

**Monitoring Results  
Natural Gas Wells  
Near Project Rulison  
First Quarter 2009**

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

Date Sampled:

22 January 2009

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 institutional-control boundary. These samples were collected before the DOE *Rulison Monitoring Plan* was released in July 2010. The *Rulison Monitoring Plan* provides guidance for sample collection frequency, based on distance from the Rulison detonation point, the types of analyses, 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. Three gas samples were collected from three of the six wells. The wells sampled are listed in Table 1.

Sample Locations:

The bottom-hole locations (BHLs) of the 6 gas wells sampled are between 0.9 and 1.1 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 (see Table 3).

Table 1. Sample Collection Locations

Pad	Collection Location	Well Name
26N	Well head separator	Battlement Mesa (BM) 26-42
35C	Well head separator	BM 35-12, -21D, -32A
36L	Well head separator	BM 36-13B, -13D

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 36-13D	15468	NG-Angl	X	X	81.7	220	~3.5 L of produced water; ~35 psi gas in 18L bottle
2	BM 36-13B	15469	NG-Angl	X	X	77	200	~3.5 L of produced water; ~35 psi gas in 18L bottle
3	BM 35-21D	12505	NG-Angl	NA	X	65.6	195	~0.5 L of produced water
4	BM 35-12	10412	NG-Vert	NA	X	65.6	195	~0.5 L of produced water
5	BM 35-32A	10919	NG-Angl	NA	X	65.6	195	~0.5 L of produced water
6	BM 26-42	10666	NG-Vert	X	X	99.9	192.4	~3.5 L of produced water; ~35 psi gas in 18L bottle

T: Temperature  
L: liter

P: Pressure  
NG-Vert: Vertical well

BM: Battlement Mesa  
NA: Missing or not applicable

NG-Angl: Angled well

PW: produced water

### 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	$5.183 \times 10^{-6}$ 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
<b>Lab Method</b>				
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. Three gas samples was collected from three of the 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 gas and liquid phases are in Table 4a. Liquid-phase results for gross alpha/beta are summarized in Table 4b and potassium-40 results in Table 4c. Sample volumes not adequate for laboratory analysis are counted as missing or not applicable (NA).

*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	3/6	0	3	0	0	6	0

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	6	1	2	3	3	0	3

NA: Missing or not applicable

Data validation assigned “J” to the gross-alpha “detect” result and one of the three gross-beta “detect” results.

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	6	3	0	3

NA: Missing or not applicable

Table 5 summarizes the statistics for gross-beta and potassium-40 results. Backgrounds for gross alpha or gross beta have not been established.

Table 5. Statistics for Detected Gross-Beta and Potassium-40 Results

Counting Statistic	Gross Beta	Potassium-40	Units
Number of detects	3	3	NA
Maximum	216.0	422.0	pCi/L
Third quartile	209.5	395.5	pCi/L
Mean	158.7	277.0	pCi/L
Median	203.0	369.0	pCi/L
First quartile	130.1	204.4	pCi/L
Minimum	57.2	39.9	pCi/L

NA: Missing or not applicable

The distance and heading from the Rulison detonation horizon to the bottom-hole-locations of the wells sampled 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
36L	BM 36-13D	10,053	NWSW	36	39.390940	-107.953075	1.02	S18.7°W	
36L	BM 36-13B	10,123	NWSW	36	39.392803	-107.953060	0.90	S20.2°W	
35C	BM 35-21D	10,220	NENW	35	39.397821	107966204	1.08	S67.0°W	
35C	BM 35-12	10,100	NENW	35	39.398871	-107.966701	1.07	S70.4°W	Vertical well
35C	BM 35-32A	10,278	NENW	35	39.396958	-107.962789	0.96	S60.0°W	
26N	BM 26-42	9,423	SESW	26	39.404443	-107.967220	1.01	S87.2°W	Vertical well

Q-Q: quarter-quarter section

S: Section

Lat: latitude

Long: longitude

NAD 83: North American Datum of 1983

## **Liquid Phase Sample Results**

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**RESULTS REPORT****RIN: 09012065****Site: Rulison Site****Location: 05-045-10412 WELL Battlement Mesa 35-12****Ticket Number: HCY 495****Report Date: 12/1/2011**

