Monitoring Results
Natural Gas Wells
Near Project Rulison
Third Quarter 2013

U.S. Department of Energy Office of Legacy Management
Grand Junction, Colorado

Date Sampled: June 12, 2013

Background:

Project Rulison was the second Plowshare Program test to stimulate natural-gas recovery from deep and low permeability formations. On September 10, 1969, a 40-kiloton-yield nuclear device was detonated 8,426 feet (1.6 miles) below the ground surface in the Williams Fork Formation at what is now the Rulison, Colorado, Site. Following the detonation, a series of production tests were conducted. Afterwards, the site was shut down, then remediated and the emplacement well (R-E) and reentry well (R-Ex) plugged.

Purpose:

As part of the U.S. Department of Energy (DOE) Office of Legacy Management (LM) mission to protect human health and the environment, LM will monitor natural gas wells that are near the Rulison site for radionuclides associated with the detonation. While the very low permeability of Williams Fork Formation limits migration, institutional-control restrictions limit subsurface access in the detonation zone. Oversight is permitted for wells within 3 miles of the site, which allows the State of Colorado and DOE to review drilling permits and gas-well development practices to help protect human health and the environment from the Rulison-related contaminates. The DOE *Rulison Monitoring Plan* (LMS/RUL/S06178) provides guidance for sample collection frequency, based on distance from the Rulison detonation point, the types of analyses, and the reporting thresholds.

Summary of Results:

Of the 13 wells sampled for gas and water, no analytical result exceeded the screening levels specified in the DOE *Rulison Monitoring Plan*. The gas- and liquid-phase levels are reproduced in Table 3a and Table 3b, respectively.

During the third-quarter sampling event conducted on June 12, 2013, 12 gas samples and 11 produced-water samples plus one duplicate sample from well BM 26-34B were collected from 13 gas wells identified in the third-quarter sample plan. One of the wells on Pad 26N and one well on Pad 26K produced no water during the collection activities.

Two wells on Pad 26N produced approximately 250 ml of production water, which was enough sample volume for only tritium analysis. The 13 wells are listed in Table 1. Sample collection information is listed in Table 2, ordered by sample collection sequence.

Table 1. Sample Collection Locations

Pad	Collection Location	Well Name
26N	Well head separator	Battlement Mesa (BM) 26-33B, -33C, -33D, BM 26-34A, 34B, -34C-34D
26K	Well head separator	BM 26-22B, -22C, -22D
35C	Well head separator	BM 35-32A
36L	Well head separator	BM 36-13B
36B	Well head separator	BM 36-13

Samples Collected

Seq.	Pad	Well Name	Location			Sample Phase		Well	
			API # 05-045-	Type	Subtype	Gas	Liquid	T (^{o}F)	P (psi)
1	26K	BM 26-22B	16086	WL	NGSA	Yes	No	56.7	256
2	26K	BM 26-22C	16087	WL	NGSA	Yes	Yes	59.7	280
3	26K	BM 26-22D	16074	WL	NGSA	Yes	Yes	62.3	277
4	26N	BM 26-33B	15743	WL	NGSA	Yes	Yes	57.2	256
5	26N	BM 26-33C	15742	WL	NGSA	Yes	Yes	56	275
6	26N	BM 26-33D	15739	WL	NGSA	Yes	Yes*	61.5	274
7	26N	BM 26-34A	15744	WL	NGSA	Yes	No	59.5	275
8	26N	BM 26-34B	15745	WL	NGSA	Yes	Yes	57.9	276
9	26N	BM 26-34C	15741	WL	NGSA	Yes	Yes*	59	265
10	26N	BM 26-34D	15748	WL	NGSA	Yes	Yes	61	260
11	35C	BM 35-32A	10919	WL	NGSV	Yes	Yes	54.2	257
12	36L	BM 36-13B	15469	WL	NGSV	No	Yes	65.7	287
13	36B	BM 36-13	10840	WL	NGSV	Yes	Yes	88	275

Abbreviations:
API American Petroleum Institute
BM Battlement Mesa
NGSA Natural gas well–angle
NGSV Natural gas well–vertical
P (psi) pressure in pounds per square inch
Seq. sampling sequence
T (^{o}F) temperature in degrees Fahrenheit
WL well
* Approximately 250 ml of production water
Note: No gas sample was collected at well BM 36-13B, defective gas collection container

Sample Locations:

The bottom-hole locations of the 10 gas wells planned for sample collection are between 0.75 and 1.07 miles from the Project Rulison detonation point. All gas wells sampled are producing gas from the Williams Fork Formation at a depth near the Rulison detonation point.

Sample Collection:

A produced-water sample is collected at the well head from a tap on the common line connecting two gas-liquid separators and the accumulation tank. The produced water collected from one well separator is isolated from the other well separator by valves. Lines from each of the two separators are purged of produced water and condensate prior to sample collection. Each sample is collected in a new 1-gallon plastic container.

