in or adjacent to the effluent stream or passing an extracted sample of the effluent stream through a chamber or cell containing the detector.

3.5 Counting Methods. All of the above methods with the exception of Method A-5 involve counting the radiation emitted by the radionuclide. Counting methods applicable to the measurement of alpha, beta and gamma radiations are listed below. The equipment needed and the counting principles involved are described in detail in ASTM-3648(8).

3.5.1 Alpha Counting:

• *Gas Flow Proportional Counters.* The alpha particles cause ionization in the counting gas and the resulting electrical pulses are counted. These counters may be windowless or have very thin windows.

• *Scintillation Counters.* The alpha particles transfer energy to a scintillator resulting in a production of light photons which strike a photomultiplier tube converting the light photons to electrical pulses which are counted. The counters may involve the use of solid scintillation materials such as zinc sulfide or liquid scintillation solutions.

• *Solid-State Counters.* Semiconductor materials, such as silicon surface-barrier p-n junctions, act as solid ionization chambers. The alpha particles interact which the detector producing electron hole pairs. The charged pair is collected by an applied electrical field and the resulting electrical pulses are counted.

• *Alpha Spectrometers.* Semiconductor detectors used in conjunction with multichannel analyzers for energy discrimination.

3.5.2 Beta Counting:

• *Ionization Chambers.* These chambers contain the beta-emitting nuclide in gaseous form. The ionization current produced is measured.

• *Geiger-Muller (GM) Counters-or Gas Flow Proportional Counters.* The beta particles cause ionization in the counting gas and the resulting electrical pulses are counted. Proportional gas flow counters which are heavily shielded by lead or other metal, and provided with an anti-coincidence shield to reject cosmic rays, are called low background beta counters.

• *Scintillation Counters.* The beta particles transfer energy to a scintillator resulting in a production of light photons, which strike a photomultiplier tube converting the light photon to electrical pulses which are counted. This may involve the use of anthracene crystals, plastic scintillator, or liquid scintillation solutions with organic phosphors.

• *Liquid Scintillation Spectrometers.* Liquid scintillation counters which use two photomultiplier tubes in coincidence to reduce background counts. This counter may also electronically discriminate among pulses of a given range of energy.

3.5.3 Gamma Counting:

• *Low-Resolution Gamma Spectrometers.* The gamma rays interact with thallium activated sodium iodide or cesium iodide crystal resulting in the release of light photons which strike a photomultiplier tube converting the light pulses to electrical pulses proportional to the energy of the gamma ray. Multi-channel analyzers are used to separate and store the pulses according to the energy absorbed in the crystal.

• *High-Resolution gamma Spectrometers.* Gamma rays interact with a lithium-drifted (Ge(Li)) or high-purity germanium (HPGe) semiconductor detectors resulting in a production of electron-hole pairs. The charged pair is collected by an applied electrical field. A very stable low noise preamplifier amplifies the pulses of electrical charge resulting from the gamma photon interactions. Multichannel analyzers or computers are used to separate and store the pulses according to the energy absorbed in the crystal.

• *Single Channel Analyzers.* Thallium activated sodium iodide crystals used with a single window analyzer. Pulses from the photomultiplier tubes are separated in a single predetermined energy range.

3.5.4 Calibration of Counters. Counters are calibrated for specific radionuclide measurements using a standard of the radionuclide under either identical or very similar conditions as the sample to be counted. For gamma spectrometers a series of standards covering the energy range of interest may be used to construct a calibration curve relating gamma energy to counting efficiency.

In those cases where a standard is not available for a radionuclide, counters may be calibrated using a standard with energy characteristics as similar as possible to the radionuclide to be measured. For gross alpha and beta measurements of the unidentified mixtures of radionuclides, alpha counters are calibrated with a natural uranium standard and beta counters with a cesium-137 standard. The standard must contain the same weight and distribution of solids as the samples, and be mounted in an identical manner. If the samples contain variable amounts of solids, calibration curves relating weight of solids present to counting efficiency are prepared. Standards other than those prescribed may be used provided it can be shown that such standards are more applicable to the radionuclide mixture measured.