Parameter	Units	Sample Date	Sample ID	Result	TPU <sup>1</sup>	Lab	Qualifiers Data	QA
Chloride	mg/L	01/22/2009	N001	19700			J	#
Chlorine-36	pCi/L	01/22/2009	N001	-26.6	17.6	U	J	#
Tritium	pCi/L	01/22/2009	N001	78.1	196	U		#

**RESULTS REPORT**

RIN: 09012065

Site: Rulison Site

Location: 05-045-10666 WELL Battlement Mesa 26-42

Ticket Number: HCQ 477

Report Date: 12/1/2011

Parameter	Units	Sample Date	ID	Result	TPU <sup>1</sup>	Lab	Qualifiers Data	QA
Actinium-228	pCi/L	01/22/2009	N001	14	7.21		J	#
Actinium-228	pCi/L	01/22/2009	N002 <sup>1</sup>	15.8	4.47			#
Americium-241	pCi/L	01/22/2009	N001	0.479	4.82	U		#
Americium-241	pCi/L	01/22/2009	N002	-806	4.33	U		#
Antimony-125	pCi/L	01/22/2009	N001	1.59	2.3	U		#
Antimony-125	pCi/L	01/22/2009	N002	-1.06	2.28	U		#
Cerium-144	pCi/L	01/22/2009	N001	3.35	6.15	U		#
Cerium-144	pCi/L	01/22/2009	N002	1.53	5.82	U		#
Cesium-134	pCi/L	01/22/2009	N001	0.791	1.06	U		#
Cesium-134	pCi/L	01/22/2009	N002	0.431	0.955	U		#
Cesium-137	pCi/L	01/22/2009	N001	-.174	0.92	U		#
Cesium-137	pCi/L	01/22/2009	N002	0.833	0.831	U		#
Chloride	mg/L	01/22/2009	N001	12100			J	#
Chloride	mg/L	01/22/2009	N002	7860			J	#
Chlorine-36	pCi/L	01/22/2009	N001	0.119	24.3	U	J	#
Chlorine-36	pCi/L	01/22/2009	N002	61.7	54.6	U	J	#
Cobalt-60	pCi/L	01/22/2009	N001	-.102	0.945	U		#
Cobalt-60	pCi/L	01/22/2009	N002	-.287	0.784	U		#
Europium-152	pCi/L	01/22/2009	N001	1.12	2.62	U		#
Europium-152	pCi/L	01/22/2009	N002	1.93	2.5	U		#
Europium-154	pCi/L	01/22/2009	N001	1.24	2.56	U		#
Europium-154	pCi/L	01/22/2009	N002	-.164	2.35	U		#
Europium-155	pCi/L	01/22/2009	N001	0.511	3.23	U		#
Europium-155	pCi/L	01/22/2009	N002	-.838	3.06	U		#
Gross Alpha	pCi/L	01/22/2009	N001	47	27.4		J	#
Gross Alpha	pCi/L	01/22/2009	N002	33.2	16		J	#
Gross Beta	pCi/L	01/22/2009	N001	57.2	34.9		J	#

**RESULTS REPORT****RIN: 09012065****Site: Rulison Site****Location: 05-045-10666 WELL Battlement Mesa 26-42****Ticket Number: HCQ 477****Report Date: 12/1/2011**