A gas sample is collected from a tap on the gas line at the separator output. The line between the tap and the sample bottle is purged before sample collection. Each gas sample is collected in an evacuated 18-liter bottle furnished by the laboratory.

Monitoring Protocol:

The *Rulison Monitoring Plan* provides guidance regarding the type and frequency of sample collection as a function of distance and heading from the Rulison detonation point; it also specifies the types of analyses. A copy of the monitoring plan is available at http://www.lm.doe.gov/Rulison/Documents.aspx.

Table 3a. Gas-Phase Concentrations for Tritium Sample Results

Analyte	Reporting Units	Screening Concentration	Action Concentration	Comment
Tritium	TU	19,293	TBD	5.183×10^{-6} pCi/cc/TU

Abbreviations:
pCi/cc/TU picocuries per cubic centimeter of methane gas per tritium unit
TBD to be determined
TU tritium unit

Table 3b. Liquid-Phase Concentrations for Tritium and Various Analytical Method Results

Analyte	Reporting Units	Screening Concentration	Action Concentration	Comment
Tritium	pCi/L	800	TBD	20,000 pCi/L = EPA drinking water standard
Lab Method				
Gross alpha	pCi/L	3 × background	TBD	
Gross beta	pCi/L	3 × background	TBD	
High-resolution gamma spectrometry	pCi/L	20	TBD	Based on cesium-137

Abbreviations:
EPA U.S. Environmental Protection Agency
pCi/L picocuries per liter of water
TBD to be determined

Notes:
See the *Rulison Monitoring Plan,* Table 2, for response scenarios to use when the screening and/or action concentrations are exceeded.
The derived air effluent concentration for a 50 millirem per year (mrem/year) dose from tritium exposure is 0.10 pCi (tritium)/cc (methane).

Results:

Twelve gas samples were collected from 13 producing gas wells that were sampled. At well BM 36-13B, no gas sample was collected because of a defective gas container. At two locations, BM 26-22B and BM 26 26-34, no production water was collected during sampling activities. At wells BM 26-33D and BM 26- 34C, approximately 250 ml were collected, which was enough sample volume for only tritium analysis.

Gas and water analytic results are tabulated by well in Appendix A and Appendix B, respectively.

Laboratory Qualifiers:

A "detect" is a result greater than the laboratory's reporting threshold or minimum detectable concentration (MDC).

A "non-detect" is a result that is less than the laboratory's MDC for that sample. The laboratory assigns the qualifier "U" to a "non-detect" result.

Data Validation Qualifiers:

A "detect" result less than 3 times the sample MDC is assigned the data validation qualifier "J."

A laboratory "detect" result less than three times the one-sigma total propagated uncertainty is considered a "non-detect." Data validation assigns qualifier "U" to this result.

Results Summaries:

Results for gas- and liquid-phase tritium are summarized in Table 4a. Liquid-phase results for gross alpha/beta are summarized in Table 4b, and potassium-40 results are in Table 4c. Sample volumes not adequate for laboratory analysis are counted as not applicable (NA).

Table 4a. Summary of Tritium Samples, Based on Laboratory-Assigned Qualifiers

Collection Location	Total Samples (gas/liquid)	Tritium Results (gas phase)			Tritium Results (liquid phase)		
		Detect	Non-Detect	NA	Detect	Non-Detect	NA
Natural gas wells	12/11	0	12	1	0	12	2

Abbreviation:
NA Missing or not applicable, no production water was collected at wells BM 26-22B and BM 26-34A

No gas sample was collected at well BM 36-13B because of a defective gas collection container. Two wells, BM 26-33D and BM26- 34C, produced approximately 250 ml of production water, enough for only tritium analysis.
A duplicate sample was collected at well BM 26-34B.
Data validation assigned "J" to the gas detect result.

Table 4b. Summary of Gross Alpha/Beta Liquid-Phase Samples, Based on Laboratory-Assigned Qualifiers

Collection Location	Total Liquid Samples	Gross Alpha Results			Gross Beta Results		
		Detect	Non-Detect	NA	Detect	Non-Detect	NA
Natural gas wells	12	6	4	4	10	0	4

Abbreviation:
NA Missing or not applicable
Data validation assigned "J" to five of the six gross-alpha "detect" results
Data validation assigned "J" to five of the 10 gross-beta "detect" results
NA was assigned to four samples because production water was collected from wells BM 26-22B and BM 26-34A or an insufficient amount of water was collected for analysis of all contaminants at wells BM 26-33D and BM 26-34C
A duplicate sample was collected at well BM 26-34B

Table 4c. Summary of Potassium-40 Liquid-Phase Samples, Based on Laboratory-Assigned Qualifiers

Collection Location	Total Samples	Potassium-40 Results		
		Detect	Non-Detect	NA
Natural gas wells	12	7	3	4

Abbreviation:
NA Sample not collected or sample volume insufficient for analysis

Data validation assigned a "J" qualifier to two of the seven potassium-40 detect results.
A duplicate sample was collected at well BM 26-34B.
NA was assigned to four samples because no production water was collected from wells BM 26-22B and BM 26-34A or an insufficient amount of production water was collected for analysis of all contaminants at wells BM 26-33D and BM 26-34C.

