

**Monitoring Results
Natural Gas Wells
Near Project Rulison**

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

Date Sampled:

1 September 2011

Purpose:

The purpose of this environmental sample collection is to monitor natural gas and production water from natural gas wells drilled near the Project Rulison test site. As part of the Department of Energy's (DOE's) directive to protect human health and the environment, samples are collected from producing gas wells and analyzed to ensure no Rulison related radionuclides have migrated outside the DOE institution control boundary. Using the DOE *Rulison Monitoring Plan* as guidance, sample collection frequency is based on distance from the Rulison detonation point. The monitoring plan also specifies the type of analysis and the reporting thresholds.

Background:

Project Rulison was the second Plowshare Program test to stimulate natural-gas recovery. 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.

Samples Collected:

A produced-water sample was collected from each of six producing natural-gas wells. A seventh producing well was sampled but did not make enough water for laboratory analysis. No natural-gas samples were collected (per guidance in the *DOE Rulison Monitoring Plan*, referenced on page 2). The wells sampled are listed by name in Table 1.

Sample Locations:

The bottom-hole locations (BHLs) of the 7 gas wells sampled are between 0.76 and 0.90 miles from the Project Rulison detonation point. All wells sampled are producing gas from the Williams Fork Formation at a depth near the Rulison detonation point.

Summary of Results:

No analytical result exceeded its respective screening level.

Table 1. Sample Collection Locations

Pad	Collection Location	Well Name
26N	Well head separator	Battlement Mesa (BM) 26-33B,-33C,-33D,-34A,-34B,-34C,-34D

Produced-water samples were collected from a tap on the common line connecting two gas-liquid separators and the accumulation tank. The produced water collected from one well separator was isolated from the other well separator by valves. Lines from each of the two separators were purged of produced water and condensate prior to sample collection.

Table 2 lists the wells in the order of sample collection.

Table 2. Sample Collection Information

Seq.	Name	API # 05-045-	Location subtype	Sample Phase		BHL Data		Comments
				Gas	Liquid	T (°F)	P (psi)	
1	BM 26-33B	15743	NG-Angl	NA	X	62.2	252.7	~2.2 L sample collected: water and condensate
2	BM 26-33C	15742	NG-Angl	NA	X	62.0	256.5	~2.2 L sample collected: water and condensate
3	BM 26-33D	15739	NG-Angl	NA	X	60.9	257.1	~0.75 L sample collected: water and condensate
4	BM 26-34A	15744	NG-Angl	NA	NA	62.4	158.0	Well did not make an adequate sample for analysis
5	BM 26-34B	15745	NG-Angl	NA	X	62.1	256.0	~2.1 L sample collected: water and condensate
6	BM 26-34C	15741	NG-Angl	NA	X	59.2	255.9	~2.3 L sample collected: water and condensate
7	BM 26-34D	15748	NG-Angl	NA	X	60.3	252.5	~2.0 L sample collected: water and condensate

T: Temperature
L: liter

P: Pressure
NG-Vert: Vertical well

BM: Battlement Mesa
NA: Missing or not applicable

NG-Angl: Angled well

Monitoring Protocol:

The *Rulison Monitoring Plan* (July 2010, LMS/RUL/S06178) 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 Screening and Action Concentrations for Tritium Sample Results

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

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

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

Table 3 Notes: See the Rulison Monitoring Plan, Table 2, for response scenarios when the screening and/or action concentrations are exceeded.
 The derived air effluent concentration for 50 mrem-per-year dose from tritium exposure is 0.10 pCi (tritium) / (cc of methane).
 TU: tritium unit
 pCi/cc/TU: picocurie per cubic centimeter per tritium unit

Results:

Six unique liquid samples were collected from six producing gas wells.

Analytic results for each well sampled are listed after Table 6.

Laboratory Qualifiers:

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

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

Data Validation Qualifiers:

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

A laboratory result less than three times the one-sigma total propagated uncertainty is considered a “nondetect” and assigned the data qualifier “U.” Three times the one-sigma propagated uncertainty is called the Decision Level Concentration.