Parameter	Units	Sample Date	ID	Result	TPU <sup>1</sup>	Lab	Qualifiers Data	QA
Gross Beta	pCi/L	01/22/2009	N002	43.7	22.3		J	#
Lead-212	pCi/L	01/22/2009	N001	0	3.3	UI		#
Lead-212	pCi/L	01/22/2009	N002	0	3.06	UI		#
Potassium-40	pCi/L	01/22/2009	N001	39.9	21.1			#
Potassium-40	pCi/L	01/22/2009	N002	45.1	21			#
Promethium-144	pCi/L	01/22/2009	N001	-0.648	0.85	U		#
Promethium-144	pCi/L	01/22/2009	N002	-0.45	1.26	U		#
Promethium-146	pCi/L	01/22/2009	N001	-0.00518	1.14	U		#
Promethium-146	pCi/L	01/22/2009	N002	0.142	1.06	U		#
Ruthenium-106	pCi/L	01/22/2009	N001	-2.71	7.73	U		#
Ruthenium-106	pCi/L	01/22/2009	N002	-0.503	7.19	U		#
Thorium-234	pCi/L	01/22/2009	N001	-20.7	67	U		#
Thorium-234	pCi/L	01/22/2009	N002	61.9	60	U		#
Tritium	pCi/L	01/22/2009	N001	-101	168	U		#
Tritium	pCi/L	01/22/2009	N002	18	193	U		#
Uranium-235	pCi/L	01/22/2009	N001	-0.232	9.5	U		#
Uranium-235	pCi/L	01/22/2009	N002	-4.53	9.04	U		#
Uranium-238	pCi/L	01/22/2009	N001	-20.7	67	U		#
Uranium-238	pCi/L	01/22/2009	N002	61.9	60		J	#
Yttrium-88	pCi/L	01/22/2009	N001	-0.184	1	U		#
Yttrium-88	pCi/L	01/22/2009	N002	-0.354	0.828	U		#

<sup>1</sup> N002 – Duplicate sample.

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**RESULTS REPORT****RIN: 09012065****Site: Rulison Site****Location: 05-045-10919 WELL Battlement Mesa 35-32A****Ticket Number: HCY 497****Report Date: 12/1/2011**

Parameter	Units	Sample Date	Sample ID	Result	TPU <sup>1</sup>	Lab	Qualifiers Data	QA
Chloride	mg/L	01/22/2009	N001	10600			J	#
Chlorine-36	pCi/L	01/22/2009	N001	12.1	26.1	U	J	#
Tritium	pCi/L	01/22/2009	N001	12.3	190	U		#

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**RESULTS REPORT****RIN: 09012065****Site: Rulison Site****Location: 05-045-12505 WELL Battlement Mesa 35-21D****Ticket Number: HCY 496****Report Date: 12/1/2011**

Parameter	Units	Sample Date	Sample ID	Result	TPU <sup>1</sup>	Lab	Qualifiers Data	QA
Chloride	mg/L	01/22/2009	N001	15100			J	#
Chlorine-36	pCi/L	01/22/2009	N001	-32.8	40.8	U	J	#
Tritium	pCi/L	01/22/2009	N001	-70.2	172	U		#

**RESULTS REPORT****RIN: 09012065****Site: Rulison Site****Location: 05-045-15468 WELL Battlement Mesa 36-13D****Ticket Number: HCY 494****Report Date: 12/1/2011**

Parameter	Units	Sample Date	ID	Result	TPU <sup>1</sup>	Lab	Qualifiers Data	QA
Actinium-228	pCi/L	01/22/2009	N001	13.6	6.45		J	#
Americium-241	pCi/L	01/22/2009	N001	5.81	6.48	U		#
Antimony-125	pCi/L	01/22/2009	N001	-1.71	2.72	U		#
Cerium-144	pCi/L	01/22/2009	N001	-3.04	7.42	U		#
Cesium-134	pCi/L	01/22/2009	N001	0.408	1.22	U		#
Cesium-137	pCi/L	01/22/2009	N001	-.508	1.02	U		#
Chloride	mg/L	01/22/2009	N001	18500			J	#
Chlorine-36	pCi/L	01/22/2009	N001	8.59	31.2	U	J	#
Cobalt-60	pCi/L	01/22/2009	N001	-.228	1.09	U		#
Europium-152	pCi/L	01/22/2009	N001	-.478	3.58	U		#
Europium-154	pCi/L	01/22/2009	N001	-.769	2.87	U		#
Europium-155	pCi/L	01/22/2009	N001	3.43	3.89	U		#
Gross Alpha	pCi/L	01/22/2009	N001	9.28	24.3	U		#
Gross Beta	pCi/L	01/22/2009	N001	216	49.9			#
Lead-212	pCi/L	01/22/2009	N001	3.45	3.08	U		#
Potassium-40	pCi/L	01/22/2009	N001	422	46.3			#
Promethium-144	pCi/L	01/22/2009	N001	0.968	0.976	U		#
Promethium-146	pCi/L	01/22/2009	N001	-.273	1.28	U		#
Ruthenium-106	pCi/L	01/22/2009	N001	11.4	9.5	U		#
Thorium-234	pCi/L	01/22/2009	N001	14.5	74.3	U		#
Tritium	pCi/L	01/22/2009	N001	-32.8	181	U		#
Uranium-235	pCi/L	01/22/2009	N001	3.67	8.41	U		#
Uranium-238	pCi/L	01/22/2009	N001	14.5	74.3	U		#
Yttrium-88	pCi/L	01/22/2009	N001	0.686	1.08	U		#

