

Monitoring Results Natural Gas Wells Near Project Rulison Fourth Quarter 2015

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

Date Sampled: September 9, 2015

Background

Project Rulison was the second Plowshare Program test 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 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, the surface was 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 monitors 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 contaminant migration, and institutional controls restrict subsurface access in the detonation zone. When exploration companies apply for a permit to drill wells within 3 miles of the site, the Colorado Oil and Gas Conservation Commission notifies DOE, and the State of Colorado and DOE have an opportunity to review and comment on drilling permits and gas well development practices to help protect human health and the environment from the Rulison-related contaminants. 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

Analytical results of production water samples collected on September 9, 2015, were all below the screening levels specified in the *Rulison Monitoring Plan*. The laboratory results are in the Data Validation Package in Appendix A of this monitoring report.

The September 9 sampling effort was planned to include the collection of production water from 13 natural gas wells. Natural gas well BM 36-13 was undergoing production line maintenance and was shut down at the time of sampling, and no production water was collected. Production water samples were collected from 11 wells and included a duplicate sample from well BM 26-33C. As planned during this September 9 sampling, no natural gas samples were collected.

Table 1. Sample Collection Locations

Pad	Collection Location	Well Name
26N	Wellhead separator	BM 26-33B–D, BM 26-34A–D
26K	Wellhead separator	BM 26-22B–D
35C	Wellhead separator	BM 35-32A
36L	Wellhead separator	BM 36-13B
36B	Wellhead separator	BM 36-13

Table 2. Samples Collected

Sequence	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	56.5	237
2	26N	BM 26-33C	15742	WL	NGSA	No	Yes	58.5	233
Duplicate	26N	BM 26-33C	15742	WL	NGSA	No	Yes	58.5	233
3	26N	BM 26-33D	15739	WL	NGSA	No	Yes	57.5	241
4	26N	BM 26-34A	15744	WL	NGSA	No	Yes	55	238
5	26N	BM 26-34B	15745	WL	NGSA	No	No	58	245
6	26N	BM 26-34C	15741	WL	NGSA	No	Yes	57	248
7	26N	BM 26-34D	15748	WL	NGSA	No	No	57.5	250
8	26K	BM 26-22B	16086	WL	NGSA	No	Yes	59	233
9	26K	BM 26-22C	16087	WL	NGSA	No	Yes	56.5	231
10	26K	BM 26-22D	16074	WL	NGSA	No	Yes	57	241
11	35C	BM 35-32A	10919	WL	NGSA	No	Yes	59	227
12	36L	BM 36-13B	15469	WL	NGSV	No	Yes	60	232
13	36B	BM 36-13	10840	WL	NGSV	No	No ^a	NA	NA

Notes:

^a No production water was collected from well BM 36-13 because of unscheduled maintenance on the main production line from the well. Wells BM 26-34B and BM 26-34D did not produce enough production water during sampling for laboratory analysis and BM 26-22B produced only enough sample for tritium analysis. A duplicate sample was collected from well BM 26-33C during this sampling event.

Abbreviations:

API American Petroleum Institute
 NGSA natural gas well—angle
 NGSV natural gas well—vertical
 P (psi) pressure in pounds per square inch
 T (°F) temperature in degrees Fahrenheit
 WL well

Sample Locations

The bottom-hole locations of the 13 gas wells planned for sample collection were between 0.75 mile 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.

Sample Collection Procedure

A produced-water sample is collected at the wellhead 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.

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

Monitoring Protocol

The *Rulison Monitoring Plan* provides guidance regarding the type and frequency of sample collection as a function of distance and heading from the Rulison detonation point. It also specifies the types of analyses. A copy of the monitoring plan is available at <http://www.lm.doe.gov/Rulison/Documents.aspx>. Table 3a lists gas-phase screening concentrations for tritium and carbon-14, and Table 3b lists liquid-phase screening concentrations for tritium, gross alpha, gross beta, and a suite of radionuclides identified by high-resolution gamma spectrometry.

Table 3a. Gas-Phase Screening Concentrations for Tritium and Carbon-14

Analyte	Reporting Units	Screening Concentration	Action Concentration	Comment
Tritium	TU	19,293	TBD	5.183×10^{-6} pCi cc ⁻¹ TU ⁻¹
Carbon-14	pMC	2 pMC	5 pMC	6.54×10^{-5} pCi/cc and 16.4×10^{-5} pCi/cc, respectively

Abbreviations:

pCi/cc	picocuries per cubic centimeter
pCi cc ⁻¹ TU ⁻¹	picocuries per cubic centimeter of methane gas per tritium unit
pMC	percent modern carbon
TBD	to be determined
TU	tritium unit

Table 3b. Liquid-Phase Screening Concentrations for Tritium and Other Radionuclides

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 concentrations, action concentrations, or both, 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
 TBD to be determined

Results

Nine of the total 13 sampling locations produced enough production water to analyze for the Rulison-related contaminants. No analysis values were above screening levels for any of the locations tested.

Production water analytical results are tabulated by well in Attachment 1 of the Data Validation Package.

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 3 times the sample MDC is assigned the data validation qualifier “J” (estimated quantity).

A laboratory detect result less than 3 times the 1-sigma total propagated uncertainty is considered a nondetect. Data validation assigns the qualifier “U” to this result.

Results Summaries

Table 4a is a summary of analytical results for liquid-phase tritium, Table 4b is a summary of results for liquid-phase gross alpha and gross beta, and Table 4c shows results for potassium-40 analyses. 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) Collected	Tritium Results (gas phase)			Tritium Results (liquid phase)			Carbon-14 (gas phase)		
		Detect	Nondetect	NA	Detect	Nondetect	NA	Detect	Nondetect	NA
Natural gas wells	0/11 ^a	0	0	0	0	11	3 ^b	0	0	0

Notes:

^a Total liquid samples collected include a duplicate from well BM 26-33C. As scheduled, no natural gas samples were collected during this sampling event.

