

**Monitoring Results
Natural Gas Wells
Near Project Rulison
Second Quarter 2012**

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

Date Sampled:

19 June 2012

Background:

Project Rulison was the second Plowshare Program test to stimulate natural-gas recovery from deep and low permeability formations. On 10 September 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 10 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.

Samples Collected:

During the second quarter of 2012, ten gas samples and eight produced-water samples were collected from ten gas wells identified in the second-quarter sample plan. Two of the wells produced no water. The ten 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; BM 26-34B, -34C, -34D
26K	Well head separator	BM 26-22B, -22C, -22D

Table 2. Sample Collection Information

Seq.	Name	API # 05-045-	Location Type/ Subtype	Sample Phase		BHL Data		Comments
				Gas	Liquid	T (°F)	P (psi)	
1	BM 26-33B	15743	WL / NGSA	Yes	Yes	55.8	241.6	~20 psi gas in a 18L sample bottle; ~ 1 gal of produced water
2	BM 26-33C	15742	WL / NGSA	Yes	Yes	55.5	239.9	~22 psi gas; ~ 1 gal water
3	BM 26-33D	15739	WL / NGSA	Yes	No	58.1	240.0	~24 psi gas
4	BM 26-34A	15744	WL / NGSA	Yes	No	57.5	240.9	~22 psi gas
5	BM 26-34B	15745	WL / NGSA	Yes	Yes	56.6	241.7	~22 psi gas; ~ 1 gal water
6	BM 26-34C	15741	WL / NGSA	Yes	Yes	57.5	241.3	~22 psi gas; ~ 1 gal water
7	BM 26-34D	15748	WL / NGSA	Yes	Yes	56.1	243.1	~22 psi gas; ~ 1 gal water
8	BM 26-22B	16086	WL / NGSA	Yes	Yes	67.2	235.4	~22 psi gas; ~ 0.7 gal water
9	BM 26-22C	16087	WL / NGSA	Yes	Yes	64.8	234.8	~22 psi gas; ~ 1 gal water
10	BM 26-22D	16074	WL / NGSA	Yes	Yes	62.2	236.3	~21 psi gas; ~ 1 gal water

Abbreviations:

API American Petroleum Institute
 BHL Bottom-hole location
 BM Battlement Mesa
 L liter
 NA missing or not applicable
 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 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 one-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 (BBQ style) 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

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).

Abbreviations:

pCi/L picocuries per liter of water
 TBD to be determined

Results:

Ten gas samples were collected from ten producing gas wells. Eight produced water samples were collected from eight of the ten gas wells.

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	10/8	1	9	0	0	8	0

Abbreviation:

NA Missing or not applicable

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	8	0	8	0	8	0	0

Abbreviation:

NA Missing or not applicable

Data validation assigned “J” to six of the eight 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	Non-detect	NA
Natural gas wells	8	2	6	0

Abbreviation:

NA Missing or not applicable

Data validation assigned “J” to the potassium-40 detect results.

Table 5 summarizes the statistics for detected gross-beta results. Backgrounds for gross alpha or gross beta have not been established.

Table 5. Statistics for Detected Gross-Alpha and Gross Beta Results

Counting Statistic	Gross Beta	Units
Number of detects	8	NA
Maximum	249.0	pCi/L
Third quartile	184.0	pCi/L
Mean	148.9	pCi/L
Median	141.0	pCi/L
First quartile	93.5	pCi/L
Minimum	80.7	pCi/L

Abbreviations:

NA missing or not applicable
pCi/L picocuries per liter of water

The distance and heading from the Rulison emplacement well to the bottom-hole locations of the wells planned for sample collection are listed in Table 6.

Table 6. Bottom-Hole Locations of Wells Sampled and Ground Zero

Pad	Well Name	Total Depth (ft)	Location				Rulison GZ to BHL		Comment
			Q-Q	S	Lat (NAD 83)	Long (NAD 83)	Distance (miles)	Heading (degrees)	
	25-95 (R-E)	8,701	NENW	25	39.405361	-107.948444	0		GZ, vertical well
26N	BM 26-33B	9,966	NWSE	26	39.406892	-107.962558	0.76	W9.5°N	
26N	BM 26-33C	10,072	NWSE	26	39.406006	-107.962544	0.76	W4.9°N	
26N	BM 26-33D	10,068	NWSE	26	39.405124	-107.962544	0.75	W0.3°N	
26N	BM 26-34A	10,087	SWSE	26	39.404311	-107.962565	0.76	S86.1°W	
26N	BM 26-34B	10,046	SWSE	26	39.403498	-107.962561	0.77	S81.9°W	
26N	BM 26-34C	9,986	SWSE	26	39.402515	-107.962576	0.78	S77.0°W	
26N	BM 26-34D	9,986	SWSE	26	39.401665	-107.964508	0.90	S75.0°W	
26K	BM 26-22B	10,094	SENW	26	39.410530	-107.967228	1.07	W21.1°N	
26K	BM 26-22C	10,047	SENW	26	39.409618	-107.967223	1.05	W17.8°N	
26K	BM 26-22D	10,057	SENW	26	39.408687	-107.967163	1.03	W14.6°N	