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General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 09/11/2013

Location: 05-045-10840 WELL BM 36-13

Parameter	Units	Sample ID	Date	Result	Qualifiers Data	Qualifiers QA	Lab	Detection Limit	Uncertainty
Actinium-228	pCi/L	06/12/2013	N001	40.7	U		#	49	23.8
Americium-241	pCi/L	06/12/2013	N001	24.3	U		#	85	51.2
Antimony-125	pCi/L	06/12/2013	N001	13.2	U		#	22	12.9
Cerium-144	pCi/L	06/12/2013	N001	19	U		#	39	24
Cesium-134	pCi/L	06/12/2013	N001	1.98	U		#	7.8	3.58
Cesium-137	pCi/L	06/12/2013	N001	-3.44	U		#	9.8	5.41
Chloride	mg/L	06/12/2013	N001	11000			#	200	
Cobalt-60	pCi/L	06/12/2013	N001	-6.47	U		#	11	5.29
Europium-152	pCi/L	06/12/2013	N001	-1.5	U		#	45	24.6
Europium-154	pCi/L	06/12/2013	N001	-8.03	U		#	53	29.3
Europium-155	pCi/L	06/12/2013	N001	6.92	U		#	25	14.9
Gross Alpha	pCi/L	06/12/2013	N001	23.9	U		#	45	27.9
Gross Beta	pCi/L	06/12/2013	N001	220			#	52	49.5
Lead-212	pCi/L	06/12/2013	N001	11.2	U		#	12	7.88
Potassium-40	pCi/L	06/12/2013	N001	69.6	U		#	200	118
Promethium-144	pCi/L	06/12/2013	N001	0.738	U		#	8.5	4.92
Promethium-146	pCi/L	06/12/2013	N001	5.59	U		#	9.4	5.85
Ruthenium-106	pCi/L	06/12/2013	N001	0	U		#	79	45.4
Thorium-234	pCi/L	06/12/2013	N001	61.4	U		#	130	78.2
Tritium	pCi/L	06/12/2013	N001	-30.4	U		#	320	190
Uranium-235	pCi/L	06/12/2013	N001	-6.3	U		#	48	27.8
Yttrium-88	pCi/L	06/12/2013	N001	6.34	U		#	9.3	5.84

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 09/11/2013

Location: 05-045-10919 WELL BM 35-32A

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	06/12/2013	N001	18.7	U		#	24	15.6
Americium-241	pCi/L	06/12/2013	N001	-21.8	U		#	40	22.2
Antimony-125	pCi/L	06/12/2013	N001	0.151	U		#	18	10.1
Cerium-144	pCi/L	06/12/2013	N001	-8.98	U		#	31	17.8
Cesium-134	pCi/L	06/12/2013	N001	-3.68	U		#	7.6	4.21
Cesium-137	pCi/L	06/12/2013	N001	0.3	U		#	7.4	4.31
Chloride	mg/L	06/12/2013	N001	9700			#	200	
Cobalt-60	pCi/L	06/12/2013	N001	-0.672	U		#	8	4.41
Europium-152	pCi/L	06/12/2013	N001	4.19	U		#	15	8.23
Europium-154	pCi/L	06/12/2013	N001	0.991	U		#	40	22.5
Europium-155	pCi/L	06/12/2013	N001	-0.844	U		#	18	10.7
Gross Alpha	pCi/L	06/12/2013	N001	38.5		J	#	38	25.2
Gross Beta	pCi/L	06/12/2013	N001	209			#	42	43.7
Lead-212	pCi/L	06/12/2013	N001	-1.32	U		#	14	8.01
Potassium-40	pCi/L	06/12/2013	N001	218		J	#	130	91.3
Promethium-144	pCi/L	06/12/2013	N001	-3.41	U		#	7.9	4.39
Promethium-146	pCi/L	06/12/2013	N001	0.437	U		#	8.1	4.71
Ruthenium-106	pCi/L	06/12/2013	N001	-42.7	U		#	72	39.6
Thorium-234	pCi/L	06/12/2013	N001	1.1	U		#	140	84.6
Tritium	pCi/L	06/12/2013	N001	-27.5	U		#	320	189
Uranium-235	pCi/L	06/12/2013	N001	-10.5	U		#	31	17.6
Yttrium-88	pCi/L	06/12/2013	N001	1.68	U		#	12	7.4