^b Wells BM 26-34B and BM 26-34D did not produce enough production water for laboratory analysis. No sampling occurred at well BM 36-13 because the well was undergoing unscheduled maintenance of the main production line.

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

Collection Location	Total Liquid Samples Collected	Gross Alpha Results			Gross Beta Results		
		Detect	Nondetect	NA	Detect	Nondetect	NA
Natural gas wells	11 ^a	1 ^c	10	3 ^b	11 ^c	0	3 ^b

Notes:

^a Total liquid samples collected included a duplicate from well BM 26-33C.

^b Wells BM 26-34B and BM 26-34D did not produce enough production water for laboratory analysis. No sample was collected from Well BM 36-13 because the well was undergoing unscheduled maintenance.

^c Data validation has assigned (J) qualifiers, which were less than 3× the MDC, for BM 26-34C for gross alpha analysis. Analysis for gross beta from wells BM 26-33B, BM 26-33D, BM 26-34C, and BM 26-22C were assigned (J) qualifiers for detections that were less than 3× the MDC. Wells BM 26-33C, 34A, 22B, 22D, BM 35-32A, BM 13-B, and the duplicate from BM 26-33C all had gross beta laboratory detections.

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

Collection Location	Total Liquid Samples Collected	Potassium-40 Results		
		Detect	Nondetect	NA
Natural gas wells	11 ^a	0	11	3 ^b

Notes:

^a Total liquid samples collected include a duplicate from well BM 26-33C.

^b Two wells BM 26-34B and BM 26-34D did not produce enough production water for laboratory analysis. No sample was collected from Well BM 36-13 because the well was undergoing unscheduled maintenance.

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Appendix A

Data Validation Package

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Data Validation Package

**September 2015
Produced Water Sampling at the
Rulison, Colorado, Site**

January 2016



U.S. DEPARTMENT OF
ENERGY

Legacy
Management

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Contents

Sampling Event Summary	1
Rulison, Colorado, Site, Sample Location Map	2
Data Assessment Summary.....	3
Water Sampling Field Activities Verification Checklist	5
Laboratory Performance Assessment	7
Sampling Quality Control Assessment	14
Certification	16

Attachment 1—Data Presentation

Produced Water Quality Data

Attachment 2—Trip Report

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Sampling Event Summary

Site: Rulison, Colorado, Site

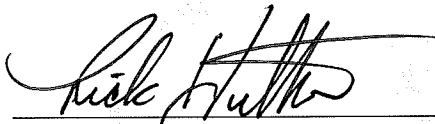
Sampling Period: September 9, 2015

The U.S. Department of Energy Office of Legacy Management conducted sampling at the Rulison, Colorado, Site on September 9, 2015, in accordance with the 2010 *Rulison Monitoring Plan*. The 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. Produced water samples are analyzed for radionuclides to determine if contamination is migrating from the Rulison detonation zone to producing gas wells. Samples were submitted for analysis as follows:

- Produced-water samples were submitted under requisition 15097352 to ALS Laboratory Group in Fort Collins, Colorado, for the determination of gross alpha/beta, gamma-emitting nuclides, and tritium.

Sampling and analyses were conducted as specified in the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (LMS/PRO/S04351, continually updated). A duplicate sample of produced water was collected at location 05-045-15742.

Sample radionuclide results are compared to the screening levels listed in the Monitoring Plan to determine if any further action is merited. None of the results for the ten wells sampled during this event exceeded the screening levels specified in the Monitoring Plan. The produced water sample results are presented in Attachment 1.



Rick Hutton, Site Lead
Navarro Research and Engineering, Inc.

1-13-16

Date



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Rulison, Colorado, Site, Sample Location Map

Data Assessment Summary

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Water Sampling Field Activities Verification Checklist

Project	<u>Rulison, Colorado</u>	Date(s) of Water Sampling	<u>September 9, 2015</u>
Date(s) of Verification	<u>December 30, 2015</u>	Name of Verifier	<u>Stephen Donovan</u>

	Response (Yes, No, NA)	Comments
1. Is the SAP the primary document directing field procedures? List any Program Directives or other documents, SOPs, instructions.	<u>Yes</u>	
	<u>NA</u>	
2. Were the sampling locations specified in the planning documents sampled?	<u>No</u>	<u>Limited volume of produced water was available from well 05-045-16086.</u>
3. Were calibrations conducted as specified in the above-named documents?	<u>NA</u>	<u>Field measurements were not required.</u>
4. Was an operational check of the field equipment conducted daily? Did the operational checks meet criteria?		
5. Were the number and types (alkalinity, temperature, specific conductance, pH, turbidity, DO, ORP) of field measurements taken as specified?		
6. Were wells categorized correctly?	<u>NA</u>	<u>This sampling event did not include groundwater.</u>
7. Were the following conditions met when purging a Category I well: Was one pump/tubing volume purged prior to sampling? Did the water level stabilize prior to sampling? Did pH, specific conductance, and turbidity measurements meet criteria prior to sampling? Was the flow rate less than 500 mL/min?	<u>NA</u>	<u>This sampling event did not include groundwater.</u>

Water Sampling Field Activities Verification Checklist (continued)

	Response (Yes, No, NA)	Comments
8. Were the following conditions met when purging a Category II well: Was the flow rate less than 500 mL/min? Was one pump/tubing volume removed prior to sampling?	NA	This sampling event did not include groundwater.
9. Were duplicates taken at a frequency of one per 20 samples?	Yes	A duplicate sample was collected at location 05-045-15742.
10. Were equipment blanks taken at a frequency of one per 20 samples that were collected with non-dedicated equipment?	NA	
11. Were trip blanks prepared and included with each shipment of VOC samples?	NA	
12. Were the true identities of the QC samples documented?	Yes	
13. Were samples collected in the containers specified?	Yes	
14. Were samples filtered and preserved as specified?	Yes	
15. Were the number and types of samples collected as specified?	Yes	
16. Were chain of custody records completed and was sample custody maintained?	Yes	
17. Was all pertinent information documented on the field data sheets?	Yes	
18. Was the presence or absence of ice in the cooler documented at every sample location?	NA	Sample cooling was not required.
19. Were water levels measured at the locations specified in the planning documents?	NA	

