

**Monitoring Results for  
Natural Gas Wells  
Near Project Rulison  
Second Quarter 2013**

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

**Date Sampled:** April 3, 2013

**Background:**

Project Rulison was the second underground nuclear test under the Plowshare Program to stimulate natural-gas recovery from deep, 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. Afterward, the site was shut down and then remediated, and the emplacement well (R-E) and the reentry well (R-Ex) were 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. The very low permeability of the Williams Fork Formation limits migration of radionuclides away from the detonation cavity, and institutional controls restrict subsurface access in the detonation zone. Oversight is required for wells drilled within a 3-mile radius 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 test-related radionuclides. 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 production water on April 3, 2013, three wells produced no water, and no sample was collected. In samples from the remaining 10 wells, no analytical result exceeded the screening levels specified in the DOE *Rulison Monitoring Plan*. The gas- and liquid-phase concentrations are shown in Table 3a and Table 3b, respectively.

**Samples Collected:**

The 2012 fourth quarter sampling was delayed twice—once due to road construction in September 2012, and once due to a winter storm on December 18, 2012. As a result, the sampling scheduled for the fourth quarter of 2012 did not occur until early in the first quarter of 2013. The January 10, 2013, sampling event and resulting data set will also serve as the first quarter data set for 2013. During the April 3, 2013, sampling event, 13 producing gas wells were sampled on 5 drill pads; 7 wells on Pad 26N, 3 wells on Pad 26K, and 1 well each on Pads 35C, 36L, and 36B. One duplicate sample was collected. Two of the wells on Pad 26N and one well

on Pad 26K produced no water. 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

*Table 2. Sample Collection Information*

Seq.	Pad	Well Name	Location			Sample Phase		Well	
			API # 05-045-	Type	Subtype	Gas	Liquid	T (°F)	P (psi)
1	26N	BM 26-33B	15743	WL	NGSA	No	Yes	58.0	195.8
2	26N	BM 26-33C	15742	WL	NGSA	No	Yes	67.2	214.8
3	26N	BM 26-33D	15739	WL	NGSA	No	Yes	77.7	233.8
4	26N	BM 26-34A	15744	WL	NGSA	No	No	58.8	233.0
5	26N	BM 26-34B	15745	WL	NGSA	No	Yes	76.1	234.2
6	26N	BM 26-34C	15741	WL	NGSA	No	No	78.5	232.8
7	26N	BM 26-34D	15748	WL	NGSA	No	Yes	61.3	223.4
8	26K	BM 26-22B	16086	WL	NGSA	No	No	64.2	249.7
9	26K	BM 26-22C	16087	WL	NGSA	No	Yes	76.7	250.8
10	26K	BM 26-22D	16074	WL	NGSA	No	Yes	72.7	253.5
11	35C	BM 35-32A	10919	WL	NGSV	No	Yes	79.7	247.1
12	36L	BM 36-13B	15469	WL	NGSV	No	Yes	74.4	244.1
13	36B	BM 36-13	10840	WL	NGSV	No	Yes	66.1	244.9

**Abbreviations:**

API American Petroleum Institute  
 BM Battlement Mesa  
 NGSA natural gas well – angle  
 P pressure  
 psi pounds per square inch  
 Seq. sequence  
 T temperature  
 WL well location

**Sample Locations:**

The bottom-hole locations of the 13 gas wells sampled are between 0.55 and 1.07 miles from the Project Rulison detonation point. All gas wells sampled were producing gas from the Williams Fork Formation at a depth near that of the Rulison detonation point.

*Rulison Surface Collection Locations*

Pad	Location				Pad Elevation (feet)	Surface Location		Comment
	Q-Q	S	T	R		Latitude (NAD 83)	Longitude (NAD 83)	
26K	NWSW	26	7S	95W	8,983.5	39.405750	-107.970095	Surface location is for BM 26-22D well head.
26N	SESW	26	7S	95W	8,964	39.404547	-107.967268	BM 26-33B well head location; some well heads are in NESW.
35C	NENW	36	7S	95W	9,236	39.398911	-107.966542	Surface location is for BM 35-32A well head.
36L	NWSW	36	7S	95W	8,901	39.392146	-107.952819	Surface location is for BM 36-13B well head.
36B	NWNE	36	7S	95W	8,683	39.398165	-107.943943	Surface location is for BM 36-13 well head.