Abbreviations:

BHL bottom-hole location
 GZ ground zero
 Lat latitude
 Long longitude
 NAD 83 North American Datum of 1983
 Q-Q quarter-quarter section
 S Section

Appendix A
Liquid-Phase Sample Results

RESULTS REPORT
RIN: 12064624
Site: Rulison Site
Location: BM 26-22B
Ticket Number: KHW 691
Report Date: 9/12/2012

Parameter	Units	Sample Date	ID	Result	TPU ¹	Lab	Qualifiers Data	QA
Actinium-228	pCi/L	06/19/2012	N001	5.79	18.8	U		#
Americium-241	pCi/L	06/19/2012	N001	26.3	59.9	U		#
Antimony-125	pCi/L	06/19/2012	N001	5.24	5.64	U		#
Cerium-144	pCi/L	06/19/2012	N001	3.57	13.4	U		#
Cesium-134	pCi/L	06/19/2012	N001	-1.33	2.46	U		#
Cesium-137	pCi/L	06/19/2012	N001	-2.75	2.32	U		#
Chloride	mg/L	06/19/2012	N001	9200				#
Cobalt-60	pCi/L	06/19/2012	N001	0.468	2.47	U		#
Europium-152	pCi/L	06/19/2012	N001	-1.38	11.8	U		#
Europium-154	pCi/L	06/19/2012	N001	-4.31	12.5	U		#
Europium-155	pCi/L	06/19/2012	N001	10.4	12.7	U		#
Gross Alpha	pCi/L	06/19/2012	N001	43.7	30.3	U		#
Gross Beta	pCi/L	06/19/2012	N001	147	47		J	#
Lead-212	pCi/L	06/19/2012	N001	8.34	7.63	U		#
Potassium-40	pCi/L	06/19/2012	N001	50.9	68.1	U		#
Promethium-144	pCi/L	06/19/2012	N001	-1.26	2.43	U		#
Promethium-146	pCi/L	06/19/2012	N001	1.25	2.57	U		#
Ruthenium-106	pCi/L	06/19/2012	N001	-5.06	21.4	U		#
Thorium-234	pCi/L	06/19/2012	N001	88.4	120	U		#
Tritium	pCi/L	06/19/2012	N001	-159	198	U		#
Uranium-235	pCi/L	06/19/2012	N001	17.6	16.8	U		#
Uranium-238	pCi/L	06/19/2012	N001	88.4	120	U		#
Yttrium-88	pCi/L	06/19/2012	N001	-1.75	4.58	U		#

RESULTS REPORT
RIN: 12064624
Site: Rulison Site
Location: BM 26-22C
Ticket Number: KHW 692
Report Date: 9/12/2012

Parameter	Units	Sample		Result	TPU ¹	Qualifiers	
		Date	ID			Lab	Data
Actinium-228	pCi/L	06/19/2012	N001	38.8	10.8		J #
Americium-241	pCi/L	06/19/2012	N001	11.2	15.6	U	#
Antimony-125	pCi/L	06/19/2012	N001	-3.4	7.59	U	#
Cerium-144	pCi/L	06/19/2012	N001	0.353	13.5	U	#
Cesium-134	pCi/L	06/19/2012	N001	-1.59	4.74	U	#
Cesium-137	pCi/L	06/19/2012	N001	-0.291	3.34	U	#
Chloride	mg/L	06/19/2012	N001	13000			#
Cobalt-60	pCi/L	06/19/2012	N001	-2.74	3.72	U	#
Europium-152	pCi/L	06/19/2012	N001	-11.2	19.5	U	#
Europium-154	pCi/L	06/19/2012	N001	-19.8	18.6	U	#
Europium-155	pCi/L	06/19/2012	N001	5.13	8	U	#
Gross Alpha	pCi/L	06/19/2012	N001	25.6	36.8	U	#
Gross Beta	pCi/L	06/19/2012	N001	223	58.2		#
Lead-212	pCi/L	06/19/2012	N001	11	9.04	U	#
Potassium-40	pCi/L	06/19/2012	N001	182	94.9		J #
Promethium-144	pCi/L	06/19/2012	N001	0.924	3.52	U	#
Promethium-146	pCi/L	06/19/2012	N001	-1.94	3.7	U	#
Ruthenium-106	pCi/L	06/19/2012	N001	-12.1	30.1	U	#
Thorium-234	pCi/L	06/19/2012	N001	15.2	86.6	U	#
Tritium	pCi/L	06/19/2012	N001	-274	196	U	#
Uranium-235	pCi/L	06/19/2012	N001	10.3	13.7	U	#
Uranium-238	pCi/L	06/19/2012	N001	15.2	86.6	U	#
Yttrium-88	pCi/L	06/19/2012	N001	3.13	3.73	U	#