Results Summaries:

Summary results for tritium in the liquid phase are in Table 4a. Liquid-phase results for gross alpha/beta are summarized in Table 4b and potassium-40 results in Table 4c.

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

Collection Location	Total Samples (gas/liquid)	Tritium Results (gas phase)			Tritium Results (liquid phase)		
		Detect	Nondetect	NA	Detect	Nondetect	NA
Natural gas wells	0/7	0	0	0	0	6	1

NA: Missing or not applicable

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

Collection Location	Total Samples	Gross Alpha Results			Gross Beta Results		
		Detect	Nondetect	NA	Detect	Nondetect	NA
Natural gas wells	7	1	5	1	6	0	1

NA: Missing or not applicable

Data validation assigned “J” to four of the six gross beta results listed as “detect.”

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

Collection Location	Total Samples	Potassium-40 Results		
		Detect	Nondetect	NA
Natural gas wells	7	1	5	1

NA: Missing or not applicable

Data validation assigned “J” to the potassium-40 result listed as detect.

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

Table 5. Statistics for Detected Gross-Beta Results

Counting Statistic	Gross Beta	Units
Number of detects	6	NA
Maximum	254.0	pCi/L
Third quartile	176.2	pCi/L
Mean	155.5	pCi/L
Median	124.5	pCi/L
First quartile	120.0	pCi/L
Minimum	118.0	pCi/L

NA: Missing or not applicable

The distance and heading from the Rulison detonation horizon to the bottom-hole-locations of the wells samples 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		Ground zero (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	

Q-Q: quarter-quarter section

S: Section

Lat: latitude

Long: longitude

NAD 83: North American Datum of 1983

Liquid Phase Sample Results

RESULTS REPORT
RIN: 11084060
Site: Rulison Site
Location: BM 26-33B
Ticket Number: JJU 904
Report Date: 10/07/2011

Parameter	Units	Sample Date	Sample ID	Result	TPU ¹	Lab	Qualifiers Data	QA
CHLORIDE	MG/L	09/01/2011	N001	11000				#
GROSS ALPHA	pCi/L	09/01/2011	N001	-2.64	27.2	U		#
GROSS BETA	pCi/L	09/01/2011	N001	123	39.7		J	#
H-3	pCi/L	09/01/2011	N001	-54.4	175	U		#
Actinium-228	pCi/L	09/01/2011	N001	18.3	14.3	U		#
Americium-241	pCi/L	09/01/2011	N001	-15.5	29.6	U		#
Antimony-125	pCi/L	09/01/2011	N001	1.71	9.67	U		#
Cerium-144	pCi/L	09/01/2011	N001	3.2	19.4	U		#
Cesium-134	pCi/L	09/01/2011	N001	-2.32	4.27	U		#
Cesium-137	pCi/L	09/01/2011	N001	-5.51	4	U		#
Cobalt-60	pCi/L	09/01/2011	N001	-2.01	4.49	U		#
Europium-152	pCi/L	09/01/2011	N001	-19.8	20.6	U		#
Europium-154	pCi/L	09/01/2011	N001	20.8	22.4	U		#
Europium-155	pCi/L	09/01/2011	N001	6.31	11.2	U		#
Lead-212	pCi/L	09/01/2011	N001	-3.69	8.79	U		#
Potassium-40	pCi/L	09/01/2011	N001	98.7	79.9	U		#
Promethium-144	pCi/L	09/01/2011	N001	-0.202	4.01	U		#
Promethium-146	pCi/L	09/01/2011	N001	-3.54	4.42	U		#
Ruthenium-106	pCi/L	09/01/2011	N001	-5.57	34.3	U		#
Thorium-234	pCi/L	09/01/2011	N001	-1.55	103	U		#
Uranium-235	pCi/L	09/01/2011	N001	28.3	18.9	U		#
Uranium-238	pCi/L	09/01/2011	N001	-1.55	103	U		#
Yttrium-88	pCi/L	09/01/2011	N001	0	4.65	U		#

¹ TPU – Total Propagated Uncertainty reported at 2-sigma.