**Abbreviations:**

BM Battlement Mesa  
 NAD 83 North American Datum of 1983  
 Q-Q Quarter-quarter section  
 R Range  
 S Section  
 T Township

*Rulison Bottom-Hole Locations*

Pad	Well Name	API # 05-045	Total Depth (ft)	Location				Rulison GZ to BHL		Comment
				Q-Q	S	Latitude (NAD 83)	Longitude (NAD 83)	Distance (miles)	Heading (degs)	
	25-95 (R-E)	06002	8,701	NENW	25	39.405361	-107.948444	0		GZ; vertical well
26N	BM 26-33B	15743	9,966	NWSE	26	39.406892	-107.962558	0.76	W9.5°N	
26N	BM 26-33C	15742	10,072	NWSE	26	39.406006	-107.962544	0.76	W4.9°N	
26N	BM 26-33D	15739	10,068	NWSE	26	39.405124	-107.962544	0.75	W0.3°N	
26N	BM 26-34A	15744	10,087	SWSE	26	39.404311	-107.962565	0.76	S86.1°W	
26N	BM 26-34B	15745	10,046	SWSE	26	39.403498	-107.962561	0.77	S81.9°W	
26N	BM 26-34C	15741	9,986	SWSE	26	39.402515	-107.962576	0.78	S77.0°W	
26N	BM 26-34D	15748	9,986	SWSE	26	39.401665	-107.964508	0.90	S75.0°W	
26K	BM 26-22B	16086	10,094	SESW	26	39.410530	-107.967228	1.07	W21.1°N	
26K	BM 26-22C	16087	10,047	SESW	26	39.409618	-107.967223	1.05	W17.8°N	
26K	BM 26-22D	16074	10,057	SESW	26	39.408687	-107.967163	1.03	W14.6°N	
35C	BM 35-32A	10919	10,278	SWNE	35	39.397066	-107.962633	0.95	S54.5°W	
36L	BM 36-13B	15469	10,123	NWSW	36	39.392109	-107.952831	0.94	S16.0°W	
36B	BM 36-13	10840	8,903	NWNE	36	39.398165	-107.943943	0.55	S24.3°E	

**Abbreviations:**

API American Petroleum Institute  
 BHL Bottom-hole location  
 degs degrees  
 ft feet  
 BM Battlement Mesa  
 GZ Ground Zero

## 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.

No gas samples were collected during this sampling event. When gas samples are collected, they are obtained 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 analytical 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	$5.183 \times 10^{-6}$ 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

### Notes:

See the *Rulison Monitoring Plan*, Table 2, for response scenarios to use if the screening or action concentrations are exceeded.

The derived air effluent concentration for a 50 millirem per year dose from tritium exposure is 0.10 pCi (tritium)/cc (methane).

### Abbreviations:

EPA U.S. Environmental Protection Agency  
 pCi/L picocuries per liter of water  
 TBD to be determined  
 cc cubic centimeter

**Results:**

Ten produced water samples were collected from 13 gas wells within the monitoring area.

The production water analytical results are tabulated by well in Appendix A.

**Laboratory Qualifiers:**

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

A “nondetect” is a result that is less than the laboratory’s MDC for that sample. The laboratory assigns the qualifier “U” to a nondetect result.

**Data Validation Qualifiers:**

A detect result less than three times the sample MDC is assigned the data validation qualifier “J” (estimated concentration).

A laboratory detect result less than three times the one-sigma total propagated uncertainty is considered a nondetect. Data validation assigns a “U” qualifier to that type of result.

**Results Summaries:**

Results for gas- and liquid-phase tritium and carbon-14 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. Samples not collected this quarter and samples with insufficient volumes for laboratory analysis are listed as not applicable (NA).

*Table 4a. Summary of Tritium and Carbon-14 Samples, Based on Laboratory-Assigned Qualifiers*

Collection Location	Total Samples (gas/liquid)	Tritium Results (Gas Phase)			Tritium (Liquid Phase)		
		Detect	Nondetect	NA	Detect	Nondetect	NA
Natural gas wells	0/13	NA	NA	NA	0	10	3
Collection Location	Total Samples (gas/liquid)	Carbon-14 Results (gas phase)			Carbon-14 Results (liquid phase)		
Natural gas wells	NA	NA	NA	NA	NA	NA	NA

**Abbreviation:**

NA Sample not collected or sample volume insufficient for analysis

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

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

**Abbreviation:**

NA Sample not collected or sample volume insufficient for analysis

Data validation assigned a “J” qualifier to 3 of the 4 gross-alpha detect results and to 8 of the 10 gross-beta detect results.

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

Collection Location	Total Samples	Potassium-40 Results		
		Detect	Nondetect	NA
Natural gas wells	10	7	3	

**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.

**Appendix A**  
**Liquid-Phase Sample Results**

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**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 8/22/2013**  
**Location: 05-045-10840 WELL Battlement Mesa 36-13**