Laboratory Performance Assessment

General Information

Requisition No. (RIN): 15097352
 Sample Event: September 9, 2015
 Site(s): Rulison Site
 Laboratory: ALS Laboratory Group, Fort Collins, Colorado
 Work Order No.: 1509161
 Analysis: Radiochemistry
 Validator: Stephen Donovan
 Review Date: December 18, 2015

This validation was performed according to the *Environmental Procedures Catalog* (LMS/POL/S04325, continually updated) “Standard Practice for Validation of Environmental Data.” The procedure was applied at Level 3, Data Validation. See attached Data Validation Worksheets for supporting documentation on the data review and validation. All analyses were successfully completed. The samples were prepared and analyzed using accepted procedures based on methods specified by line item code, which are listed in Table 1.

Table 1. Analytes and Methods

Analyte	Line Item Code	Prep Method	Analytical Method
Gamma Spectrometry	GAM-A-001	PA SOP713R11	PA SOP713R11
Gross Alpha/Beta	GPC-A-001	PA SOP702R19	PA SOP724R10
Tritium	LCS-A-001	PA SOP700R10	PA SOP704R9

Data Qualifier Summary

Analytical results were qualified as listed in Table 2. Refer to the sections below for an explanation of the data qualifiers applied.

Table 2. Data Qualifier Summary

Sample Number	Location	Analyte	Flag	Reason
1509161-3	BM 26-22C	Gross Beta	J	Less than the determination limit
1509161-4	BM 26-22D	Actinium-228	U	Nuclide identification criteria
1509161-5	BM 26-33B	Gross Beta	J	Less than the determination limit
1509161-7	BM 26-33D	Actinium-228	J	Less than the determination limit
1509161-7	BM 26-33D	Gross Beta	J	Less than the determination limit
1509161-8	BM 26-34A	Actinium-228	J	Less than the determination limit
1509161-9	BM 26-34C	Gross Beta	J	Less than the determination limit
1509161-11	BM 36-13B	Gross Alpha	J	Less than the determination limit

Sample Shipping/Receiving

ALS Laboratory Group in Fort Collins, Colorado, received 11 water samples on September 10, 2015, accompanied by a Chain of Custody form. The Chain of Custody form was checked to confirm that all of the samples were listed with sample collection dates and times, and that signatures and dates were present indicating sample relinquishment and receipt. Copies of the shipping labels were included in the receiving documentation. The Chain of Custody form was complete with no errors or omissions.

Preservation and Holding Times

The sample shipment was received intact at ambient temperature which complies with requirements. All samples were received in the correct container types and had been preserved correctly for the requested analyses. Sample analysis was completed within the applicable holding times.

Detection and Quantitation Limits

The method detection limit (MDL) was reported for all metal, organic, and wet chemical analytes as required. The MDL, as defined in 40 CFR 136, is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. The practical quantitation limit (PQL) for these analytes is the lowest concentration that can be reliably measured, and is defined as 5 times the MDL.

For radiochemical analytes (those measured by radiometric counting) the MDL and PQL are not applicable, and these results are evaluated using the minimum detectable concentration (MDC), Decision Level Concentration (DLC), and Determination Limit (DL). The MDC is a measure of radiochemical method performance and was calculated and reported as specified in *Quality Systems for Analytical Services*. The DLC is the minimum concentration of an analyte that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero, and is estimated as 3 times the one-sigma total propagated uncertainty. Results that are greater than the MDC, but less than the DLC are qualified with a “U” flag (not detected). The DL for radiochemical results is the lowest concentration that can be reliably measured, and is defined as 3 times the MDC. Results not previously “U” qualified that are less than the DL are qualified with a “J” flag as estimated values.

The reported MDCs for radiochemical analytes met the detection limit requirements with the following exceptions. The required detection limits were not met for several gross alpha and gross beta samples because of the elevated levels of dissolved solids in the samples.

Laboratory Instrument Calibration

Compliance requirements for satisfactory instrument calibration are established to ensure that the instrument is capable of producing acceptable qualitative and quantitative data for all analytes. Initial calibration verification demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run. Compliance requirements for continuing calibration checks are established to ensure that the instrument continues to be capable of producing acceptable qualitative and quantitative data. All laboratory instrument calibrations

were performed correctly in accordance with the cited methods. All calibration and laboratory spike standards were prepared from independent sources.

Gamma Spectrometry

Activity concentrations above the MDC were reported in some instances where minimum nuclide identification criteria were not met. Such tentative identifications result when the software attempts to calculate net activity concentrations for analytes where either one or both of the following criteria are not satisfied: one or more characteristic peaks for a nuclide must be identified above the critical level, or the minimum library peak abundance must be attained. Sample results for gamma-emitting radionuclides that do not meet the identification criteria are qualified with a “U” flag as not detected.

Method and Calibration Blanks

Method blanks are analyzed to assess any contamination that may have occurred during sample preparation. Calibration blanks are analyzed to assess instrument contamination prior to and during sample analysis. All radiochemical method blank results were below the Decision Level Concentration.

Laboratory Control Sample

Laboratory control samples were analyzed at the correct frequency to provide information on the accuracy of the analytical method and the overall laboratory performance, including sample preparation. All control sample results were acceptable.