RESULTS REPORT
RIN: 12064624
Site: Rulison Site
Location: BM 26-22D
Ticket Number: KHW 694
Report Date: 9/12/2012

Parameter	Units	Sample		Result	TPU ¹	Qualifiers	
		Date	ID			Lab	Data
Actinium-228	pCi/L	06/19/2012	N001	36.5	11		J #
Americium-241	pCi/L	06/19/2012	N001	3.8	16.8	U	#
Antimony-125	pCi/L	06/19/2012	N001	-0.838	7.44	U	#
Cerium-144	pCi/L	06/19/2012	N001	6.52	14.1	U	#
Cesium-134	pCi/L	06/19/2012	N001	2.67	4.26	U	#
Cesium-137	pCi/L	06/19/2012	N001	-1.35	2.9	U	#
Chloride	mg/L	06/19/2012	N001	14000			#
Cobalt-60	pCi/L	06/19/2012	N001	-0.771	3.31	U	#
Europium-152	pCi/L	06/19/2012	N001	-7.94	15.5	U	#
Europium-154	pCi/L	06/19/2012	N001	7.45	16	U	#
Europium-155	pCi/L	06/19/2012	N001	7.04	7.57	U	#
Gross Alpha	pCi/L	06/19/2012	N001	23.3	40.8	U	#
Gross Beta	pCi/L	06/19/2012	N001	249	62.6		#
Lead-212	pCi/L	06/19/2012	N001	17.5	8.2		J #
Potassium-40	pCi/L	06/19/2012	N001	137	85.2	U	#
Promethium-144	pCi/L	06/19/2012	N001	2.11	3.17	U	#
Promethium-146	pCi/L	06/19/2012	N001	2.42	3.34	U	#
Ruthenium-106	pCi/L	06/19/2012	N001	25.9	30.6	U	#
Thorium-234	pCi/L	06/19/2012	N001	-0.351	78.8	U	#
Tritium	pCi/L	06/19/2012	N001	-218	197	U	#
Uranium-235	pCi/L	06/19/2012	N001	24.9	14.3		U #
Uranium-238	pCi/L	06/19/2012	N001	-0.351	78.8	U	#
Yttrium-88	pCi/L	06/19/2012	N001	4.55	3.17	U	#

RESULTS REPORT
RIN: 12064624
Site: Rulison Site
Location: BM 26-33B
Ticket Number: KHW 684
Report Date: 9/12/2012

Parameter	Units	Sample		Result	TPU ¹	Qualifiers	
		Date	ID			Lab	Data
Actinium-228	pCi/L	06/19/2012	N001	29.7	10.8		J #
Americium-241	pCi/L	06/19/2012	N001	-16.2	16.2	U	#
Antimony-125	pCi/L	06/19/2012	N001	-3.31	6.03	U	#
Cerium-144	pCi/L	06/19/2012	N001	-9.14	16.1	U	#
Cesium-134	pCi/L	06/19/2012	N001	-2.86	2.55	U	#
Cesium-137	pCi/L	06/19/2012	N001	0.167	2.38	U	#
Chloride	mg/L	06/19/2012	N001	13000			#
Cobalt-60	pCi/L	06/19/2012	N001	-0.496	2.62	U	#
Europium-152	pCi/L	06/19/2012	N001	-4.52	13.3	U	#
Europium-154	pCi/L	06/19/2012	N001	-5.86	13	U	#
Europium-155	pCi/L	06/19/2012	N001	5.07	6.28	U	#
Gross Alpha	pCi/L	06/19/2012	N001	28.8	37.2	U	#
Gross Beta	pCi/L	06/19/2012	N001	91.8	47		J #
Lead-212	pCi/L	06/19/2012	N001	8.1	7.05	U	#
Potassium-40	pCi/L	06/19/2012	N001	43.6	71.9	U	#
Promethium-144	pCi/L	06/19/2012	N001	-0.786	2.85	U	#
Promethium-146	pCi/L	06/19/2012	N001	-2.99	2.63	U	#
Ruthenium-106	pCi/L	06/19/2012	N001	10.2	22	U	#
Thorium-234	pCi/L	06/19/2012	N001	25.4	70.6	U	#
Tritium	pCi/L	06/19/2012	N001	-70.6	202	U	#
Uranium-235	pCi/L	06/19/2012	N001	15.8	11	U	#
Uranium-238	pCi/L	06/19/2012	N001	25.4	70.6	U	#
Yttrium-88	pCi/L	06/19/2012	N001	-0.07	2.62	U	#