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 09/11/2013

Location: 05-045-15469 WELL BM 36-13B

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	06/12/2013	N001	26.6	TI	U	#	26	17.2
Americium-241	pCi/L	06/12/2013	N001	-11.9	U		#	47	27.4
Antimony-125	pCi/L	06/12/2013	N001	3.92	U		#	22	13.2
Cerium-144	pCi/L	06/12/2013	N001	3.23	U		#	35	20.8
Cesium-134	pCi/L	06/12/2013	N001	-0.838	U		#	9.7	5.63
Cesium-137	pCi/L	06/12/2013	N001	2.58	U		#	8.8	5.23
Chloride	mg/L	06/12/2013	N001	11000			#	200	
Cobalt-60	pCi/L	06/12/2013	N001	1.87	U		#	10	6.06
Europium-152	pCi/L	06/12/2013	N001	3.99	U		#	52	30
Europium-154	pCi/L	06/12/2013	N001	8.14	U		#	53	31
Europium-155	pCi/L	06/12/2013	N001	-2.27	U		#	20	11.5
Gross Alpha	pCi/L	06/12/2013	N001	141			#	44	40.5
Gross Beta	pCi/L	06/12/2013	N001	227			#	52	50.4
Lead-212	pCi/L	06/12/2013	N001	13.6	U		#	18	11
Potassium-40	pCi/L	06/12/2013	N001	96.5	U		#	160	101
Promethium-144	pCi/L	06/12/2013	N001	0.94	U		#	9.4	5.49
Promethium-146	pCi/L	06/12/2013	N001	1.29	U		#	10	5.98
Ruthenium-106	pCi/L	06/12/2013	N001	11.5	U		#	81	47.5
Thorium-234	pCi/L	06/12/2013	N001	-15.4	U		#	170	100
Tritium	pCi/L	06/12/2013	N001	-110	U		#	310	182
Uranium-235	pCi/L	06/12/2013	N001	23.2	U		#	34	20.9
Yttrium-88	pCi/L	06/12/2013	N001	3.65	U		#	9.9	5.98

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 09/11/2013
Location: 05-045-15739 WELL BM 26-33D

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Chloride	mg/L	06/12/2013	N001	16000			#	200	
Tritium	pCi/L	06/12/2013	N001	-269	U		#	370	214

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 09/11/2013
Location: 05-045-15741 WELL BM 26-34C

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Chloride	mg/L	06/12/2013	N001	12000			#	200	
Tritium	pCi/L	06/12/2013	N001	8.26	U		#	320	192

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 09/11/2013

Location: 05-045-15742 WELL BM 26-33C

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	06/12/2013	N001	12.2	U		#	46	27.7
Americium-241	pCi/L	06/12/2013	N001	-26.4	U		#	43	24.6
Antimony-125	pCi/L	06/12/2013	N001	1.7	U		#	16	9.64
Cerium-144	pCi/L	06/12/2013	N001	2.52	U		#	33	19.7
Cesium-134	pCi/L	06/12/2013	N001	-2.98	U		#	10	5.74
Cesium-137	pCi/L	06/12/2013	N001	-0.612	U		#	7.2	4.12
Chloride	mg/L	06/12/2013	N001	12000			#	200	
Cobalt-60	pCi/L	06/12/2013	N001	2.2	U		#	8.1	4.77
Europium-152	pCi/L	06/12/2013	N001	5.95	U		#	37	21.5
Europium-154	pCi/L	06/12/2013	N001	0.83	U		#	40	23.3
Europium-155	pCi/L	06/12/2013	N001	1.92	U		#	17	10.2
Gross Alpha	pCi/L	06/12/2013	N001	56.9		J	#	44	30.5
Gross Beta	pCi/L	06/12/2013	N001	208			#	55	49.1
Lead-212	pCi/L	06/12/2013	N001	7.06	U		#	12	7.68
Potassium-40	pCi/L	06/12/2013	N001	99.1	U		#	150	94.2
Promethium-144	pCi/L	06/12/2013	N001	-4.56	U		#	7.5	4.16
Promethium-146	pCi/L	06/12/2013	N001	-0.55	U		#	8.3	4.81
Ruthenium-106	pCi/L	06/12/2013	N001	9.15	U		#	62	36.7
Thorium-234	pCi/L	06/12/2013	N001	34.6	U		#	150	92.8
Tritium	pCi/L	06/12/2013	N001	18.3	U		#	320	190
Uranium-235	pCi/L	06/12/2013	N001	26	U		#	31	19.6
Yttrium-88	pCi/L	06/12/2013	N001	3.32	U		#	8	4.86