Parameter	Units	Sample		Depth Range			Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID	(Ft BLS)				Lab	Data	QA		
Actinium-228	pCi/L	04/03/2013	N001	0	-	0	21.3	U		#	34.6	19.8
Americium-241	pCi/L	04/03/2013	N001	0	-	0	-8.76	U		#	35.5	20.8
Antimony-125	pCi/L	04/03/2013	N001	0	-	0	1.63	U		#	13.1	7.75
Cerium-144	pCi/L	04/03/2013	N001	0	-	0	-16.1	U		#	32.3	21.2
Cesium-134	pCi/L	04/03/2013	N001	0	-	0	1.7	U		#	6.38	2.66
Cesium-137	pCi/L	04/03/2013	N001	0	-	0	0.356	U		#	5.79	3.4
Chloride	mg/L	04/03/2013	N001	0	-	0	8960	H		#	168	
Cobalt-60	pCi/L	04/03/2013	N001	0	-	0	0.577	U		#	6.73	3.28
Europium-152	pCi/L	04/03/2013	N001	0	-	0	1.86	U		#	15.9	9.65
Europium-154	pCi/L	04/03/2013	N001	0	-	0	2.12	U		#	21.2	10.6
Europium-155	pCi/L	04/03/2013	N001	0	-	0	1.08	U		#	18.7	10.6
Gross Alpha	pCi/L	04/03/2013	N001	0	-	0	53.7		J	#	47.8	33.2
Gross Beta	pCi/L	04/03/2013	N001	0	-	0	132		J	#	57	42.4
Lead-212	pCi/L	04/03/2013	N001	0	-	0	10.3	U		#	13.7	9.59
Potassium-40	pCi/L	04/03/2013	N001	0	-	0	208			#	54.8	74.2
Promethium-144	pCi/L	04/03/2013	N001	0	-	0	0.382	U		#	5.18	2.65
Promethium-146	pCi/L	04/03/2013	N001	0	-	0	1.28	U		#	6.85	4.09
Ruthenium-106	pCi/L	04/03/2013	N001	0	-	0	-12.4	U		#	50.6	28.6
Thorium-234	pCi/L	04/03/2013	N001	0	-	0	-40.4	U		#	347	208
Tritium	pCi/L	04/03/2013	N001	0	-	0	-24.1	U		#	236	116
Uranium-235	pCi/L	04/03/2013	N001	0	-	0	-6.61	U		#	36.1	21.9
Uranium-238	pCi/L	04/03/2013	N001	0	-	0	-40.4	U		#	347	208
Yttrium-88	pCi/L	04/03/2013	N001	0	-	0	-1.36	U		#	8.01	4.43

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 8/22/2013**  
**Location: 05-045-10919 WELL Battlement Mesa 35-32A**

Parameter	Units	Sample		Depth Range			Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID	(Ft BLS)				Lab	Data	QA		
Actinium-228	pCi/L	04/03/2013	N001	0	-	0	2.46	U		#	26.5	16.6
Americium-241	pCi/L	04/03/2013	N001	0	-	0	17.4	U		#	21.9	15.3
Antimony-125	pCi/L	04/03/2013	N001	0	-	0	2.79	U		#	15.4	8.66
Cerium-144	pCi/L	04/03/2013	N001	0	-	0	6.96	U		#	32.6	19.2
Cesium-134	pCi/L	04/03/2013	N001	0	-	0	0.928	U		#	6.92	3.74
Cesium-137	pCi/L	04/03/2013	N001	0	-	0	-2.43	U		#	6.21	4.02
Chloride	mg/L	04/03/2013	N001	0	-	0	8440	H		#	168	
Cobalt-60	pCi/L	04/03/2013	N001	0	-	0	0.563	U		#	5.82	2.94
Europium-152	pCi/L	04/03/2013	N001	0	-	0	5.59	U		#	16.3	10.4
Europium-154	pCi/L	04/03/2013	N001	0	-	0	-1.83	U		#	17.7	11.2
Europium-155	pCi/L	04/03/2013	N001	0	-	0	-1.4	U		#	16.9	9.46
Gross Alpha	pCi/L	04/03/2013	N001	0	-	0	-30.6	U		#	61.2	29.4
Gross Beta	pCi/L	04/03/2013	N001	0	-	0	136			#	42.8	36.3
Lead-212	pCi/L	04/03/2013	N001	0	-	0	6.65	U		#	8.9	8.25
Potassium-40	pCi/L	04/03/2013	N001	0	-	0	207			#	57.7	73.4
Promethium-144	pCi/L	04/03/2013	N001	0	-	0	-0.214	U		#	5.7	3.15
Promethium-146	pCi/L	04/03/2013	N001	0	-	0	-0.993	U		#	6.36	3.75
Ruthenium-106	pCi/L	04/03/2013	N001	0	-	0	4.64	U		#	52	28
Thorium-234	pCi/L	04/03/2013	N001	0	-	0	24.9	U		#	225	165
Tritium	pCi/L	04/03/2013	N001	0	-	0	0	U		#	237	120
Uranium-235	pCi/L	04/03/2013	N001	0	-	0	-7.47	U		#	33.1	21.6
Uranium-238	pCi/L	04/03/2013	N001	0	-	0	24.9	U		#	225	165
Yttrium-88	pCi/L	04/03/2013	N001	0	-	0	-0.23	U		#	6.25	3.24

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 8/22/2013**  
**Location: 05-045-15469 WELL Battlement Mesa 36-13B**