3.6 Radiochemical Methods for Selected Radionuclides. Methods for a selected list of radionuclides are listed in Table 1. The radionuclides listed are those which are most commonly used and which have the greatest potential for causing doses to members of the public. For radionuclides not listed in Table 1, methods based on any of the applicable “principles of measurement” described in section 3.1 through 3.4 may be used.

3.7 Applicability of Gross Alpha and Beta Measurements to Unidentified Mixtures of Radionuclides. Gross alpha and beta measurements may be used as a screening measurement as a part of an emission measurement program to identify the need to do specific radionuclide analyses or to confirm or verify that unexpected radionuclides are not being released in significant quantities.

Gross alpha (Method A-4) or gross beta (Methods B-2 or B-4) measurements may also be used for the purpose of comparing the measured concentrations in the effluent stream with the limiting “Concentration Levels for Environmental Compliance” in table 2 of appendix E. For unidentified mixtures, the measured concentration value shall be compared with the lowest environmental concentration limit for any radionuclide which is not known to be absent from the effluent stream.

Expand Table

Table 1—List of Approved Methods for Specific Radionuclides

Radionuclide	Approved methods of analysis
Am-241	A-1, A-2, A-3, A-4
Ar-41	B-1, B-2, G-1, G-2, G-3, G-4
Ba-140	G-1, G-2, G-3, G-4
Br-82	G-1, G-2, G-3, G-4
C-11	B-1, B-2, G-1, G-2, G-3, G-4
C-14	B-5
Ca-45	B-3, B-4, B-5

Table 1—List of Approved Methods for Specific Radionuclides

Radionuclide	Approved methods of analysis
Ce-144	G-1, G-2, G-3, G-4
Cm-244	A-1, A-2, A-3, A-4
Co-60	G-1, G-2, G-3, G-4
Cr-51	G-1, G-2, G-3, G-4
Cs-134	G-1, G-2, G-3, G-4
Cs-137	G-1, G-2, G-3, G-4
Fe-55	B-5, G-1
Fe-59	G-1, G-2, G-3, G-4
Ga-67	G-1, G-2, G-3, G-4
H-3 (H_2O)	B-5
H-3 (gas)	B-1
I-123	G-1, G-2, G-3, G-4
I-125	G-1
I-131	G-1, G-2, G-3, G-4
In-113m	G-1, G-2, G-3, G-4
Ir-192	G-1, G-2, G-3, G-4
Kr-85	B-1, B-2, B-5, G-1, G-2, G-3, G-4

Table 1—List of Approved Methods for Specific Radionuclides

Radionuclide	Approved methods of analysis
Kr-87	B-1, B-2, G-1, G-2, G-3, G-4
Kr-88	B-1, B-2, G-1, G-2, G-3, G-4
Mn-54	G-1, G-2, G-3, G-4
Mo-99	G-1, G-2, G-3, G-4
N-13	B-1, B-2, G-1, G-2, G-3, G-4
O-15	B-1, B-2, G-1, G-2, G-3, G-4
P-32	B-3, B-4, B-5
Pm-147	B-3, B-4, B-5
Po-210	A-1, A-2, A-3, A-4
Pu-238	A-1, A-2, A-3, A-4
Pu-239	A-1, A-2, A-3, A-4
Pu-240	A-1, A-2, A-3, A-4
Ra-226	A-1, A-2, G-1, G-2
S-35	B-5
Se-75	G-1, G-2, G-3, G-4
Sr-90	B-3, B-4, B-5
Tc-99	B-3, B-4, B-5

Table 1—List of Approved Methods for Specific Radionuclides

Radionuclide	Approved methods of analysis
Te-201	G-1, G-2, G-3, G-4
Uranium (total alpha)	A-1, A-2, A-3, A-4
Uranium (Isotopic)	A-1, A-3
Uranium (Natural)	A-5
Xe-133	G-1
Yb-169	G-1, G-2, G-3, G-4
Zn-65	G-1, G-2, G-3, G-4