**RESULTS REPORT****RIN: 09012065****Site: Rulison Site****Location: 05-045-15469 WELL Battlement Mesa 36-13B****Ticket Number: HCY 493****Report Date: 12/1/2011**

Parameter	Units	Sample Date	ID	Result	TPU <sup>1</sup>	Lab	Qualifiers Data	QA
Actinium-228	pCi/L	01/22/2009	N001	1.88	11.5	U		#
Americium-241	pCi/L	01/22/2009	N001	-13.4	18.6	U		#
Antimony-125	pCi/L	01/22/2009	N001	3.27	6.21	U		#
Cerium-144	pCi/L	01/22/2009	N001	-5.39	16.8	U		#
Cesium-134	pCi/L	01/22/2009	N001	-3.37	2.81	U		#
Cesium-137	pCi/L	01/22/2009	N001	0.294	2.27	U		#
Chloride	mg/L	01/22/2009	N001	15800			J	#
Chlorine-36	pCi/L	01/22/2009	N001	3.32	25.9	U	J	#
Cobalt-60	pCi/L	01/22/2009	N001	0.0306	2.49	U		#
Europium-152	pCi/L	01/22/2009	N001	-.226	7.36	U		#
Europium-154	pCi/L	01/22/2009	N001	-5.82	6.64	U		#
Europium-155	pCi/L	01/22/2009	N001	-3.85	9.17	U		#
Gross Alpha	pCi/L	01/22/2009	N001	-24.2	24.7	U		#
Gross Beta	pCi/L	01/22/2009	N001	203	49.9			#
Lead-212	pCi/L	01/22/2009	N001	0.323	5.18	U		#
Potassium-40	pCi/L	01/22/2009	N001	369	82.1			#
Promethium-144	pCi/L	01/22/2009	N001	-.949	2.2	U		#
Promethium-146	pCi/L	01/22/2009	N001	1.77	3.13	U		#
Ruthenium-106	pCi/L	01/22/2009	N001	-3.31	22	U		#
Thorium-234	pCi/L	01/22/2009	N001	25.7	205	U		#
Tritium	pCi/L	01/22/2009	N001	-15	182	U		#
Uranium-235	pCi/L	01/22/2009	N001	0.803	19.8	U		#
Uranium-238	pCi/L	01/22/2009	N001	25.7	205	U		#
Yttrium-88	pCi/L	01/22/2009	N001	0.546	2.5	U		#

<sup>1</sup> TPU – Total Propagated Uncertainty reported at 2-sigma.

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

LAB QUALIFIER: U Analytical result below detection limit.

DATA QUALIFIER: J Estimated value.

QA QUALIFIER: # Validated according to quality assurance guidelines.