RESULTS REPORT
RIN: 11084060
Site: Rulison Site
Location: BM 26-33C
Ticket Number: JJU 905
Report Date: 10/07/2011

Parameter	Units	Sample Date	Sample ID	Result	TPU ¹	Lab	Qualifiers Data	QA
CHLORIDE	MG/L	09/01/2011	N001	12000				#
GROSS ALPHA	pCi/L	09/01/2011	N001	12.9	27.8	U		#
GROSS BETA	pCi/L	09/01/2011	N001	254	54.1			#
H-3	pCi/L	09/01/2011	N001	-58.6	174	U		#
Actinium-228	pCi/L	09/01/2011	N001	22.3	18.9	U		#
Americium-241	pCi/L	09/01/2011	N001	18.2	19.7	U		#
Antimony-125	pCi/L	09/01/2011	N001	-9.89	11.3	U		#
Cerium-144	pCi/L	09/01/2011	N001	9.52	19.2	U		#
Cesium-134	pCi/L	09/01/2011	N001	-5.38	4.83	U		#
Cesium-137	pCi/L	09/01/2011	N001	0.232	4.98	U		#
Cobalt-60	pCi/L	09/01/2011	N001	-1.95	5.7	U		#
Europium-152	pCi/L	09/01/2011	N001	-8.61	27.3	U		#
Europium-154	pCi/L	09/01/2011	N001	-10.5	28.9	U		#
Europium-155	pCi/L	09/01/2011	N001	1.87	10.1	U		#
Lead-212	pCi/L	09/01/2011	N001	1.61	9.42	U		#
Potassium-40	pCi/L	09/01/2011	N001	282	111		J	#
Promethium-144	pCi/L	09/01/2011	N001	3.54	5.01	U		#
Promethium-146	pCi/L	09/01/2011	N001	3.1	5.23	U		#
Ruthenium-106	pCi/L	09/01/2011	N001	-25.7	42.5	U		#
Thorium-234	pCi/L	09/01/2011	N001	-58.3	108	U		#
Uranium-235	pCi/L	09/01/2011	N001	16.9	18.9	U		#
Uranium-238	pCi/L	09/01/2011	N001	-58.3	108	U		#
Yttrium-88	pCi/L	09/01/2011	N001	-0.855	8.46	U		#

¹ TPU – Total Propagated Uncertainty reported at 2-sigma.

RESULTS REPORT
RIN: 11084060
Site: Rulison Site
Location: BM 26-33D
Ticket Number: JJU 906
Report Date: 10/07/2011

Parameter	Units	Sample Date	Sample ID	Result	TPU ¹	Lab	Qualifiers Data	QA
CHLORIDE	MG/L	09/01/2011	N001	3000				#
GROSS ALPHA	pCi/L	09/01/2011	N001	72.8	16.7			#
GROSS BETA	pCi/L	09/01/2011	N001	193	34.3			#
H-3	pCi/L	09/01/2011	N001	-58.7	173	U		#
Actinium-228	pCi/L	09/01/2011	N001	47	27.6		U	#
Americium-241	pCi/L	09/01/2011	N001	-1.45	15.1	U		#
Antimony-125	pCi/L	09/01/2011	N001	5.82	15.2	U		#
Cerium-144	pCi/L	09/01/2011	N001	27.3	31.3	U		#
Cesium-134	pCi/L	09/01/2011	N001	-6.58	6.65	U		#
Cesium-137	pCi/L	09/01/2011	N001	0	7.23	U		#
Cobalt-60	pCi/L	09/01/2011	N001	2.19	8.46	U		#
Europium-152	pCi/L	09/01/2011	N001	-17.9	43.1	U		#
Europium-154	pCi/L	09/01/2011	N001	2.48	38	U		#
Europium-155	pCi/L	09/01/2011	N001	0.719	15.7	U		#
Lead-212	pCi/L	09/01/2011	N001	3.25	15.5	U		#
Potassium-40	pCi/L	09/01/2011	N001	22.6	195	U		#
Promethium-144	pCi/L	09/01/2011	N001	5.45	7.38	U		#
Promethium-146	pCi/L	09/01/2011	N001	-1.64	7.92	U		#
Ruthenium-106	pCi/L	09/01/2011	N001	-40.7	58.3	U		#
Thorium-234	pCi/L	09/01/2011	N001	42.1	148	U		#
Uranium-235	pCi/L	09/01/2011	N001	25.2	20.8	U		#
Uranium-238	pCi/L	09/01/2011	N001	42.1	148	U		#
Yttrium-88	pCi/L	09/01/2011	N001	7.4	9.1	U		#