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 09/11/2013

Location: 05-045-15743 WELL BM 26-33B

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	06/12/2013	N001	13.3	U		#	36	21.6
Americium-241	pCi/L	06/12/2013	N001	-12.9	U		#	46	26.6
Antimony-125	pCi/L	06/12/2013	N001	2.53	U		#	23	13.4
Cerium-144	pCi/L	06/12/2013	N001	10.8	U		#	35	20.9
Cesium-134	pCi/L	06/12/2013	N001	-0.466	U		#	9.5	5.49
Cesium-137	pCi/L	06/12/2013	N001	1.53	U		#	9.3	5.43
Chloride	mg/L	06/12/2013	N001	6400			#	200	
Cobalt-60	pCi/L	06/12/2013	N001	-2.42	U		#	12	6.39
Europium-152	pCi/L	06/12/2013	N001	54.7	NQ	U	#	40	29.3
Europium-154	pCi/L	06/12/2013	N001	11.6	U		#	53	30.9
Europium-155	pCi/L	06/12/2013	N001	-0.253	U		#	20	11.7
Gross Alpha	pCi/L	06/12/2013	N001	36.7		J	#	24	17.4
Gross Beta	pCi/L	06/12/2013	N001	61.4		J	#	22	17.3
Lead-212	pCi/L	06/12/2013	N001	3.25	U		#	18	11
Potassium-40	pCi/L	06/12/2013	N001	48.8	U		#	190	115
Promethium-144	pCi/L	06/12/2013	N001	1.04	U		#	9.7	5.7
Promethium-146	pCi/L	06/12/2013	N001	-5.78	U		#	11	5.81
Ruthenium-106	pCi/L	06/12/2013	N001	-38.2	U		#	93	51.6
Thorium-234	pCi/L	06/12/2013	N001	16	U		#	170	98.2
Tritium	pCi/L	06/12/2013	N001	-22.1	U		#	310	184
Uranium-235	pCi/L	06/12/2013	N001	-3.16	U		#	38	22.1
Yttrium-88	pCi/L	06/12/2013	N001	0.238	U		#	11	6.51

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 09/11/2013

Location: 05-045-15745 WELL BM 26-34B

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	06/12/2013	N001	22.5	U		#	39	20.7
Actinium-228	pCi/L	06/12/2013	N002	9.23	U		#	48	28.3
Americium-241	pCi/L	06/12/2013	N001	4.26	U		#	8.6	5.24
Americium-241	pCi/L	06/12/2013	N002	-16.3	U		#	45	25.3
Antimony-125	pCi/L	06/12/2013	N001	5.06	U		#	16	9.74
Antimony-125	pCi/L	06/12/2013	N002	7.53	U		#	16	9.78
Cerium-144	pCi/L	06/12/2013	N001	-2.78	U		#	30	17.5
Cerium-144	pCi/L	06/12/2013	N002	-0.971	U		#	32	18.5
Cesium-134	pCi/L	06/12/2013	N001	-1.75	U		#	7.7	4.35
Cesium-134	pCi/L	06/12/2013	N002	-5.14	U		#	8.4	4.62
Cesium-137	pCi/L	06/12/2013	N001	-1.55	U		#	7.6	4.26
Cesium-137	pCi/L	06/12/2013	N002	-1.23	U		#	7.8	4.38
Chloride	mg/L	06/12/2013	N001	12000			#	200	
Chloride	mg/L	06/12/2013	N002	12000			#	200	
Cobalt-60	pCi/L	06/12/2013	N001	0.543	U		#	5.4	2.77
Cobalt-60	pCi/L	06/12/2013	N002	-3.13	U		#	9.7	5.22
Europium-152	pCi/L	06/12/2013	N001	-3.76	U		#	44	24.5
Europium-152	pCi/L	06/12/2013	N002	8.21	U		#	41	24
Europium-154	pCi/L	06/12/2013	N001	9.65	U		#	40	23.6
Europium-154	pCi/L	06/12/2013	N002	-4.12	U		#	41	22.8
Europium-155	pCi/L	06/12/2013	N001	3.57	U		#	12	7.18
Europium-155	pCi/L	06/12/2013	N002	-0.675	U		#	18	10.6
Gross Alpha	pCi/L	06/12/2013	N001	16	U		#	52	30.9
Gross Alpha	pCi/L	06/12/2013	N002	85.3		J	#	38	30.8
Gross Beta	pCi/L	06/12/2013	N001	95.1		J	#	54	37.1