Parameter	Units	Sample		Depth Range			Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID	(Ft BLS)				Lab	Data	QA		
Actinium-228	pCi/L	04/03/2013	N001	0	-	0	14.2	U		#	26.7	14.8
Americium-241	pCi/L	04/03/2013	N001	0	-	0	-2.1	U		#	31.6	20.5
Antimony-125	pCi/L	04/03/2013	N001	0	-	0	4.06	U		#	14.1	7.74
Cerium-144	pCi/L	04/03/2013	N001	0	-	0	4.91	U		#	32.3	18.6
Cesium-134	pCi/L	04/03/2013	N001	0	-	0	3.93	U		#	6.56	3.62
Cesium-137	pCi/L	04/03/2013	N001	0	-	0	2.08	U		#	4.23	3.73
Chloride	mg/L	04/03/2013	N001	0	-	0	10700	H		#	168	
Cobalt-60	pCi/L	04/03/2013	N001	0	-	0	0.796	U		#	5.33	3.02
Europium-152	pCi/L	04/03/2013	N001	0	-	0	4.52	U		#	15.3	9.46
Europium-154	pCi/L	04/03/2013	N001	0	-	0	2.22	U		#	13.3	6.39
Europium-155	pCi/L	04/03/2013	N001	0	-	0	-0.86	U		#	17.7	10.2
Gross Alpha	pCi/L	04/03/2013	N001	0	-	0	70.1		J	#	66.4	45.6
Gross Beta	pCi/L	04/03/2013	N001	0	-	0	166			#	51.2	45.8
Lead-212	pCi/L	04/03/2013	N001	0	-	0	0	U		#	13.4	10.6
Potassium-40	pCi/L	04/03/2013	N001	0	-	0	209			#	48.9	67.3
Promethium-144	pCi/L	04/03/2013	N001	0	-	0	-0.457	U		#	4.31	2.37
Promethium-146	pCi/L	04/03/2013	N001	0	-	0	2.68	U		#	6.46	3.57
Ruthenium-106	pCi/L	04/03/2013	N001	0	-	0	-8.38	U		#	39.9	22.5
Thorium-234	pCi/L	04/03/2013	N001	0	-	0	134	U		#	299	183
Tritium	pCi/L	04/03/2013	N001	0	-	0	-59.3	U		#	239	110
Uranium-235	pCi/L	04/03/2013	N001	0	-	0	33.6	U		#	37.8	28.2
Uranium-238	pCi/L	04/03/2013	N001	0	-	0	134	U		#	299	183
Yttrium-88	pCi/L	04/03/2013	N001	0	-	0	-0.438	U		#	5.41	2.76

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 8/22/2013**  
**Location: 05-045-15739 WELL Battlement Mesa 26-33D**

Parameter	Units	Sample		Depth Range			Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID	(Ft BLS)				Lab	Data	QA		
Actinium-228	pCi/L	04/03/2013	N001	0	-	0	33.4		U	#	20.3	22
Americium-241	pCi/L	04/03/2013	N001	0	-	0	0.469	U		#	36.7	22.2
Antimony-125	pCi/L	04/03/2013	N001	0	-	0	2.72	U		#	15.8	8.67
Cerium-144	pCi/L	04/03/2013	N001	0	-	0	6.39	U		#	35.6	20.1
Cesium-134	pCi/L	04/03/2013	N001	0	-	0	1.85	U		#	6.18	3.23
Cesium-137	pCi/L	04/03/2013	N001	0	-	0	-1.15	U		#	4.84	2.76
Chloride	mg/L	04/03/2013	N001	0	-	0	11,600	H		#	168	
Cobalt-60	pCi/L	04/03/2013	N001	0	-	0	-1.99	U		#	6.21	3.72
Europium-152	pCi/L	04/03/2013	N001	0	-	0	0.146	U		#	15.7	8.98
Europium-154	pCi/L	04/03/2013	N001	0	-	0	0.681	U		#	18.5	9.59
Europium-155	pCi/L	04/03/2013	N001	0	-	0	17.3	U		#	20.9	15.3
Gross Alpha	pCi/L	04/03/2013	N001	0	-	0	-37.1	U		#	102	49.2
Gross Beta	pCi/L	04/03/2013	N001	0	-	0	134		J	#	86.8	58.4
Lead-212	pCi/L	04/03/2013	N001	0	-	0	-2.34	U		#	9.92	5.78
Potassium-40	pCi/L	04/03/2013	N001	0	-	0	84.5		U	#	54.2	61.3
Promethium-144	pCi/L	04/03/2013	N001	0	-	0	0.161	U		#	5.17	2.76
Promethium-146	pCi/L	04/03/2013	N001	0	-	0	1.42	U		#	7.55	4.46
Ruthenium-106	pCi/L	04/03/2013	N001	0	-	0	-2.94	U		#	46.3	25
Thorium-234	pCi/L	04/03/2013	N001	0	-	0	188	U		#	393	264
Tritium	pCi/L	04/03/2013	N001	0	-	0	-36.2	U		#	236	113
Uranium-235	pCi/L	04/03/2013	N001	0	-	0	22.8	U		#	31.9	30.8
Uranium-238	pCi/L	04/03/2013	N001	0	-	0	188	U		#	393	264
Yttrium-88	pCi/L	04/03/2013	N001	0	-	0	0.345	U		#	7.28	3.61