Laboratory Replicate Analysis

Laboratory replicate sample results demonstrate acceptable laboratory precision. The relative percent difference value for the chloride matrix spike replicate met the acceptance criteria. The radiochemical relative error ratio (calculated using the one-sigma total propagated uncertainty) for the sample replicates was less than three for all duplicates.

Matrix Spike Analysis

Matrix spike and matrix spike duplicate (MS/MSD) samples are used to measure method performance in the sample matrix. The MS/MSD data are not evaluated when the concentration of the unspiked sample is greater than 4 times the spike concentration. The spike recoveries met the recovery and precision criteria for all analytes evaluated.

Completeness

Results were reported in the correct units for all analytes requested using contract-required laboratory qualifiers.

Electronic Data Deliverable (EDD) File

The EDD file arrived on November 19, 2015. The Sample Management System EDD validation module was used to verify that the EDD files were complete and in compliance with requirements. The module compares the contents of the file to the requested analyses to ensure all and only the requested data are delivered. The contents of the EDD were manually examined to verify that the sample results accurately reflect the data contained in the sample data package.

SAMPLE MANAGEMENT SYSTEM

General Data Validation Report

RIN: 15097352 Lab Code: PAR Validator: Stephen Donovan Validation Date: 12/17/2015
Project: Rulison Site Analysis Type: Metals General Chem Rad Organics
of Samples: 11 Matrix: WATER Requested Analysis Completed: Yes

Chain of Custody

Present: OK Signed: OK Dated: OK

Sample

Integrity: OK Preservation: OK Temperature: OK

Select Quality Parameters

- Holding Times
- Detection Limits
- Field/Trip Blanks
- Field Duplicates

All analyses were completed within the applicable holding times.

The reported detection limits are equal to or below contract requirements.

There was 1 duplicate evaluated.

SAMPLE MANAGEMENT SYSTEM
Radiochemistry Data Validation Worksheet

RIN: 15097352 **Lab Code:** PAR **Date Due:** 10/08/2015
Matrix: Water **Site Code:** RUL01 **Date Completed:** 10/20/2015

Sample	Analyte	Date Analyzed	Result	Flag	Tracer %R	LCS %R	MS %R	Duplicate RER
2657	Actinium-228	10/02/2015						0.03
2657	Americium-241	10/02/2015						1.76
Blank_Spike	Americium-241	10/05/2015				105.00		
2657	Antimony-125	10/02/2015						1.60
2657	Cerium-144	10/02/2015						0.20
2657	Cesium-134	10/02/2015						0.18
2657	Cesium-137	10/02/2015						0.48
Blank_Spike	Cesium-137	10/05/2015				99.50		
2657	Cobalt-60	10/02/2015						1.36
Blank_Spike	Cobalt-60	10/05/2015				98.90		
2657	Europium-152	10/02/2015						0.39
2657	Europium-154	10/02/2015						1.88
2657	Europium-155	10/02/2015						0.65
BM 26-33C	GROSS ALPHA	09/28/2015						0.07
Blank	GROSS ALPHA	09/28/2015	0.2290	U				
BM 36-13B	GROSS ALPHA	09/28/2015					118.0	
Blank_Spike	GROSS ALPHA	09/28/2015				92.80		
BM 26-33C	GROSS BETA	09/28/2015						0.95
Blank	GROSS BETA	09/28/2015	0.3160					
BM 36-13B	GROSS BETA	09/28/2015					99.2	
Blank_Spike	GROSS BETA	09/28/2015				98.00		
BM 26-22B	H-3	10/12/2015						0.27
2657	H-3	10/12/2015					110.0	
Blank_Spike	H-3	10/14/2015				105.00		
Blank	H-3	10/14/2015	-47.8000	U				
2657	Lead-212	10/02/2015						0.40
2657	Potassium-40	10/02/2015						0.27
2657	Promethium-144	10/02/2015						1.15
2657	Promethium-146	10/02/2015						0.28
2657	Ruthenium-106	10/02/2015						0.76
2657	Thorium-234	10/02/2015						0.28
2657	Uranium-235	10/02/2015						0.80

SAMPLE MANAGEMENT SYSTEM
Radiochemistry Data Validation Worksheet

RIN: 15097352 **Lab Code:** PAR **Date Due:** 10/08/2015
Matrix: Water **Site Code:** RUL01 **Date Completed:** 10/20/2015

Sample	Analyte	Date Analyzed	Result	Flag	Tracer %R	LCS %R	MS %R	Duplicate RER
2657	Yttrium-88	10/02/2015						1.04

Sampling Quality Control Assessment

The following information summarizes and assesses quality control for this sampling event.

Sampling Protocol

The produced-water samples were collected from a tap on a common line connecting the output of two separators (each servicing a well) and the nearby accumulation tanks. The collected water sample from one separator was isolated from the other separator by valves. Lines from each of the two separators were purged before sample collection.

Equipment Blank Assessment

Equipment blanks are prepared and analyzed to document contamination attributable to the sample collection process. An equipment blank was not required.

Field Duplicate Assessment

Field duplicate samples are collected and analyzed as an indication of overall precision of the measurement process. The precision observed includes both field and laboratory precision and has more variability than laboratory duplicates, which measure only laboratory performance. A duplicate sample was collected from location 05-045-15742. For radiochemical measurements, the relative error ratio (the ratio of the absolute difference between the sample and duplicate results and the sum of the 1-sigma uncertainties) is used to evaluate duplicate results and should be less than 3. All duplicate results met these criteria demonstrating acceptable precision.