4. *Quality Assurance Methods*

Each facility required to measure their radionuclide emissions shall conduct a quality assurance program in conjunction with the radionuclide emission measurements. This program shall assure that the emission measurements are representative, and are of known precision and accuracy and shall include administrative controls to assure prompt response when emission measurements indicate unexpectedly large emissions. The program shall consist of a system of policies, organizational responsibilities, written procedures, data quality specifications, audits, corrective actions and reports. This quality assurance program shall include the following program elements:

4.1 The organizational structure, functional responsibilities, levels of authority and lines of communications for all activities related to the emissions measurement program shall be identified and documented.

4.2 Administrative controls shall be prescribed to ensure prompt response in the event that emission levels increase due to unplanned operations.

4.3 The sample collection and analysis procedures used in measuring the emissions shall be described including where applicable:

4.3.1 Identification of sampling sites and number of sampling points, including the rationale for site selections.

4.3.2 A description of sampling probes and representativeness of the samples.

4.3.3 A description of any continuous monitoring system used to measure emissions, including the sensitivity of the system, calibration procedures and frequency of calibration.

4.3.4 A description of the sample collection systems for each radionuclide measured, including frequency of collection, calibration procedures and frequency of calibration.

4.3.5 A description of the laboratory analysis procedures used for each radionuclide measured, including frequency of analysis, calibration procedures and frequency of calibration.

4.3.6 A description of the sample flow rate measurement systems or procedures, including calibration procedures and frequency of calibration.

4.3.7 A description of the effluent flow rate measurement procedures, including frequency of measurements, calibration procedures and frequency of calibration.

4.4 The objectives of the quality assurance program shall be documented and shall state the required precision, accuracy and completeness of the emission measurement data including a description of the procedures used to assess these parameters. Accuracy is the degree of agreement of a measurement with a true or known value. Precision is a measure of the agreement among individual measurements of the same parameters under similar conditions. Completeness is a measure of the amount of valid data obtained compared to the amount expected under normal conditions.

4.5 A quality control program shall be established to evaluate and track the quality of the emissions measurement data against preset criteria. The program should include where applicable a system of replicates, spiked samples, split samples, blanks and control charts. The number and frequency of such quality control checks shall be identified.

4.6 A sample tracking system shall be established to provide for positive identification of samples and data through all phases of the sample collection, analysis and reporting system. Sample handling and preservation procedures shall be established to maintain the integrity of samples during collection, storage and analysis.

4.7 Regular maintenance, calibration and field checks shall be performed for each sampling system in use by satisfying the requirements found in Table 2: Maintenance, Calibration and Field Check Requirements.

Expand Table

Table 2—Maintenance, Calibration and Field Check Requirements

Sampling system components	Frequency of activity
Cleaning of thermal anemometer elements	As required by application.
Inspect pitot tubes for contaminant deposits	At least annually.
Inspect pitot tube systems for leaks	At least annually.
Inspect sharp-edged nozzles for damage	At least annually or after maintenance that could cause damage.
Check nozzles for alignment, presence of deposits, or other potentially degrading factors	Annually.
Check transport lines of HEPA-filtered applications to determine if cleaning is required	Annually.

Table 2—Maintenance, Calibration and Field Check Requirements

Sampling system components	Frequency of activity
Clean transport lines	Visible deposits for HEPA-filtered applications. Mean mass of deposited material exceeds 1g/m^2 for other applications.
Inspect or test the sample transport system for leaks	At least annually.
Check mass flow meters of sampling systems with a secondary or transfer standard	At least quarterly.
Inspect rotameters of sampling systems for presence of foreign matter	At the start of each sampling period.
Check response of stack flow rate systems	At least quarterly.
Calibration of flow meters of sampling systems	At least annually.
Calibration of effluent flow measurement devices	At least annually.
Calibration of timing devices	At least annually.