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 8/22/2013**  
**Location: 05-045-15742 WELL Battlement Mesa 26-33C**

Parameter	Units	Sample		Depth Range			Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID	(Ft BLS)				Lab	Data	QA		
Actinium-228	pCi/L	04/03/2013	N001	0	-	0	26.3		U	#	20	19
Americium-241	pCi/L	04/03/2013	N001	0	-	0	-3.09	U		#	22.2	12.8
Antimony-125	pCi/L	04/03/2013	N001	0	-	0	0.291	U		#	15	8.35
Cerium-144	pCi/L	04/03/2013	N001	0	-	0	-0.756	U		#	30.4	17.7
Cesium-134	pCi/L	04/03/2013	N001	0	-	0	2.11	U		#	6.85	3.63
Cesium-137	pCi/L	04/03/2013	N001	0	-	0	1.63	U		#	5.57	2.9
Chloride	mg/L	04/03/2013	N001	0	-	0	9600	H		#	168	
Cobalt-60	pCi/L	04/03/2013	N001	0	-	0	-1.16	U		#	4.9	2.84
Europium-152	pCi/L	04/03/2013	N001	0	-	0	2.71	U		#	16.6	9.18
Europium-154	pCi/L	04/03/2013	N001	0	-	0	3.7	U		#	18.1	9.39
Europium-155	pCi/L	04/03/2013	N001	0	-	0	1.58	U		#	17.3	9.97
Gross Alpha	pCi/L	04/03/2013	N001	0	-	0	88.8		J	#	40	39.2
Gross Beta	pCi/L	04/03/2013	N001	0	-	0	151		J	#	71.2	52
Lead-212	pCi/L	04/03/2013	N001	0	-	0	7.94	U		#	8.73	7.38
Potassium-40	pCi/L	04/03/2013	N001	0	-	0	187			#	53.7	73.7
Promethium-144	pCi/L	04/03/2013	N001	0	-	0	0.634	U		#	5.73	3.48
Promethium-146	pCi/L	04/03/2013	N001	0	-	0	-0.466	U		#	6.81	3.86
Ruthenium-106	pCi/L	04/03/2013	N001	0	-	0	10.4	U		#	50.3	27.7
Thorium-234	pCi/L	04/03/2013	N001	0	-	0	-204	U		#	217	189
Tritium	pCi/L	04/03/2013	N001	0	-	0	46.3	U		#	235	128
Uranium-235	pCi/L	04/03/2013	N001	0	-	0	-8.62	U		#	33.9	24.1
Uranium-238	pCi/L	04/03/2013	N001	0	-	0	-204	U		#	217	189
Yttrium-88	pCi/L	04/03/2013	N001	0	-	0	3.19	U		#	7.79	3.78

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 8/22/2013**  
**Location: 05-045-15743 WELL Battlement Mesa 26-33B**

Parameter	Units	Sample		Depth Range			Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID	(Ft BLS)				Lab	Data	QA		
Actinium-228	pCi/L	04/03/2013	N001	0	-	0	5.91	U		#	28.4	22.6
Americium-241	pCi/L	04/03/2013	N001	0	-	0	-2.23	U		#	31.8	22.8
Antimony-125	pCi/L	04/03/2013	N001	0	-	0	1	U		#	15.4	8.69
Cerium-144	pCi/L	04/03/2013	N001	0	-	0	4.43	U		#	32.5	18.9
Cesium-134	pCi/L	04/03/2013	N001	0	-	0	1.61	U		#	6.44	3.44
Cesium-137	pCi/L	04/03/2013	N001	0	-	0	-1.56	U		#	7.46	4.74
Chloride	mg/L	04/03/2013	N001	0	-	0	7760	H		#	168	
Cobalt-60	pCi/L	04/03/2013	N001	0	-	0	2.89	U		#	7.06	3.63
Europium-152	pCi/L	04/03/2013	N001	0	-	0	-8.31	U		#	14.8	10.1
Europium-154	pCi/L	04/03/2013	N001	0	-	0	-2.15	U		#	16.8	9.22
Europium-155	pCi/L	04/03/2013	N001	0	-	0	-10.2	U		#	17	11.4
Gross Alpha	pCi/L	04/03/2013	N001	0	-	0	29.6	U		#	66.5	39.4
Gross Beta	pCi/L	04/03/2013	N001	0	-	0	103		J	#	50	36.3
Lead-212	pCi/L	04/03/2013	N001	0	-	0	6.2	U		#	12.1	9.1
Potassium-40	pCi/L	04/03/2013	N001	0	-	0	80.6		U	#	53.6	57.8
Promethium-144	pCi/L	04/03/2013	N001	0	-	0	0.741	U		#	6.16	3.37
Promethium-146	pCi/L	04/03/2013	N001	0	-	0	1.88	U		#	7.4	4.17
Ruthenium-106	pCi/L	04/03/2013	N001	0	-	0	-8.66	U		#	46.6	26.4
Thorium-234	pCi/L	04/03/2013	N001	0	-	0	47	U		#	243	262
Tritium	pCi/L	04/03/2013	N001	0	-	0	-24.2	U		#	237	116
Uranium-235	pCi/L	04/03/2013	N001	0	-	0	-23.2	U		#	34.1	25.6
Uranium-238	pCi/L	04/03/2013	N001	0	-	0	47	U		#	243	262
Yttrium-88	pCi/L	04/03/2013	N001	0	-	0	3.66	U		#	7.9	4.74