RESULTS REPORT
RIN: 12064624
Site: Rulison Site
Location: BM 26-33C
Ticket Number: KHW 685
Report Date: 9/12/2012

Parameter	Units	Sample		Result	TPU ¹	Qualifiers	
		Date	ID			Lab	Data
Actinium-228	pCi/L	06/19/2012	N001	32	12		U #
Americium-241	pCi/L	06/19/2012	N001	-1.04	2.58	U	#
Antimony-125	pCi/L	06/19/2012	N001	3.51	4.91	U	#
Cerium-144	pCi/L	06/19/2012	N001	-1.71	8.59	U	#
Cesium-134	pCi/L	06/19/2012	N001	-0.947	2.32	U	#
Cesium-137	pCi/L	06/19/2012	N001	-0.243	2.27	U	#
Chloride	mg/L	06/19/2012	N001	12000			#
Cobalt-60	pCi/L	06/19/2012	N001	-2.16	2.62	U	#
Europium-152	pCi/L	06/19/2012	N001	-0.384	11.7	U	#
Europium-154	pCi/L	06/19/2012	N001	-13.6	13.3	U	#
Europium-155	pCi/L	06/19/2012	N001	0.955	4.18	U	#
Gross Alpha	pCi/L	06/19/2012	N001	5.31	36	U	#
Gross Beta	pCi/L	06/19/2012	N001	171	52.3		J #
Lead-212	pCi/L	06/19/2012	N001	6.63	6.55	U	#
Potassium-40	pCi/L	06/19/2012	N001	104	73.4	U	#
Promethium-144	pCi/L	06/19/2012	N001	-1.42	2.37	U	#
Promethium-146	pCi/L	06/19/2012	N001	-2.08	2.51	U	#
Ruthenium-106	pCi/L	06/19/2012	N001	-13.7	21.1	U	#
Thorium-234	pCi/L	06/19/2012	N001	13.4	44.5	U	#
Tritium	pCi/L	06/19/2012	N001	-204	199	U	#
Uranium-235	pCi/L	06/19/2012	N001	14.7	8.52		U #
Uranium-238	pCi/L	06/19/2012	N001	13.4	44.5	U	#
Yttrium-88	pCi/L	06/19/2012	N001	3.66	2.54	U	#

RESULTS REPORT
RIN: 12064624
Site: Rulison Site
Location: BM 26-34B
Ticket Number: KHW 688
Report Date: 9/12/2012

Parameter	Units	Sample		Result	TPU ¹	Qualifiers	
		Date	ID			Lab	Data
Actinium-228	pCi/L	06/19/2012	N001	24.1	13.4	U	#
Americium-241	pCi/L	06/19/2012	N001	5.97	3.85	U	#
Antimony-125	pCi/L	06/19/2012	N001	3.21	6.43	U	#
Cerium-144	pCi/L	06/19/2012	N001	-9.7	12.3	U	#
Cesium-134	pCi/L	06/19/2012	N001	-1.47	2.74	U	#
Cesium-137	pCi/L	06/19/2012	N001	0.743	3.08	U	#
Chloride	mg/L	06/19/2012	N001	12000			#
Cobalt-60	pCi/L	06/19/2012	N001	-0.336	3.52	U	#
Europium-152	pCi/L	06/19/2012	N001	8.67	17	U	#
Europium-154	pCi/L	06/19/2012	N001	-9.87	16.4	U	#
Europium-155	pCi/L	06/19/2012	N001	0.0664	5.31	U	#
Gross Alpha	pCi/L	06/19/2012	N001	22.1	31.9	U	#
Gross Beta	pCi/L	06/19/2012	N001	80.7	47.1		J #
Lead-212	pCi/L	06/19/2012	N001	7.41	7.23	U	#
Potassium-40	pCi/L	06/19/2012	N001	60.8	79	U	#
Promethium-144	pCi/L	06/19/2012	N001	3.95	3.11	U	#
Promethium-146	pCi/L	06/19/2012	N001	-2.39	3.37	U	#
Ruthenium-106	pCi/L	06/19/2012	N001	1.03	26.9	U	#
Thorium-234	pCi/L	06/19/2012	N001	57.2	51	U	#
Tritium	pCi/L	06/19/2012	N001	-294	198	U	#
Uranium-235	pCi/L	06/19/2012	N001	15.4	12.1	U	#
Uranium-238	pCi/L	06/19/2012	N001	57.2	51	U	#
Yttrium-88	pCi/L	06/19/2012	N001	2.64	5.34	U	#