## **Gas Phase Sample Results**

**RESULTS REPORT****RIN: 09012066****Site: Rulison Site****Location: 05-045-10666 WELL, Natural Gas Well - Vertical, Battlement Mesa 26-42****Ticket Number: HCQ 476****Report Date: 12/1/2011**

Parameter	Units	Sample		Result	Qualifiers	
		Date	ID		Lab	Data QA
Helium	percent	04/28/2009	0001	0.0026		#
Hydrogen	percent	04/28/2009	0001	0.0035		#
Argon	percent	04/28/2009	0001	nd <sup>1</sup>		#
Oxygen	percent	04/28/2009	0001	0.0076		#
Nitrogen	percent	04/28/2009	0001	0.039		#
Carbon Dioxide	percent	04/28/2009	0001	3.21		#
Methane	percent	04/28/2009	0001	89.43		#
Ethane	percent	04/28/2009	0001	4.62		#
Propane	percent	04/28/2009	0001	1.46		#
Isobutane	percent	04/28/2009	0001	0.314		#
Butane	percent	04/28/2009	0001	0.344		#
Isopentane	percent	04/28/2009	0001	0.146		#
Pentane	percent	04/28/2009	0001	0.116		#
Hexanes	percent	04/28/2009	0001	0.304		#
Carbon-14	Percent modern carbon	04/28/2009	0001	0.2	U	#
Tritium	pCi/L methane	04/28/2009	0001	0.0514	U	#

<sup>1</sup> Not detected.

**RESULTS REPORT****RIN: 09012066****Site: Rulison Site****Location: 05-045-15468 WELL, Natural Gas Well - Angle, Battlement Mesa 36-13D****Ticket Number: HCY 499****Report Date: 12/1/2011**

Parameter	Units	Sample		Result	Qualifiers	
		Date	ID		Lab	Data QA
Helium	percent	04/28/2009	0001	0.0026		#
Hydrogen	percent	04/28/2009	0001	0.0034		#
Argon	percent	04/28/2009	0001	nd <sup>1</sup>		#
Oxygen	percent	04/28/2009	0001	0.0054		#
Nitrogen	percent	04/28/2009	0001	0.038		#
Carbon Dioxide	percent	04/28/2009	0001	5.51		#
Methane	percent	04/28/2009	0001	86.41		#
Ethane	percent	04/28/2009	0001	5.68		#
Propane	percent	04/28/2009	0001	1.36		#
Isobutane	percent	04/28/2009	0001	0.302		#
Butane	percent	04/28/2009	0001	0.273		#
Isopentane	percent	04/28/2009	0001	0.115		#
Pentane	percent	04/28/2009	0001	0.0855		#
Hexanes	percent	04/28/2009	0001	0.216		#
Carbon-14	Percent modern carbon	04/28/2009	0001	0.2	U	#
Tritium	pCi/L methane	04/28/2009	0001	0.0591	U	#

<sup>1</sup> Not detected.

**RESULTS REPORT****RIN: 09012066****Site: Rulison Site****Location: 05-045-15469 WELL, Natural Gas Well - Angle, Battlement Mesa 36-13B****Ticket Number: HCY 498****Report Date: 12/1/2011**

Parameter	Units	Sample		Result	Qualifiers	
		Date	ID		Lab	Data QA
Helium	percent	04/28/2009	0001	0.0026		#
Hydrogen	percent	04/28/2009	0001	0.0037		#
Argon	percent	04/28/2009	0001	nd <sup>1</sup>		#
Oxygen	percent	04/28/2009	0001	nd <sup>1</sup>		#
Nitrogen	percent	04/28/2009	0001	.033		#
Carbon Dioxide	percent	04/28/2009	0001	5.39		#
Methane	percent	04/28/2009	0001	87.41		#
Ethane	percent	04/28/2009	0001	5.15		#
Propane	percent	04/28/2009	0001	1.17		#
Isobutane	percent	04/28/2009	0001	0.250		#
Butane	percent	04/28/2009	0001	0.221		#
Isopentane	percent	04/28/2009	0001	0.0909		#
Pentane	percent	04/28/2009	0001	0.0673		#
Hexanes	percent	04/28/2009	0001	0.208		#
Carbon-14	Percent modern carbon	04/28/2009	0001	0.2	U	#
Tritium	pCi/L methane	04/28/2009	0001	0.0514	U	#

<sup>1</sup> Not detected.

LAB QUALIFIER: U Analytical result below detection limit.

QA QUALIFIER: # Validated according to quality assurance guidelines.