¹ TPU – Total Propagated Uncertainty reported at 2-sigma.

RESULTS REPORT
RIN: 11084060
Site: Rulison Site
Location: BM 26-34B
Ticket Number: JJU 908
Report Date: 10/07/2011

Parameter	Units	Sample Date	Sample ID	Result	TPU ¹	Lab	Qualifiers Data	QA
CHLORIDE	MG/L	09/01/2011	N001	12000				#
GROSS ALPHA	pCi/L	09/01/2011	N001	-18.2	24.4	U		#
GROSS BETA	pCi/L	09/01/2011	N001	118	38.1		J	#
H-3	pCi/L	09/01/2011	N001	-16.1	175	U		#
Actinium-228	pCi/L	09/01/2011	N001	23	15.7	U		#
Americium-241	pCi/L	09/01/2011	N001	-6.72	22.2	U		#
Antimony-125	pCi/L	09/01/2011	N001	-3.65	9.57	U		#
Cerium-144	pCi/L	09/01/2011	N001	-6.35	18.7	U		#
Cesium-134	pCi/L	09/01/2011	N001	3.74	5.63	U		#
Cesium-137	pCi/L	09/01/2011	N001	0.845	3.87	U		#
Cobalt-60	pCi/L	09/01/2011	N001	0.586	4.36	U		#
Europium-152	pCi/L	09/01/2011	N001	-4.93	19.7	U		#
Europium-154	pCi/L	09/01/2011	N001	8.06	21.5	U		#
Europium-155	pCi/L	09/01/2011	N001	-1.24	10.7	U		#
Lead-212	pCi/L	09/01/2011	N001	3.88	8.11	U		#
Potassium-40	pCi/L	09/01/2011	N001	36.2	81.6	U		#
Promethium-144	pCi/L	09/01/2011	N001	4.73	4.34	U		#
Promethium-146	pCi/L	09/01/2011	N001	-3.64	4.17	U		#
Ruthenium-106	pCi/L	09/01/2011	N001	-21.6	35.1	U		#
Thorium-234	pCi/L	09/01/2011	N001	11.6	91.7	U		#
Uranium-235	pCi/L	09/01/2011	N001	7.49	35.3	U		#
Uranium-238	pCi/L	09/01/2011	N001	11.6	91.7	U		#
Yttrium-88	pCi/L	09/01/2011	N001	4.46	4.59	U		#

¹ TPU – Total Propagated Uncertainty reported at 2-sigma.

RESULTS REPORT
RIN: 11084060
Site: Rulison Site
Location: BM 26-34C
Ticket Number: JJU 909
Report Date: 10/07/2011