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 09/11/2013

Location: 05-045-15745 WELL BM 26-34B

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Gross Beta	pCi/L	06/12/2013	N002	101		J	#	52	36.9
Lead-212	pCi/L	06/12/2013	N001	1.66	U		#	15	9.12
Lead-212	pCi/L	06/12/2013	N002	-0.686	U		#	14	8.52
Potassium-40	pCi/L	06/12/2013	N001	122	U		#	150	94.4
Potassium-40	pCi/L	06/12/2013	N002	47	U		#	140	86.9
Promethium-144	pCi/L	06/12/2013	N001	3.29	U		#	8.2	4.95
Promethium-144	pCi/L	06/12/2013	N002	0.492	U		#	8.2	4.76
Promethium-146	pCi/L	06/12/2013	N001	1.72	U		#	7.5	4.42
Promethium-146	pCi/L	06/12/2013	N002	-0.1	U		#	7.7	4.39
Ruthenium-106	pCi/L	06/12/2013	N001	-12.9	U		#	67	37.8
Ruthenium-106	pCi/L	06/12/2013	N002	-6.25	U		#	72	40.8
Thorium-234	pCi/L	06/12/2013	N001	9.61	U		#	96	47
Thorium-234	pCi/L	06/12/2013	N002	-3.13	U		#	140	84.2
Tritium	pCi/L	06/12/2013	N001	19.8	U		#	300	178
Tritium	pCi/L	06/12/2013	N002	99.2	U		#	310	186
Uranium-235	pCi/L	06/12/2013	N001	-13.3	U		#	44	25.8
Uranium-235	pCi/L	06/12/2013	N002	3.93	U		#	39	23.1
Yttrium-88	pCi/L	06/12/2013	N001	3.16	U		#	8.1	4.89
Yttrium-88	pCi/L	06/12/2013	N002	-2.24	U		#	8.7	4.77

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 09/11/2013

Location: 05-045-15748 WELL BM 26-34D

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	06/12/2013	N001	10.2	U		#	44	26.6
Americium-241	pCi/L	06/12/2013	N001	1.65	U		#	41	23.7
Antimony-125	pCi/L	06/12/2013	N001	0.937	U		#	16	8.61
Cerium-144	pCi/L	06/12/2013	N001	-18.9	U		#	32	17.8
Cesium-134	pCi/L	06/12/2013	N001	-0.439	U		#	7.8	4.5
Cesium-137	pCi/L	06/12/2013	N001	-2.29	U		#	7.4	4.16
Chloride	mg/L	06/12/2013	N001	13000			#	200	
Cobalt-60	pCi/L	06/12/2013	N001	-2.54	U		#	8.7	4.71
Europium-152	pCi/L	06/12/2013	N001	3.86	U		#	39	22.6
Europium-154	pCi/L	06/12/2013	N001	-19.6	U		#	44	24.1
Europium-155	pCi/L	06/12/2013	N001	-6.2	U		#	18	10.6
Gross Alpha	pCi/L	06/12/2013	N001	33.2	U		#	56	34.7
Gross Beta	pCi/L	06/12/2013	N001	174		J	#	68	52.1
Lead-212	pCi/L	06/12/2013	N001	8.91	U		#	14	8.71
Potassium-40	pCi/L	06/12/2013	N001	18.2	U		#	150	89
Promethium-144	pCi/L	06/12/2013	N001	-2.1	U		#	8.2	4.67
Promethium-146	pCi/L	06/12/2013	N001	-0.384	U		#	6.9	3.98
Ruthenium-106	pCi/L	06/12/2013	N001	-9.88	U		#	69	39.5
Thorium-234	pCi/L	06/12/2013	N001	64	U		#	150	80.1
Tritium	pCi/L	06/12/2013	N001	-148	U		#	310	180
Uranium-235	pCi/L	06/12/2013	N001	2.2	U		#	30	17.5
Yttrium-88	pCi/L	06/12/2013	N001	2.92	U		#	7.1	4.29

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 09/11/2013

Location: 05-045-16074 WELL BM 26-22D

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Americium-241	pCi/L	06/12/2013	N001	0 - 0	13.4	U		#	81	48
Antimony-125	pCi/L	06/12/2013	N001	0 - 0	-0.612	U		#	23	13.3
Cerium-144	pCi/L	06/12/2013	N001	0 - 0	-8.47	U		#	56	32.8
Cesium-134	pCi/L	06/12/2013	N001	0 - 0	5.29	U		#	8	5.01
Cesium-137	pCi/L	06/12/2013	N001	0 - 0	-0.203	U		#	9	5.14
Chloride	mg/L	06/12/2013	N001	0 - 0	13000			#	200	
Cobalt-60	pCi/L	06/12/2013	N001	0 - 0	-0.176	U		#	9.2	5.1
Europium-152	pCi/L	06/12/2013	N001	0 - 0	36	U		#	36	24.7
Europium-154	pCi/L	06/12/2013	N001	0 - 0	-21.4	U		#	54	28.6
Europium-155	pCi/L	06/12/2013	N001	0 - 0	3.73	U		#	25	14.8
Gross Alpha	pCi/L	06/12/2013	N001	0 - 0	69.1		J	#	62	41.4
Gross Beta	pCi/L	06/12/2013	N001	0 - 0	231			#	72	59.5
Lead-212	pCi/L	06/12/2013	N001	0 - 0	9.82	U		#	20	11.9
Potassium-40	pCi/L	06/12/2013	N001	0 - 0	131	U		#	200	125
Promethium-144	pCi/L	06/12/2013	N001	0 - 0	2.2	U		#	9	5.32
Promethium-146	pCi/L	06/12/2013	N001	0 - 0	-4.22	U		#	14	7.97
Ruthenium-106	pCi/L	06/12/2013	N001	0 - 0	-18.6	U		#	87	48.7
Thorium-234	pCi/L	06/12/2013	N001	0 - 0	69.8	U		#	190	116
Tritium	pCi/L	06/12/2013	N001	0 - 0	-28.4	U		#	300	176
Uranium-235	pCi/L	06/12/2013	N001	0 - 0	0.094	U		#	40	23.5
Yttrium-88	pCi/L	06/12/2013	N001	0 - 0	4.1	U		#	11	6.56