SAMPLE MANAGEMENT SYSTEM

Validation Report: Field Duplicates

RIN: 15097352 Lab Code: PAR Project: Rulison Site Validation Date: 12/17/2015

Duplicate: 2657

Sample: BM 26-33C

Analyte	Sample				Duplicate				RPD	RER	Units
	Result	Flag	Error	Dilution	Result	Flag	Error	Dilution			
Actinium-228	23.8	U	15.7	1	21.2	U	17	1		0.2	pCi/L
Americium-241	1.29	U	3.78	1	1.17	U	32.6	1		0	pCi/L
Antimony-125	-3.48	U	7.9	1	7.04	U	9.02	1		1.7	pCi/L
Cerium-144	8.57	U	11.9	1	2.68	U	18	1		0.5	pCi/L
Cesium-134	0.0736	U	3.26	1	-1.9	U	4.05	1		0.7	pCi/L
Cesium-137	-3.57	U	3.39	1	-0.483	U	3.76	1		1.2	pCi/L
Cobalt-60	0.691	U	3.37	1	0.555	U	3.78	1		0.1	pCi/L
Europium-152	-2.06	U	17.4	1	5.34	U	18.2	1		0.6	pCi/L
Europium-154	-5.42	U	17.8	1	8.76	U	21.8	1		1.0	pCi/L
Europium-155	5.8	U	4.93	1	-4.16	U	16.3	1		1.1	pCi/L
GROSS ALPHA	37.7	U	40.9	1	18	U	35.3	1		0.7	pCi/L
GROSS BETA	147		37.3	1	160		38.1	1		0.5	pCi/L
H-3	23.8	U	154	1	-35.3	U	154	1		0.5	pCi/L
Lead-212	3.58	U	7.71	1	3.4	U	8.17	1		0	pCi/L
Potassium-40	86.4	U	75.1	1	92.1	U	112	1		0.1	pCi/L
Promethium-144	2.13	U	3.72	1	4.47	U	4.57	1		0.8	pCi/L
Promethium-146	0.236	U	3.35	1	0	U	4.45	1		0.1	pCi/L
Ruthenium-106	-10.7	U	29.7	1	15.6	U	37	1		1.1	pCi/L
Thorium-234	28.2	U	47.8	1	27.5	U	106	1		0	pCi/L
Uranium-235	-3.22	U	11.9	1	-5.74	U	27.5	1		0.2	pCi/L
Yttrium-88	0.379	U	6.87	1	1.45	U	5.01	1		0.2	pCi/L

Certification

All laboratory analytical quality control criteria were met except as qualified in this report. The data qualifiers listed on the SEEPro database reports are defined on the last page of each report. All data in this package are considered validated and available for use.

Laboratory Coordinator: Stephen Donovan 1-11-2016
Stephen Donovan Date

Data Validation Lead: Stephen Donovan 1-11-2016
Stephen Donovan Date

Attachment 1

Data Presentation

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Produced Water Quality Data

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

REPORT DATE: 12/30/2015

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

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)	Result	Qualifiers			Detection Limit	Uncertainty
						Lab	Data	QA		
Actinium-228	pCi/L	09/09/2015	N001	0 - 0	18.8	U		#	32	16.4
Americium-241	pCi/L	09/09/2015	N001	0 - 0	14.3	U		#	43	26
Antimony-125	pCi/L	09/09/2015	N001	0 - 0	-11	U		#	27	15.6
Cerium-144	pCi/L	09/09/2015	N001	0 - 0	4.06	U		#	36	21.4
Cesium-134	pCi/L	09/09/2015	N001	0 - 0	-.551	U		#	13	7.41
Cesium-137	pCi/L	09/09/2015	N001	0 - 0	3.47	U		#	7.9	4.82
Cobalt-60	pCi/L	09/09/2015	N001	0 - 0	2.35	U		#	11	6.28
Europium-152	pCi/L	09/09/2015	N001	0 - 0	-18.1	U		#	52	28.5
Europium-154	pCi/L	09/09/2015	N001	0 - 0	26	U		#	49	30.3
Europium-155	pCi/L	09/09/2015	N001	0 - 0	0	U		#	19	11.1
Gross Alpha	pCi/L	09/09/2015	N001	0 - 0	25.9	U		#	41	25.7
Gross Beta	pCi/L	09/09/2015	N001	0 - 0	138			#	43	35.7
Lead-212	pCi/L	09/09/2015	N001	0 - 0	1.98	U		#	17	10.4
Potassium-40	pCi/L	09/09/2015	N001	0 - 0	84.4	U		#	220	131
Promethium-144	pCi/L	09/09/2015	N001	0 - 0	4.21	U		#	9.2	5.62
Promethium-146	pCi/L	09/09/2015	N001	0 - 0	2.11	U		#	8.6	5.12
Ruthenium-106	pCi/L	09/09/2015	N001	0 - 0	-26.6	U		#	84	48
Thorium-234	pCi/L	09/09/2015	N001	0 - 0	0.563	U		#	170	102
Tritium	pCi/L	09/09/2015	N001	0 - 0	14.2	U		#	260	154
Uranium-235	pCi/L	09/09/2015	N001	0 - 0	19.5	U		#	35	18.3
Yttrium-88	pCi/L	09/09/2015	N001	0 - 0	-.596	U		#	15	8.62