4.8 Periodic internal and external audits shall be performed to monitor compliance with the quality assurance program. These audits shall be performed in accordance with written procedures and conducted by personnel who do not have responsibility for performing any of the operations being audited.

4.9 A corrective action program shall be established including criteria for when corrective action is needed, what corrective actions will be taken and who is responsible for taking the corrective action.

4.10 Periodic reports to responsible management shall be prepared on the performance of the emissions measurements program. These reports should include assessment of the quality of the data, results of audits and description of corrective actions.

4.11 The quality assurance program should be documented in a quality assurance project plan that should address each of the above requirements.

5. *References*

(1) American National Standards Institute “Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities”, ANSI-N13.1-1969, American National Standards Institute, New York, New York (1969).

(2) American Public Health Association, “Methods of Air Sampling”, 2nd Edition, Method 605, “Tentative Method of Analysis for Plutonium Content of Atmospheric Particulate Matter”. American Public Health Association, New York, NY (1977).

(3) Ibid, Method 601, “Tentative Method of Analysis for Gross Alpha Radioactivity Content of the Atmosphere”.

(4) Ibid, Method 602, “Tentative Method of the Analysis for Gross Beta Radioactivity Content of the Atmosphere”.

(5) Ibid, Method 608, “Tentative Method of Analysis for Strontium-90 Content of Atmospheric Particulate Matter”.

(6) Ibid, Method 609, “Tentative Method of Analysis for Tritium Content of the Atmosphere”.

(7) Ibid, Method 603, “Tentative Method of Analysis for Iodine-131 Content of the Atmosphere”.

(8) American Society for Testing and Materials, 1986 Annual Book ASTM Standards, Designation D-3648-78, “Standard Practices for the Measurement of Radioactivity”. American Society for Testing and Materials, Philadelphia, PA (1986).

(9) Ibid, Designation D-3649-85, “Standard Practice for High Resolution Gamma Spectrometry”.

(10) Ibid, Designation D-1943-81, “Standard Test Method for Alpha Particle Radioactivity of Water”.

(11) Ibid, Designation D-1890-81, “Standard Test Method for Beta Particle Radioactivity of Water”.

(12) Ibid, Designation D-2459-72, “Standard Test Method for Gamma Spectrometry of Water”.

(13) Ibid, Designation D-3972-82, “Standard Test Method for Isotopic Uranium in Water by Radiochemistry”.

(14) Ibid, Designation D-2907-83, “Standard Test Methods for Microquantities of Uranium in Water by Fluorometry”.

(15) Ibid, Designation E-318, “Standard Test Method for Uranium in Aqueous Solutions by Colorimetry”.

(16) Ibid, Designation D-3084-75, “Standard Practice for Alpha Spectrometry of Water”.

(17) Corley, J.P. and C.D. Corbit, “A Guide for Effluent Radiological Measurements at DOE Installations”, DOE/EP-0096, Pacific Northwest Laboratories, Richland, Washington (1983).

(18) Department of Energy, “RESL Analytical Chemistry Branch Procedures Manual”, IDO-12096, U.S. Department of Energy, Idaho Falls, Idaho (1982).

(19) Environmental Protection Agency, “Radiochemical Analytical Procedures for Analysis of Environmental Samples”, EMSL-LV-0539-17, U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Las Vegas, Nevada (1979).

(20) Environmental Protection Agency, “Radiochemistry Procedures Manual”, EPA 520/5-84-006, Eastern Environmental Radiation Facility, Montgomery, Alabama (1984).

(21) National Council on Radiation Protection and Measurements, NCRP Report No. 50, “Environmental Radiation Measurements”, National Council on Radiation Protection and Measurement, Bethesda, Maryland (1976).

(22) Ibid, Report No. 47, “Tritium Measurement Techniques”. (1976).

(23) Ibid, Report No. 58 “A Handbook of Radioactivity Measurement Procedures” (1985).

(24) Environmental Protection Agency, “Indoor Radon and Radon Decay Product Measurement Protocols”, EPA 520/1-89-009, U.S. Environmental Protection Agency, Washington, DC (1989).