RESULTS REPORT
RIN: 12064624
Site: Rulison Site
Location: BM 26-34C
Ticket Number: KHW 689
Report Date: 9/12/2012

Parameter	Units	Sample		Result	TPU ¹	Qualifiers	
		Date	ID			Lab	Data
Actinium-228	pCi/L	06/19/2012	N001	15.6	11.4	U	#
Americium-241	pCi/L	06/19/2012	N001	-2.69	13.1	U	#
Antimony-125	pCi/L	06/19/2012	N001	1.83	6.2	U	#
Cerium-144	pCi/L	06/19/2012	N001	2.5	10.8	U	#
Cesium-134	pCi/L	06/19/2012	N001	-1.68	2.72	U	#
Cesium-137	pCi/L	06/19/2012	N001	-1.82	2.63	U	#
Chloride	mg/L	06/19/2012	N001	13000			#
Cobalt-60	pCi/L	06/19/2012	N001	1.28	2.69	U	#
Europium-152	pCi/L	06/19/2012	N001	0.413	12.4	U	#
Europium-154	pCi/L	06/19/2012	N001	-13	12.4	U	#
Europium-155	pCi/L	06/19/2012	N001	-3.31	6.46	U	#
Gross Alpha	pCi/L	06/19/2012	N001	7.94	30.7	U	#
Gross Beta	pCi/L	06/19/2012	N001	93.6	44.2		J #
Lead-212	pCi/L	06/19/2012	N001	8.18	6.6	U	#
Potassium-40	pCi/L	06/19/2012	N001	46.6	72.9	U	#
Promethium-144	pCi/L	06/19/2012	N001	0.604	2.69	U	#
Promethium-146	pCi/L	06/19/2012	N001	-0.0294	3.12	U	#
Ruthenium-106	pCi/L	06/19/2012	N001	16.2	24.2	U	#
Thorium-234	pCi/L	06/19/2012	N001	12.8	76.5	U	#
Tritium	pCi/L	06/19/2012	N001	-243	194	U	#
Uranium-235	pCi/L	06/19/2012	N001	18.8	10.5		U #
Uranium-238	pCi/L	06/19/2012	N001	12.8	76.5	U	#
Yttrium-88	pCi/L	06/19/2012	N001	-0.26	6.87	U	#

RESULTS REPORT
RIN: 12064624
Site: Rulison Site
Location: BM 26-34D
Ticket Number: KHW 690
Report Date: 9/12/2012

Parameter	Units	Sample		Result	TPU ¹	Qualifiers	
		Date	ID			Lab	Data
Actinium-228	pCi/L	06/19/2012	N001	27.3	8.93		J #
Americium-241	pCi/L	06/19/2012	N001	-16	16.4	U	#
Antimony-125	pCi/L	06/19/2012	N001	1.97	5.76	U	#
Cerium-144	pCi/L	06/19/2012	N001	-2.98	16.3	U	#
Cesium-134	pCi/L	06/19/2012	N001	-3.04	2.58	U	#
Cesium-137	pCi/L	06/19/2012	N001	0.389	2.46	U	#
Chloride	mg/L	06/19/2012	N001	14000			#
Cobalt-60	pCi/L	06/19/2012	N001	-1.9	2.71	U	#
Europium-152	pCi/L	06/19/2012	N001	-2.43	13.3	U	#
Europium-154	pCi/L	06/19/2012	N001	2.2	13.7	U	#
Europium-155	pCi/L	06/19/2012	N001	5.92	6.45	U	#
Gross Alpha	pCi/L	06/19/2012	N001	17.5	36	U	#
Gross Beta	pCi/L	06/19/2012	N001	135	49.7		J #
Lead-212	pCi/L	06/19/2012	N001	7.81	7.2	U	#
Potassium-40	pCi/L	06/19/2012	N001	73	73.3	U	#
Promethium-144	pCi/L	06/19/2012	N001	3	1.64	U	#
Promethium-146	pCi/L	06/19/2012	N001	1.86	2.61	U	#
Ruthenium-106	pCi/L	06/19/2012	N001	1.39	31.1	U	#
Thorium-234	pCi/L	06/19/2012	N001	5.61	68.5	U	#
Tritium	pCi/L	06/19/2012	N001	-159	195	U	#
Uranium-235	pCi/L	06/19/2012	N001	-4.26	16.5	U	#
Uranium-238	pCi/L	06/19/2012	N001	5.61	68.5	U	#
Yttrium-88	pCi/L	06/19/2012	N001	1.41	2.74	U	#