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

REPORT DATE: 12/30/2015

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

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)	Result	Qualifiers		Detection Limit	Uncertainty
						Lab	Data QA		
Actinium-228	pCi/L	09/09/2015	N001	0 - 0	22.9	U	#	31	16.4
Americium-241	pCi/L	09/09/2015	N001	0 - 0	6.96	U	#	35	21.1
Antimony-125	pCi/L	09/09/2015	N001	0 - 0	-9.08	U	#	16	8.7
Cerium-144	pCi/L	09/09/2015	N001	0 - 0	21.6	U	#	27	16.9
Cesium-134	pCi/L	09/09/2015	N001	0 - 0	-7.92	U	#	6.3	2.73
Cesium-137	pCi/L	09/09/2015	N001	0 - 0	-3.02	U	#	6.3	3.67
Cobalt-60	pCi/L	09/09/2015	N001	0 - 0	-.414	U	#	7	3.97
Europium-152	pCi/L	09/09/2015	N001	0 - 0	-10.7	U	#	38	21.3
Europium-154	pCi/L	09/09/2015	N001	0 - 0	-4.83	U	#	36	20.8
Europium-155	pCi/L	09/09/2015	N001	0 - 0	-3.98	U	#	25	14.9
Gross Alpha	pCi/L	09/09/2015	N001	0 - 0	68.5		J #	55	37.7
Gross Beta	pCi/L	09/09/2015	N001	0 - 0	164		#	43	38.7
Lead-212	pCi/L	09/09/2015	N001	0 - 0	-1.34	U	#	12	7.43
Potassium-40	pCi/L	09/09/2015	N001	0 - 0	84.1	U	#	130	80.2
Promethium-144	pCi/L	09/09/2015	N001	0 - 0	3.22	U	#	6.5	3.96
Promethium-146	pCi/L	09/09/2015	N001	0 - 0	0.593	U	#	6.6	3.88
Ruthenium-106	pCi/L	09/09/2015	N001	0 - 0	-23.6	U	#	58	32.9
Thorium-234	pCi/L	09/09/2015	N001	0 - 0	52	U	#	140	88.1
Tritium	pCi/L	09/09/2015	N001	0 - 0	-80.5	U	#	260	153
Uranium-235	pCi/L	09/09/2015	N001	0 - 0	-3.61	U	#	47	27.9
Yttrium-88	pCi/L	09/09/2015	N001	0 - 0	3.32	U	#	7.4	4.5

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

REPORT DATE: 12/30/2015

Location: 05-045-15739 WELL BM 26-33D

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)	Result	Qualifiers		Detection Limit	Uncertainty
						Lab	Data QA		
Actinium-228	pCi/L	09/09/2015	N001	0 - 0	32.2		#	31	14.1
Americium-241	pCi/L	09/09/2015	N001	0 - 0	-18.2	U	#	56	32.2
Antimony-125	pCi/L	09/09/2015	N001	0 - 0	11.2	U	#	16	9.52
Cerium-144	pCi/L	09/09/2015	N001	0 - 0	-8.13	U	#	31	18.1
Cesium-134	pCi/L	09/09/2015	N001	0 - 0	1.2	U	#	6.8	4.03
Cesium-137	pCi/L	09/09/2015	N001	0 - 0	-.846	U	#	6.2	3.53
Cobalt-60	pCi/L	09/09/2015	N001	0 - 0	-.436	U	#	6.9	3.87
Europium-152	pCi/L	09/09/2015	N001	0 - 0	10.7	U	#	33	19.4
Europium-154	pCi/L	09/09/2015	N001	0 - 0	-10.4	U	#	38	21
Europium-155	pCi/L	09/09/2015	N001	0 - 0	-2.58	U	#	19	11.2
Gross Alpha	pCi/L	09/09/2015	N001	0 - 0	-16.4	U	#	80	46.1
Gross Beta	pCi/L	09/09/2015	N001	0 - 0	108		J #	46	34
Lead-212	pCi/L	09/09/2015	N001	0 - 0	7.06	U	#	9.8	6.07
Potassium-40	pCi/L	09/09/2015	N001	0 - 0	-64.7	U	#	180	107
Promethium-144	pCi/L	09/09/2015	N001	0 - 0	-.71	U	#	7.8	4.54
Promethium-146	pCi/L	09/09/2015	N001	0 - 0	-1.17	U	#	7.7	4.41
Ruthenium-106	pCi/L	09/09/2015	N001	0 - 0	1.05	U	#	62	36.3
Thorium-234	pCi/L	09/09/2015	N001	0 - 0	63.8	U	#	94	58.3
Tritium	pCi/L	09/09/2015	N001	0 - 0	72	U	#	260	155
Uranium-235	pCi/L	09/09/2015	N001	0 - 0	15	U	#	30	16.6
Yttrium-88	pCi/L	09/09/2015	N001	0 - 0	3.48	U	#	8.5	5.15

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

REPORT DATE: 12/30/2015

Location: 05-045-15741 WELL BM 26-34C

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)	Result	Qualifiers		Detection Limit	Uncertainty
						Lab	Data QA		
Actinium-228	pCi/L	09/09/2015	N001	0 - 0	27	U	#	28	15.1
Americium-241	pCi/L	09/09/2015	N001	0 - 0	2.1	U	#	54	31.8
Antimony-125	pCi/L	09/09/2015	N001	0 - 0	0.0636	U	#	16	9
Cerium-144	pCi/L	09/09/2015	N001	0 - 0	10.7	U	#	30	18
Cesium-134	pCi/L	09/09/2015	N001	0 - 0	0.455	U	#	9.7	5.77
Cesium-137	pCi/L	09/09/2015	N001	0 - 0	0.66	U	#	6.7	3.95
Cobalt-60	pCi/L	09/09/2015	N001	0 - 0	0.338	U	#	7.3	4.2
Europium-152	pCi/L	09/09/2015	N001	0 - 0	-12.6	U	#	40	21.7
Europium-154	pCi/L	09/09/2015	N001	0 - 0	-8.87	U	#	39	21.7
Europium-155	pCi/L	09/09/2015	N001	0 - 0	2.19	U	#	19	11.1
Gross Alpha	pCi/L	09/09/2015	N001	0 - 0	49.8	U	#	68	42.8
Gross Beta	pCi/L	09/09/2015	N001	0 - 0	110		J #	44	33.4
Lead-212	pCi/L	09/09/2015	N001	0 - 0	-2.31	U	#	14	8.38
Potassium-40	pCi/L	09/09/2015	N001	0 - 0	45.4	U	#	170	101
Promethium-144	pCi/L	09/09/2015	N001	0 - 0	3.39	U	#	5.5	2.66
Promethium-146	pCi/L	09/09/2015	N001	0 - 0	-.517	U	#	8.1	4.7
Ruthenium-106	pCi/L	09/09/2015	N001	0 - 0	-29.5	U	#	87	49
Thorium-234	pCi/L	09/09/2015	N001	0 - 0	39.6	U	#	190	114
Tritium	pCi/L	09/09/2015	N001	0 - 0	-116	U	#	260	151
Uranium-235	pCi/L	09/09/2015	N001	0 - 0	25.3	U	#	28	17.4
Yttrium-88	pCi/L	09/09/2015	N001	0 - 0	4.03	U	#	7.1	4.38