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site

REPORT DATE: 09/11/2013

Location: 05-045-16087 WELL BM 26-22C

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	06/12/2013	N001	25.9	U		#	28	18.5
Americium-241	pCi/L	06/12/2013	N001	13	U		#	46	27.5
Antimony-125	pCi/L	06/12/2013	N001	-3.74	U		#	24	14.1
Cerium-144	pCi/L	06/12/2013	N001	-4.46	U		#	35	20.3
Cesium-134	pCi/L	06/12/2013	N001	1.08	U		#	9.7	5.72
Cesium-137	pCi/L	06/12/2013	N001	-1.72	U		#	10	5.63
Chloride	mg/L	06/12/2013	N001	11000			#	200	
Cobalt-60	pCi/L	06/12/2013	N001	-3.02	U		#	12	6.33
Europium-152	pCi/L	06/12/2013	N001	8.5	U		#	51	29.4
Europium-154	pCi/L	06/12/2013	N001	-10.3	U		#	54	29.7
Europium-155	pCi/L	06/12/2013	N001	0.252	U		#	20	12
Gross Alpha	pCi/L	06/12/2013	N001	38.9	U		#	44	28.3
Gross Beta	pCi/L	06/12/2013	N001	204			#	50	46.5
Lead-212	pCi/L	06/12/2013	N001	12.2	U		#	18	10.8
Potassium-40	pCi/L	06/12/2013	N001	46.7	U		#	190	116
Promethium-144	pCi/L	06/12/2013	N001	-2.25	U		#	10	5.72
Promethium-146	pCi/L	06/12/2013	N001	-2.08	U		#	11	6.33
Ruthenium-106	pCi/L	06/12/2013	N001	-12.7	U		#	87	49.6
Thorium-234	pCi/L	06/12/2013	N001	-104	U		#	180	103
Tritium	pCi/L	06/12/2013	N001	-76.6	U		#	320	187
Uranium-235	pCi/L	06/12/2013	N001	8.86	U		#	44	26.4
Yttrium-88	pCi/L	06/12/2013	N001	3.99	U		#	11	6.44

SAMPLE ID CODES: 000X = Filtered sample (0.45 µm). N00X = Unfiltered sample. X = replicate number.

LAB QUALIFIERS:

*	Replicate analysis not within control limits.
>	Result above upper detection limit.
A	TIC is a suspected aldol-condensation product.
B	Inorganic: Result is between the IDL and CRDL. Organic: Analyte also found in method blank.
C	Pesticide result confirmed by GC-MS.
D	Analyte determined in diluted sample.
E	Inorganic: Estimate value because of interference, see case narrative. Organic: Analyte exceeded calibration range of the GC-MS.
H	Holding time expired, value suspect.
I	Increased detection limit due to required dilution.
J	Estimated.
N	Inorganic or radiochemical: Spike sample recovery not within control limits. Organic: Tentatively identified compound (TIC).
P	> 25% difference in detected pesticide or Aroclor concentrations between 2 columns.
U	Analytical result below detection limit.
W	Postdigestion spike outside control limits while sample absorbance < 50% of analytical spike absorbance.
X, Y, Z	Laboratory-defined qualifier, see case narrative.

DATA QUALIFIERS:

F	Low-flow sampling method used.	G	Possible grout contamination, pH > 9.	J	Estimated value.
L	Less than 3 bore volumes purged prior to sampling.	Q	Qualitative result due to sampling technique.	R	Unusable result.
U	Parameter analyzed for but was not detected.	X	Location is undefined.		

QA QUALIFIER:

#	Validated according to quality assurance guidelines.

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Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 09/16/2013
Location: 05-045-10840 WELL, Natural Gas Well - Angle, BM 36-13

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)			Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	06/12/2013	0001	LHV 796	1682.5	-	-79.5	NATURAL GAS - DRY	0.2	U		#	0.2	
Tritium	pCi/L	06/12/2013	0001	LHV 796	1682.5	-	-79.5	NATURAL GAS - DRY	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 09/16/2013
Location: 05-045-10919 WELL, Natural Gas Well - Angle, BM 35-32A

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)			Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	06/12/2013	0001	LHV 795	1240	-	-982.9	NATURAL GAS - DRY	0.2	U		#	0.2	
Tritium	pCi/L	06/12/2013	0001	LHV 795	1240	-	-982.9	NATURAL GAS - DRY	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 09/16/2013
Location: 05-045-15739 WELL, Natural Gas Well - Angle, BM 26-33D