Appendix B
Gas-Phase Sample Results

RESULTS REPORT
RIN: 12064623
Site: Rulison Site
Location: BM 26-22B
Ticket Number: KHW 681
Report Date: 9/13/2012

Parameter	Units	Sample		Result	Qualifiers	
		Date	ID		Lab	Data QA
Hydrogen	percent	6/19/2012	0001	nd ¹		#
Argon+Oxygen	percent	6/19/2012	0001	0.016		#
Nitrogen	percent	6/19/2012	0001	0.18		#
Carbon Dioxide	percent	6/19/2012	0001	3.73		#
Methane	percent	6/19/2012	0001	90.57		#
Ethane	percent	6/19/2012	0001	3.86		#
Ethene	percent	6/19/2012	0001	nd ¹		#
Propane	percent	6/19/2012	0001	0.97		#
Propene	percent	6/19/2012	0001	nd ¹		#
Isobutane	percent	6/19/2012	0001	0.212		#
Butane	percent	6/19/2012	0001	0.182		#
Isopentane	percent	6/19/2012	0001	0.078		#
Pentane	percent	6/19/2012	0001	0.053		#
Hexanes	percent	6/19/2012	0001	0.152		#
Carbon-14	Percent modern carbon	6/19/2012	0001	0.2	U	#
Tritium	pCi/L methane	6/19/2012	0001	0.0514	U	#

¹ Not detected.

RESULTS REPORT
RIN: 12064623
Site: Rulison Site
Location: BM 26-22C
Ticket Number: KHW 682
Report Date: 9/13/2012

Parameter	Units	Sample		Result	Qualifiers	
		Date	ID		Lab	Data
Hydrogen	percent	6/19/2012	0001	nd ¹		#
Argon+Oxygen	percent	6/19/2012	0001	0.019		#
Nitrogen	percent	6/19/2012	0001	0.19		#
Carbon Dioxide	percent	6/19/2012	0001	3.54		#
Methane	percent	6/19/2012	0001	90.06		#
Ethane	percent	6/19/2012	0001	4.23		#
Ethene	percent	6/19/2012	0001	nd ¹		#
Propane	percent	6/19/2012	0001	1.15		#
Propene	percent	6/19/2012	0001	nd ¹		#
Isobutane	percent	6/19/2012	0001	0.244		#
Butane	percent	6/19/2012	0001	0.231		#
Isopentane	percent	6/19/2012	0001	0.096		#
Pentane	percent	6/19/2012	0001	0.069		#
Hexanes	percent	6/19/2012	0001	0.172		#
Carbon-14	Percent modern carbon	6/19/2012	0001	0.2	U	#
Tritium	pCi/L methane	6/19/2012	0001	0.0514	U	#

¹ Not detected.

RESULTS REPORT
RIN: 12064623
Site: Rulison Site
Location: BM 26-22D
Ticket Number: KHW 683
Report Date: 9/13/2012

Parameter	Units	Sample		Result	Qualifiers	
		Date	ID		Lab	Data QA
Hydrogen	percent	6/19/2012	0001	nd ¹		#
Argon+Oxygen	percent	6/19/2012	0001	0.007		#
Nitrogen	percent	6/19/2012	0001	0.10		#
Carbon Dioxide	percent	6/19/2012	0001	2.66		#
Methane	percent	6/19/2012	0001	91.07		#
Ethane	percent	6/19/2012	0001	4.07		#
Ethene	percent	6/19/2012	0001	nd ¹		#
Propane	percent	6/19/2012	0001	1.18		#
Propene	percent	6/19/2012	0001	nd ¹		#
Isobutane	percent	6/19/2012	0001	0.247		#
Butane	percent	6/19/2012	0001	0.261		#
Isopentane	percent	6/19/2012	0001	0.108		#
Pentane	percent	6/19/2012	0001	0.082		#
Hexanes	percent	6/19/2012	0001	0.219		#
Carbon-14	Percent modern carbon	6/19/2012	0001	0.2	U	#
Tritium	pCi/L methane	6/19/2012	0001	0.0514	U	#

¹ Not detected.