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 8/22/2013**  
**Location: 05-045-15745 WELL Battlement Mesa 26-34B**

Parameter	Units	Sample		Depth Range			Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID	(Ft BLS)				Lab	Data	QA		
Actinium-228	pCi/L	04/03/2013	N001	0	-	0	18	U	#	18.9	20.2	
Actinium-228	pCi/L	04/03/2013	N002	0	-	0	26.8	U	#	27.6	22.1	
Americium-241	pCi/L	04/03/2013	N001	0	-	0	5.33	U	#	27.9	23.5	
Americium-241	pCi/L	04/03/2013	N002	0	-	0	-8.47	U	#	20.5	12.7	
Antimony-125	pCi/L	04/03/2013	N001	0	-	0	-8.29	U	#	10.3	8.64	
Antimony-125	pCi/L	04/03/2013	N002	0	-	0	1.91	U	#	12.1	6.48	
Cerium-144	pCi/L	04/03/2013	N001	0	-	0	-7.24	U	#	33.6	22.6	
Cerium-144	pCi/L	04/03/2013	N002	0	-	0	3.81	U	#	28.7	18.3	
Cesium-134	pCi/L	04/03/2013	N001	0	-	0	4.17	U	#	6.29	4.03	
Cesium-134	pCi/L	04/03/2013	N002	0	-	0	1.99	U	#	5.29	2.67	
Cesium-137	pCi/L	04/03/2013	N001	0	-	0	0.00975	U	#	6.31	3.5	
Cesium-137	pCi/L	04/03/2013	N002	0	-	0	-0.749	U	#	4.28	2.33	
Chloride	mg/L	04/03/2013	N001	0	-	0	10,600	H	#	168		
Chloride	mg/L	04/03/2013	N002	0	-	0	10,500	H	#	168		
Cobalt-60	pCi/L	04/03/2013	N001	0	-	0	-0.621	U	#	5.28	3.38	
Cobalt-60	pCi/L	04/03/2013	N002	0	-	0	-0.245	U	#	4.88	2.6	
Europium-152	pCi/L	04/03/2013	N001	0	-	0	4.62	U	#	16	9.73	
Europium-152	pCi/L	04/03/2013	N002	0	-	0	4.99	U	#	14.6	8.17	
Europium-154	pCi/L	04/03/2013	N001	0	-	0	-1.17	U	#	12.7	6.69	
Europium-154	pCi/L	04/03/2013	N002	0	-	0	-0.329	U	#	11.4	5.81	
Europium-155	pCi/L	04/03/2013	N001	0	-	0	-3.06	U	#	18	11.9	
Europium-155	pCi/L	04/03/2013	N002	0	-	0	1.38	U	#	17.2	9.82	
Gross Alpha	pCi/L	04/03/2013	N001	0	-	0	46.1	U	#	54.9	35.9	
Gross Alpha	pCi/L	04/03/2013	N002	0	-	0	57	U	#	82.7	52.1	

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 8/22/2013**  
**Location: 05-045-15745 WELL Battlement Mesa 26-34B**