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

REPORT DATE: 12/30/2015

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

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Actinium-228	pCi/L	09/09/2015	N001	0	-	0	23.8	U		#	34	15.7
Actinium-228	pCi/L	09/09/2015	N002	0	-	0	21.2	U		#	27	17
Americium-241	pCi/L	09/09/2015	N001	0	-	0	1.29	U		#	6.3	3.78
Americium-241	pCi/L	09/09/2015	N002	0	-	0	1.17	U		#	56	32.6
Antimony-125	pCi/L	09/09/2015	N001	0	-	0	-3.48	U		#	14	7.9
Antimony-125	pCi/L	09/09/2015	N002	0	-	0	7.04	U		#	16	9.02
Cerium-144	pCi/L	09/09/2015	N001	0	-	0	8.57	U		#	20	11.9
Cerium-144	pCi/L	09/09/2015	N002	0	-	0	2.68	U		#	30	18
Cesium-134	pCi/L	09/09/2015	N001	0	-	0	0.0736	U		#	5.6	3.26
Cesium-134	pCi/L	09/09/2015	N002	0	-	0	-1.9	U		#	7.1	4.05
Cesium-137	pCi/L	09/09/2015	N001	0	-	0	-3.57	U		#	6.1	3.39
Cesium-137	pCi/L	09/09/2015	N002	0	-	0	-.483	U		#	6.6	3.76
Cobalt-60	pCi/L	09/09/2015	N001	0	-	0	0.691	U		#	5.8	3.37
Cobalt-60	pCi/L	09/09/2015	N002	0	-	0	0.555	U		#	6.6	3.78
Europium-152	pCi/L	09/09/2015	N001	0	-	0	-2.06	U		#	31	17.4
Europium-152	pCi/L	09/09/2015	N002	0	-	0	5.34	U		#	31	18.2
Europium-154	pCi/L	09/09/2015	N001	0	-	0	-5.42	U		#	32	17.8
Europium-154	pCi/L	09/09/2015	N002	0	-	0	8.76	U		#	37	21.8

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

REPORT DATE: 12/30/2015

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

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Europium-155	pCi/L	09/09/2015	N001	0	-	0	5.8	U		#	7.9	4.93
Europium-155	pCi/L	09/09/2015	N002	0	-	0	-4.16	U		#	28	16.3
Gross Alpha	pCi/L	09/09/2015	N001	0	-	0	37.7	U		#	66	40.9
Gross Alpha	pCi/L	09/09/2015	N002	0	-	0	18	U		#	59	35.3
Gross Beta	pCi/L	09/09/2015	N001	0	-	0	147			#	44	37.3
Gross Beta	pCi/L	09/09/2015	N002	0	-	0	160			#	43	38.1
Lead-212	pCi/L	09/09/2015	N001	0	-	0	3.58	U		#	13	7.71
Lead-212	pCi/L	09/09/2015	N002	0	-	0	3.4	U		#	14	8.17
Potassium-40	pCi/L	09/09/2015	N001	0	-	0	86.4	U		#	120	75.1
Potassium-40	pCi/L	09/09/2015	N002	0	-	0	92.1	U		#	180	112
Promethium-144	pCi/L	09/09/2015	N001	0	-	0	2.13	U		#	6.2	3.72
Promethium-144	pCi/L	09/09/2015	N002	0	-	0	4.47	U		#	7.4	4.57
Promethium-146	pCi/L	09/09/2015	N001	0	-	0	0.236	U		#	5.7	3.35
Promethium-146	pCi/L	09/09/2015	N002	0	-	0	0	U		#	7.6	4.45
Ruthenium-106	pCi/L	09/09/2015	N001	0	-	0	-10.7	U		#	52	29.7
Ruthenium-106	pCi/L	09/09/2015	N002	0	-	0	15.6	U		#	62	37
Thorium-234	pCi/L	09/09/2015	N001	0	-	0	28.2	U		#	79	47.8
Thorium-234	pCi/L	09/09/2015	N002	0	-	0	27.5	U		#	180	106

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/30/2015
Location: 05-045-15742 WELL BM 26-33C

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)			Result	Qualifiers			Detection Limit	Uncertainty
								Lab	Data	QA		
Tritium	pCi/L	09/09/2015	N001	0	-	0	23.8	U		#	260	154
Tritium	pCi/L	09/09/2015	N002	0	-	0	-35.3	U		#	260	154
Uranium-235	pCi/L	09/09/2015	N001	0	-	0	-3.22	U		#	20	11.9
Uranium-235	pCi/L	09/09/2015	N002	0	-	0	-5.74	U		#	46	27.5
Yttrium-88	pCi/L	09/09/2015	N001	0	-	0	0.379	U		#	12	6.87
Yttrium-88	pCi/L	09/09/2015	N002	0	-	0	1.45	U		#	8.5	5.01