RESULTS REPORT
RIN: 12064623
Site: Rulison Site
Location: BM 26-33B
Ticket Number: KHW 674
Report Date: 9/13/2012

Parameter	Units	Sample		Result	Qualifiers	
		Date	ID		Lab	Data
Hydrogen	percent	6/19/2012	0001	nd ¹		#
Argon+Oxygen	percent	6/19/2012	0001	0.62		#
Nitrogen	percent	6/19/2012	0001	2.60		#
Carbon Dioxide	percent	6/19/2012	0001	2.60		#
Methane	percent	6/19/2012	0001	87.58		#
Ethane	percent	6/19/2012	0001	4.37		#
Ethene	percent	6/19/2012	0001	nd ¹		#
Propane	percent	6/19/2012	0001	1.25		#
Propene	percent	6/19/2012	0001	nd ¹		#
Isobutane	percent	6/19/2012	0001	0.273		#
Butane	percent	6/19/2012	0001	0.264		#
Isopentane	percent	6/19/2012	0001	0.112		#
Pentane	percent	6/19/2012	0001	0.085		#
Hexanes	percent	6/19/2012	0001	0.248		#
Carbon-14	Percent modern carbon	6/19/2012	0001	0.2	U	#
Tritium	pCi/L methane	6/19/2012	0001	0.0514	U	#

¹ Not detected.

RESULTS REPORT
RIN: 12064623
Site: Rulison Site
Location: BM 26-33C
Ticket Number: KHW 675
Report Date: 9/13/2012

Parameter	Units	Sample		Result	Qualifiers	
		Date	ID		Lab	Data QA
Hydrogen	percent	6/19/2012	0001	nd ¹		#
Argon+Oxygen	percent	6/19/2012	0001	0.014		#
Nitrogen	percent	6/19/2012	0001	0.16		#
Carbon Dioxide	percent	6/19/2012	0001	2.76		#
Methane	percent	6/19/2012	0001	90.54		#
Ethane	percent	6/19/2012	0001	4.42		#
Ethene	percent	6/19/2012	0001	nd ¹		#
Propane	percent	6/19/2012	0001	1.22		#
Propene	percent	6/19/2012	0001	nd ¹		#
Isobutane	percent	6/19/2012	0001	0.262		#
Butane	percent	6/19/2012	0001	0.246		#
Isopentane	percent	6/19/2012	0001	0.098		#
Pentane	percent	6/19/2012	0001	0.071		#
Hexanes	percent	6/19/2012	0001	0.212		#
Carbon-14	Percent modern carbon	6/19/2012	0001	0.2	U	#
Tritium	pCi/L methane	6/19/2012	0001	0.0932	U	#

¹ Not detected.

RESULTS REPORT
RIN: 12064623
Site: Rulison Site
Location: BM 26-33D
Ticket Number: KHW 676
Report Date: 9/13/2012

Parameter	Units	Sample		Result	Qualifiers	
		Date	ID		Lab	Data QA
Hydrogen	percent	6/19/2012	0001	nd ¹		#
Argon+Oxygen	percent	6/19/2012	0001	0.009		#
Nitrogen	percent	6/19/2012	0001	0.13		#
Carbon Dioxide	percent	6/19/2012	0001	3.67		#
Methane	percent	6/19/2012	0001	89.40		#
Ethane	percent	6/19/2012	0001	4.57		#
Ethene	percent	6/19/2012	0001	nd ¹		#
Propane	percent	6/19/2012	0001	1.23		#
Propene	percent	6/19/2012	0001	nd ¹		#
Isobutane	percent	6/19/2012	0001	0.281		#
Butane	percent	6/19/2012	0001	0.270		#
Isopentane	percent	6/19/2012	0001	0.117		#
Pentane	percent	6/19/2012	0001	0.084		#
Hexanes	percent	6/19/2012	0001	0.245		#
Carbon-14	Percent modern carbon	6/19/2012	0001	0.2	U	#
Tritium*	pCi/L methane	6/19/2012	0001	0.072		#

¹ Not detected.

* To verify this tritium result, another gas sample was collected from well BM 26-33D on September 20, 2012. The analytical result was below the detection limit of 0.06 pCi/L (methane).

RESULTS REPORT
RIN: 12064623
Site: Rulison Site
Location: BM 26-34A
Ticket Number: KHW 677
Report Date: 9/13/2012

Parameter	Units	Sample		Result	Qualifiers	
		Date	ID		Lab	Data
Hydrogen	percent	6/19/2012	0001	nd ¹		#
Argon+Oxygen	percent	6/19/2012	0001	0.012		#
Nitrogen	percent	6/19/2012	0001	0.14		#
Carbon Dioxide	percent	6/19/2012	0001	3.55		#
Methane	percent	6/19/2012	0001	89.30		#
Ethane	percent	6/19/2012	0001	4.65		#
Ethene	percent	6/19/2012	0001	nd ¹		#
Propane	percent	6/19/2012	0001	1.34		#
Propene	percent	6/19/2012	0001	nd ¹		#
Isobutane	percent	6/19/2012	0001	0.287		#
Butane	percent	6/19/2012	0001	0.272		#
Isopentane	percent	6/19/2012	0001	0.123		#
Pentane	percent	6/19/2012	0001	0.088		#
Hexanes	percent	6/19/2012	0001	0.241		#
Carbon-14	Percent modern carbon	6/19/2012	0001	0.2	U	#
Tritium	pCi/L methane	6/19/2012	0001	0.0514	U	#

¹ Not detected.