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	06/12/2013	0001	LHV 790	-	NATURAL GAS - DRY	0.2	U		#	0.2	
Tritium	pCi/L	06/12/2013	0001	LHV 790	-	NATURAL GAS - DRY	0.0632	U		#	0.0632	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 09/16/2013
Location: 05-045-15741 WELL, Natural Gas Well - Angle, BM 26-34C

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	06/12/2013	0001	LHV 793	-	NATURAL GAS - DRY	0.2	U		#	0.2	
Tritium	pCi/L	06/12/2013	0001	LHV 793	-	NATURAL GAS - DRY	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 09/16/2013
Location: 05-045-15742 WELL, Natural Gas Well - Angle, BM 26-33C

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	06/12/2013	0001	LHV 789	-	NATURAL GAS - DRY	0.2	U		#	0.2	
Tritium	pCi/L	06/12/2013	0001	LHV 789	-	NATURAL GAS - DRY	0.0668	U		#	0.0668	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 09/16/2013
Location: 05-045-15743 WELL, Natural Gas Well - Angle, BM 26-33B

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	06/12/2013	0001	LGV 133	-	NATURAL GAS - DRY	0.2	U		#	0.2	
Tritium	pCi/L	06/12/2013	0001	LGV 133	-	NATURAL GAS - DRY	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 09/16/2013
Location: 05-045-15744 WELL, Natural Gas Well - Angle, BM 26-34A

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	06/12/2013	0001	LHV 791	-	NATURAL GAS - DRY	0.2	U		#	0.2	
Tritium	pCi/L	06/12/2013	0001	LHV 791	-	NATURAL GAS - DRY	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 09/16/2013
Location: 05-045-15745 WELL, Natural Gas Well - Angle, BM 26-34B

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	06/12/2013	0001	LHV 792	-	NATURAL GAS - DRY	0.2	U		#	0.2	
Tritium	pCi/L	06/12/2013	0001	LHV 792	-	NATURAL GAS - DRY	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 09/16/2013
Location: 05-045-15748 WELL, Natural Gas Well - Angle, BM 26-34D

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	06/12/2013	0001	LHV 794	-	NATURAL GAS - DRY	0.2	U		#	0.2	
Tritium	pCi/L	06/12/2013	0001	LHV 794	-	NATURAL GAS - DRY	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 09/16/2013
Location: 05-045-16074 WELL, Natural Gas Well - Angle, BM 26-22D

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	06/12/2013	0001	LGV 132	-	NATURAL GAS - DRY	0.2	U		#	0.2	
Tritium	pCi/L	06/12/2013	0001	LGV 132	-	NATURAL GAS - DRY	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 09/16/2013
Location: 05-045-16086 WELL, Natural Gas Well - Angle, BM 26-22B

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	06/12/2013	0001	LGV 130	-	NATURAL GAS - DRY	0.2	U		#	0.2	
Tritium	pCi/L	06/12/2013	0001	LGV 130	-	NATURAL GAS - DRY	0.0514	U		#	0.0514	

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 09/16/2013
Location: 05-045-16087 WELL, Natural Gas Well - Angle, BM 26-22C

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	06/12/2013	0001	LGV 131	-	NATURAL GAS - DRY	0.4	U		#	0.4	
Tritium	pCi/L	06/12/2013	0001	LGV 131	-	NATURAL GAS - DRY	0.0514	U		#	0.0514	

SAMPLE ID CODES: 000X = Filtered sample (0.45 µm). N00X = Unfiltered sample. X = replicate number.

LAB QUALIFIERS:

*	Replicate analysis not within control limits.
>	Result above upper detection limit.
A	TIC is a suspected aldol-condensation product.
B	Inorganic: Result is between the IDL and CRDL. Organic: Analyte also found in method blank.
C	Pesticide result confirmed by GC-MS.
D	Analyte determined in diluted sample.
E	Inorganic: Estimate value because of interference, see case narrative. Organic: Analyte exceeded calibration range of the GC-MS.
H	Holding time expired, value suspect.
I	Increased detection limit due to required dilution.
J	Estimated.
N	Inorganic or radiochemical: Spike sample recovery not within control limits. Organic: Tentatively identified compound (TIC).
P	> 25% difference in detected pesticide or Aroclor concentrations between 2 columns.
U	Analytical result below detection limit.
W	Postdigestion spike outside control limits while sample absorbance < 50% of analytical spike absorbance.
X, Y, Z	Laboratory-defined qualifier, see case narrative.

DATA QUALIFIERS:

F	Low-flow sampling method used.	G	Possible grout contamination, pH > 9.	J	Estimated value.
L	Less than 3 bore volumes purged prior to sampling.	Q	Qualitative result due to sampling technique.	R	Unusable result.
U	Parameter analyzed for but was not detected.	X	Location is undefined.		

QA QUALIFIER:

#	Validated according to quality assurance guidelines.