Parameter	Units	Sample Date	Sample ID	Result	TPU ¹	Lab	Qualifiers Data	QA
CHLORIDE	MG/L	09/01/2011	N001	11000				#
GROSS ALPHA	pCi/L	09/01/2011	N001	11	25.9	U		#
GROSS BETA	pCi/L	09/01/2011	N001	126	39.3		J	#
H-3	pCi/L	09/01/2011	N001	124	179	U		#
Actinium-228	pCi/L	09/01/2011	N001	20.3	9.27		U	#
Americium-241	pCi/L	09/01/2011	N001	-0.145	18.9	U		#
Antimony-125	pCi/L	09/01/2011	N001	2.88	7.39	U		#
Cerium-144	pCi/L	09/01/2011	N001	-5.12	14.5	U		#
Cesium-134	pCi/L	09/01/2011	N001	-1.53	3.51	U		#
Cesium-137	pCi/L	09/01/2011	N001	-1.13	3.28	U		#
Cobalt-60	pCi/L	09/01/2011	N001	-3.72	3.4	U		#
Europium-152	pCi/L	09/01/2011	N001	-3.05	17.4	U		#
Europium-154	pCi/L	09/01/2011	N001	11.6	18.5	U		#
Europium-155	pCi/L	09/01/2011	N001	1.64	8.78	U		#
Lead-212	pCi/L	09/01/2011	N001	-1.65	8.04	U		#
Potassium-40	pCi/L	09/01/2011	N001	62.7	84.6	U		#
Promethium-144	pCi/L	09/01/2011	N001	2.96	3.39	U		#
Promethium-146	pCi/L	09/01/2011	N001	0.1	3.82	U		#
Ruthenium-106	pCi/L	09/01/2011	N001	28.2	31.3	U		#
Thorium-234	pCi/L	09/01/2011	N001	-3.27	85.5	U		#
Uranium-235	pCi/L	09/01/2011	N001	13.3	14.8	U		#
Uranium-238	pCi/L	09/01/2011	N001	-3.27	85.5	U		#
Yttrium-88	pCi/L	09/01/2011	N001	0.987	3.87	U		#

¹ TPU – Total Propagated Uncertainty reported at 2-sigma.

RESULTS REPORT
RIN: 11084060
Site: Rulison Site
Location: BM 26-34D
Ticket Number: JJU 910
Report Date: 10/07/2011

Parameter	Units	Sample Date	Sample ID	Result	TPU ¹	Lab	Qualifiers Data	QA
CHLORIDE	MG/L	09/01/2011	N001	13000				#
GROSS ALPHA	pCi/L	09/01/2011	N001	10.4	32.9	U		#
GROSS BETA	pCi/L	09/01/2011	N001	119	46.3		J	#
H-3	pCi/L	09/01/2011	N001	-123	170	U		#
Actinium-228	pCi/L	09/01/2011	N001	19.7	12.2	U		#
Americium-241	pCi/L	09/01/2011	N001	3.95	4.58	U		#
Antimony-125	pCi/L	09/01/2011	N001	1.94	7.68	U		#
Cerium-144	pCi/L	09/01/2011	N001	-10.9	14.9	U		#
Cesium-134	pCi/L	09/01/2011	N001	0.181	3.72	U		#
Cesium-137	pCi/L	09/01/2011	N001	1.41	3.86	U		#
Cobalt-60	pCi/L	09/01/2011	N001	-3.09	3.98	U		#
Europium-152	pCi/L	09/01/2011	N001	6.46	20	U		#
Europium-154	pCi/L	09/01/2011	N001	7.8	20.8	U		#
Europium-155	pCi/L	09/01/2011	N001	1.72	9.91	U		#
Lead-212	pCi/L	09/01/2011	N001	4.45	8.37	U		#
Potassium-40	pCi/L	09/01/2011	N001	89.4	87.4	U		#
Promethium-144	pCi/L	09/01/2011	N001	0.948	4	U		#
Promethium-146	pCi/L	09/01/2011	N001	-3.7	4.1	U		#
Ruthenium-106	pCi/L	09/01/2011	N001	6.59	31.6	U		#
Thorium-234	pCi/L	09/01/2011	N001	-4.98	46.9	U		#
Uranium-235	pCi/L	09/01/2011	N001	9.27	15	U		#
Uranium-238	pCi/L	09/01/2011	N001	-4.98	46.9	U		#
Yttrium-88	pCi/L	09/01/2011	N001	-0.464	4.43	U		#

¹ TPU – Total Propagated Uncertainty reported at 2-sigma.