RESULTS REPORT
RIN: 12064623
Site: Rulison Site
Location: BM 26-34B
Ticket Number: KHW 678
Report Date: 9/13/2012

Parameter	Units	Sample		Result	Qualifiers	
		Date	ID		Lab	Data QA
Hydrogen	percent	6/19/2012	0001	nd ¹		#
Argon+Oxygen	percent	6/19/2012	0001	0.048		#
Nitrogen	percent	6/19/2012	0001	0.29		#
Carbon Dioxide	percent	6/19/2012	0001	3.41		#
Methane	percent	6/19/2012	0001	89.69		#
Ethane	percent	6/19/2012	0001	4.44		#
Ethene	percent	6/19/2012	0001	nd ¹		#
Propane	percent	6/19/2012	0001	1.22		#
Propene	percent	6/19/2012	0001	nd ¹		#
Isobutane	percent	6/19/2012	0001	0.273		#
Butane	percent	6/19/2012	0001	0.249		#
Isopentane	percent	6/19/2012	0001	0.103		#
Pentane	percent	6/19/2012	0001	0.075		#
Hexanes	percent	6/19/2012	0001	0.199		#
Carbon-14	Percent modern carbon	6/19/2012	0001	0.2	U	#
Tritium	pCi/L methane	6/19/2012	0001	0.0514	U	#

¹ Not detected.

RESULTS REPORT
RIN: 12064623
Site: Rulison Site
Location: BM 26-34C
Ticket Number: KHW 679
Report Date: 9/13/2012

Parameter	Units	Sample		Result	Qualifiers	
		Date	ID		Lab	Data QA
Hydrogen	percent	6/19/2012	0001	nd ¹		#
Argon+Oxygen	percent	6/19/2012	0001	0.012		#
Nitrogen	percent	6/19/2012	0001	0.14		#
Carbon Dioxide	percent	6/19/2012	0001	3.19		#
Methane	percent	6/19/2012	0001	90.29		#
Ethane	percent	6/19/2012	0001	4.28		#
Ethene	percent	6/19/2012	0001	nd ¹		#
Propane	percent	6/19/2012	0001	1.19		#
Propene	percent	6/19/2012	0001	nd ¹		#
Isobutane	percent	6/19/2012	0001	0.247		#
Butane	percent	6/19/2012	0001	0.243		#
Isopentane	percent	6/19/2012	0001	0.100		#
Pentane	percent	6/19/2012	0001	0.075		#
Hexanes	percent	6/19/2012	0001	0.230		#
Carbon-14	Percent modern carbon	6/19/2012	0001	0.2	U	#
Tritium	pCi/L methane	6/19/2012	0001	0.0514	U	#

¹ Not detected.

RESULTS REPORT
RIN: 12064623
Site: Rulison Site
Location: BM 26-34D
Ticket Number: KHW 680
Report Date: 9/13/2012

Parameter	Units	Sample		Result	Qualifiers	
		Date	ID		Lab	Data
Hydrogen	percent	6/19/2012	0001	nd ¹		#
Argon+Oxygen	percent	6/19/2012	0001	0.010		#
Nitrogen	percent	6/19/2012	0001	0.12		#
Carbon Dioxide	percent	6/19/2012	0001	2.87		#
Methane	percent	6/19/2012	0001	90.65		#
Ethane	percent	6/19/2012	0001	4.33		#
Ethene	percent	6/19/2012	0001	nd ¹		#
Propane	percent	6/19/2012	0001	1.20		#
Propene	percent	6/19/2012	0001	nd ¹		#
Isobutane	percent	6/19/2012	0001	0.241		#
Butane	percent	6/19/2012	0001	0.241		#
Isopentane	percent	6/19/2012	0001	0.094		#
Pentane	percent	6/19/2012	0001	0.070		#
Hexanes	percent	6/19/2012	0001	0.173		#
Carbon-14	Percent modern carbon	6/19/2012	0001	0.2	U	#
Tritium	pCi/L methane	6/19/2012	0001	0.0514	U	#

¹ Not detected.