Parameter	Units	Sample		Depth Range			Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID	(Ft BLS)				Lab	Data	QA		
Gross Beta	pCi/L	04/03/2013	N001	0	-	0	71.6		J	#	59.6	38.6
Gross Beta	pCi/L	04/03/2013	N002	0	-	0	110		J	#	47.4	36.8
Lead-212	pCi/L	04/03/2013	N001	0	-	0	4.49	U		#	11.4	8.86
Lead-212	pCi/L	04/03/2013	N002	0	-	0	10.5	U		#	10.9	9.41
Potassium-40	pCi/L	04/03/2013	N001	0	-	0	0	U		#	48	46.5
Potassium-40	pCi/L	04/03/2013	N002	0	-	0	80.5		J	#	50	45.6
Promethium-144	pCi/L	04/03/2013	N001	0	-	0	-0.0658	U		#	4.77	2.62
Promethium-144	pCi/L	04/03/2013	N002	0	-	0	1.02	U		#	4.65	2.38
Promethium-146	pCi/L	04/03/2013	N001	0	-	0	0.267	U		#	6.41	3.47
Promethium-146	pCi/L	04/03/2013	N002	0	-	0	-0.289	U		#	5.55	3.08
Ruthenium-106	pCi/L	04/03/2013	N001	0	-	0	7.99	U		#	49.2	26.4
Ruthenium-106	pCi/L	04/03/2013	N002	0	-	0	-9.6	U		#	30.5	21.5
Thorium-234	pCi/L	04/03/2013	N001	0	-	0	51.1	U		#	281	156
Thorium-234	pCi/L	04/03/2013	N002	0	-	0	-64.5	U		#	209	131
Tritium	pCi/L	04/03/2013	N001	0	-	0	34.9	U		#	239	128
Tritium	pCi/L	04/03/2013	N002	0	-	0	22.3	U		#	234	123
Uranium-235	pCi/L	04/03/2013	N001	0	-	0	-7.89	U		#	34.3	23.9
Uranium-235	pCi/L	04/03/2013	N002	0	-	0	-23.4	U		#	30.2	22.1
Uranium-238	pCi/L	04/03/2013	N001	0	-	0	51.1	U		#	281	156
Uranium-238	pCi/L	04/03/2013	N002	0	-	0	-64.5	U		#	209	131
Yttrium-88	pCi/L	04/03/2013	N001	0	-	0	0.609	U		#	6.32	3.03
Yttrium-88	pCi/L	04/03/2013	N002	0	-	0	0.00991	U		#	5.98	3



**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 8/22/2013**  
**Location: 05-045-15748 WELL Battlement Mesa 26-34D**

Parameter	Units	Sample		Depth Range			Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID	(Ft BLS)				Lab	Data	QA		
Actinium-228	pCi/L	04/03/2013	N001	0	-	0	0	U		#	28.9	22.6
Americium-241	pCi/L	04/03/2013	N001	0	-	0	5.47	U		#	35.3	21
Antimony-125	pCi/L	04/03/2013	N001	0	-	0	-2.03	U		#	12.7	8.18
Cerium-144	pCi/L	04/03/2013	N001	0	-	0	-1.45	U		#	30.6	17.4
Cesium-134	pCi/L	04/03/2013	N001	0	-	0	0.121	U		#	5.41	2.81
Cesium-137	pCi/L	04/03/2013	N001	0	-	0	-1.67	U		#	4.02	2.56
Chloride	mg/L	04/03/2013	N001	0	-	0	11,100	H		#	168	
Cobalt-60	pCi/L	04/03/2013	N001	0	-	0	1.7	U		#	6.17	2.96
Europium-152	pCi/L	04/03/2013	N001	0	-	0	1.96	U		#	12.9	6.96
Europium-154	pCi/L	04/03/2013	N001	0	-	0	6.18	U		#	15.6	7.4
Europium-155	pCi/L	04/03/2013	N001	0	-	0	-6.78	U		#	16.8	10.3
Gross Alpha	pCi/L	04/03/2013	N001	0	-	0	169			#	55.6	60.1
Gross Beta	pCi/L	04/03/2013	N001	0	-	0	150		J	#	61.6	47.5
Lead-212	pCi/L	04/03/2013	N001	0	-	0	0	U		#	12.2	10.5
Potassium-40	pCi/L	04/03/2013	N001	0	-	0	115		J	#	60.5	61.2
Promethium-144	pCi/L	04/03/2013	N001	0	-	0	1.21	U		#	5.31	2.73
Promethium-146	pCi/L	04/03/2013	N001	0	-	0	-3.71	U		#	5.13	3.65
Ruthenium-106	pCi/L	04/03/2013	N001	0	-	0	-6.07	U		#	35.6	20.3
Thorium-234	pCi/L	04/03/2013	N001	0	-	0	94.3	U		#	352	214
Tritium	pCi/L	04/03/2013	N001	0	-	0	22.3	U		#	235	124
Uranium-235	pCi/L	04/03/2013	N001	0	-	0	12.4	U		#	29.9	45.3
Uranium-238	pCi/L	04/03/2013	N001	0	-	0	94.3	U		#	352	214
Yttrium-88	pCi/L	04/03/2013	N001	0	-	0	-0.372	U		#	6.09	3.14

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 8/22/2013**  
**Location: 05-045-16074 WELL Battlement Mesa 26-22D**

Parameter	Units	Sample		Depth Range			Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID	(Ft BLS)				Lab	Data	QA		
Actinium-228	pCi/L	04/03/2013	N001	0	-	0	45.3			#	13.5	18.2
Americium-241	pCi/L	04/03/2013	N001	0	-	0	8.6	U		#	18.5	12.1
Antimony-125	pCi/L	04/03/2013	N001	0	-	0	-5.6	U		#	12	7.81
Cerium-144	pCi/L	04/03/2013	N001	0	-	0	3.11	U		#	32	18.3
Cesium-134	pCi/L	04/03/2013	N001	0	-	0	0.0193	U		#	5.32	2.98
Cesium-137	pCi/L	04/03/2013	N001	0	-	0	0.343	U		#	5.33	2.86
Chloride	mg/L	04/03/2013	N001	0	-	0	16,100	H		#	168	
Cobalt-60	pCi/L	04/03/2013	N001	0	-	0	0.636	U		#	5.8	2.96
Europium-152	pCi/L	04/03/2013	N001	0	-	0	-1.34	U		#	13.9	8.03
Europium-154	pCi/L	04/03/2013	N001	0	-	0	-3.18	U		#	14.3	8.35
Europium-155	pCi/L	04/03/2013	N001	0	-	0	4.91	U		#	16.3	9.04
Gross Alpha	pCi/L	04/03/2013	N001	0	-	0	62.4	U		#	108	65.7
Gross Beta	pCi/L	04/03/2013	N001	0	-	0	222		J	#	75.3	61.4
Lead-212	pCi/L	04/03/2013	N001	0	-	0	6.43	U		#	9.14	7.43
Potassium-40	pCi/L	04/03/2013	N001	0	-	0	194			#	52.6	60.3
Promethium-144	pCi/L	04/03/2013	N001	0	-	0	-0.624	U		#	4.41	2.47
Promethium-146	pCi/L	04/03/2013	N001	0	-	0	0.675	U		#	6.21	3.3
Ruthenium-106	pCi/L	04/03/2013	N001	0	-	0	1.33	U		#	46.5	25.2
Thorium-234	pCi/L	04/03/2013	N001	0	-	0	8.19	U		#	169	129
Tritium	pCi/L	04/03/2013	N001	0	-	0	0	U		#	241	123
Uranium-235	pCi/L	04/03/2013	N001	0	-	0	15.2	U		#	31.2	27.9
Uranium-238	pCi/L	04/03/2013	N001	0	-	0	8.19	U		#	169	129
Yttrium-88	pCi/L	04/03/2013	N001	0	-	0	2.09	U		#	6.3	2.99

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 8/22/2013**  
**Location: 05-045-16087 WELL Battlement Mesa 26-22C**

Parameter	Units	Sample		Depth Range			Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID	(Ft BLS)				Lab	Data	QA		
Actinium-228	pCi/L	04/03/2013	N001	0	-	0	44.2		J	#	28.7	22.1
Americium-241	pCi/L	04/03/2013	N001	0	-	0	2.43	U		#	26.2	16
Antimony-125	pCi/L	04/03/2013	N001	0	-	0	2.43	U		#	19.3	10.3
Cerium-144	pCi/L	04/03/2013	N001	0	-	0	15.5	U		#	41	23.4
Cesium-134	pCi/L	04/03/2013	N001	0	-	0	-3.12	U		#	6.66	4.25
Cesium-137	pCi/L	04/03/2013	N001	0	-	0	-0.266	U		#	6.93	3.58
Chloride	mg/L	04/03/2013	N001	0	-	0	11,700	H		#	168	
Cobalt-60	pCi/L	04/03/2013	N001	0	-	0	0.0368	U		#	8.08	3.93
Europium-152	pCi/L	04/03/2013	N001	0	-	0	-3.28	U		#	19.6	11.1
Europium-154	pCi/L	04/03/2013	N001	0	-	0	-0.086	U		#	24.3	12.1
Europium-155	pCi/L	04/03/2013	N001	0	-	0	1.12	U		#	22.2	12.6
Gross Alpha	pCi/L	04/03/2013	N001	0	-	0	31.3	U		#	63.4	37.9
Gross Beta	pCi/L	04/03/2013	N001	0	-	0	191		J	#	64.2	53.2
Lead-212	pCi/L	04/03/2013	N001	0	-	0	9.42	U		#	12.3	9.42
Potassium-40	pCi/L	04/03/2013	N001	0	-	0	155		J	#	82.3	65.1
Promethium-144	pCi/L	04/03/2013	N001	0	-	0	-1.03	U		#	6.59	3.6
Promethium-146	pCi/L	04/03/2013	N001	0	-	0	-2.55	U		#	8.44	5.09
Ruthenium-106	pCi/L	04/03/2013	N001	0	-	0	-1.99	U		#	61.4	32.7
Thorium-234	pCi/L	04/03/2013	N001	0	-	0	9.25	U		#	233	200
Tritium	pCi/L	04/03/2013	N001	0	-	0	-24.1	U		#	236	116
Uranium-235	pCi/L	04/03/2013	N001	0	-	0	-7.19	U		#	41.6	28.1
Uranium-238	pCi/L	04/03/2013	N001	0	-	0	9.25	U		#	233	200
Yttrium-88	pCi/L	04/03/2013	N001	0	-	0	0.12	U		#	7.97	3.46

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 Post-digestion 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.