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

REPORT DATE: 12/30/2015

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

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)	Result	Qualifiers		Detection Limit	Uncertainty
						Lab	Data QA		
Actinium-228	pCi/L	09/09/2015	N001	0 - 0	22.1	U	#	33	20.4
Americium-241	pCi/L	09/09/2015	N001	0 - 0	-405	U	#	35	20.5
Antimony-125	pCi/L	09/09/2015	N001	0 - 0	-824	U	#	14	8.46
Cerium-144	pCi/L	09/09/2015	N001	0 - 0	4.11	U	#	28	16.7
Cesium-134	pCi/L	09/09/2015	N001	0 - 0	-418	U	#	7.1	4.14
Cesium-137	pCi/L	09/09/2015	N001	0 - 0	-3.02	U	#	6.8	3.83
Cobalt-60	pCi/L	09/09/2015	N001	0 - 0	-1.16	U	#	7.2	4.04
Europium-152	pCi/L	09/09/2015	N001	0 - 0	-2.48	U	#	34	19.3
Europium-154	pCi/L	09/09/2015	N001	0 - 0	0.388	U	#	35	20.1
Europium-155	pCi/L	09/09/2015	N001	0 - 0	-494	U	#	25	14.8
Gross Alpha	pCi/L	09/09/2015	N001	0 - 0	22.5	U	#	66	39.5
Gross Beta	pCi/L	09/09/2015	N001	0 - 0	98		J #	43	31.3
Lead-212	pCi/L	09/09/2015	N001	0 - 0	-2.34	U	#	13	7.73
Potassium-40	pCi/L	09/09/2015	N001	0 - 0	55.2	U	#	140	83.5
Promethium-144	pCi/L	09/09/2015	N001	0 - 0	-942	U	#	7	4.07
Promethium-146	pCi/L	09/09/2015	N001	0 - 0	0.691	U	#	6.7	3.95
Ruthenium-106	pCi/L	09/09/2015	N001	0 - 0	-13	U	#	59	34
Thorium-234	pCi/L	09/09/2015	N001	0 - 0	0.691	U	#	140	81.6
Tritium	pCi/L	09/09/2015	N001	0 - 0	-133	U	#	260	155
Uranium-235	pCi/L	09/09/2015	N001	0 - 0	10.9	U	#	47	21.2
Yttrium-88	pCi/L	09/09/2015	N001	0 - 0	-408	U	#	7.3	4.2

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

REPORT DATE: 12/30/2015

Location: 05-045-15744 WELL BM 26-34A

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)	Result	Qualifiers			Detection Limit	Uncertainty
						Lab	Data	QA		
Actinium-228	pCi/L	09/09/2015	N001	0 - 0	29.8		J	#	23	12.7
Americium-241	pCi/L	09/09/2015	N001	0 - 0	-66.7	U		#	110	67
Antimony-125	pCi/L	09/09/2015	N001	0 - 0	-.145	U		#	11	6.42
Cerium-144	pCi/L	09/09/2015	N001	0 - 0	-13.8	U		#	27	16
Cesium-134	pCi/L	09/09/2015	N001	0 - 0	-4.66	U		#	4.9	2.84
Cesium-137	pCi/L	09/09/2015	N001	0 - 0	-1.31	U		#	4.5	2.64
Cobalt-60	pCi/L	09/09/2015	N001	0 - 0	-3.29	U		#	5	2.79
Europium-152	pCi/L	09/09/2015	N001	0 - 0	-.0569	U		#	21	12.4
Europium-154	pCi/L	09/09/2015	N001	0 - 0	-13.6	U		#	24	13.8
Europium-155	pCi/L	09/09/2015	N001	0 - 0	-8.41	U		#	18	10.3
Gross Alpha	pCi/L	09/09/2015	N001	0 - 0	29.7	U		#	64	39
Gross Beta	pCi/L	09/09/2015	N001	0 - 0	156			#	46	38.9
Lead-212	pCi/L	09/09/2015	N001	0 - 0	2.53	U		#	14	8.73
Potassium-40	pCi/L	09/09/2015	N001	0 - 0	66.3	U		#	130	77.6
Promethium-144	pCi/L	09/09/2015	N001	0 - 0	1.92	U		#	4.2	2.58
Promethium-146	pCi/L	09/09/2015	N001	0 - 0	-.753	U		#	5.1	3.01
Ruthenium-106	pCi/L	09/09/2015	N001	0 - 0	-25.9	U		#	45	25.8
Thorium-234	pCi/L	09/09/2015	N001	0 - 0	-35.8	U		#	210	129
Tritium	pCi/L	09/09/2015	N001	0 - 0	-133	U		#	250	149
Uranium-235	pCi/L	09/09/2015	N001	0 - 0	10.4	U		#	24	14.9
Yttrium-88	pCi/L	09/09/2015	N001	0 - 0	-.921	U		#	9.6	5.69

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

REPORT DATE: 12/30/2015

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

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)	Result	Qualifiers			Detection Limit	Uncertainty
						Lab	Data	QA		
Actinium-228	pCi/L	09/09/2015	N001	0 - 0	40.5		U	#	29	20.1
Americium-241	pCi/L	09/09/2015	N001	0 - 0	12.1	U		#	44	26.7
Antimony-125	pCi/L	09/09/2015	N001	0 - 0	4.29	U		#	27	12.8
Cerium-144	pCi/L	09/09/2015	N001	0 - 0	14.8	U		#	36	21.8
Cesium-134	pCi/L	09/09/2015	N001	0 - 0	-3.78	U		#	9.4	5.36
Cesium-137	pCi/L	09/09/2015	N001	0 - 0	-2.96	U		#	9	5.08
Cobalt-60	pCi/L	09/09/2015	N001	0 - 0	4.09	U		#	11	6.66
Europium-152	pCi/L	09/09/2015	N001	0 - 0	6.93	U		#	51	29.7
Europium-154	pCi/L	09/09/2015	N001	0 - 0	-3.81	U		#	56	32.1
Europium-155	pCi/L	09/09/2015	N001	0 - 0	-2.57	U		#	19	11.3
Gross Alpha	pCi/L	09/09/2015	N001	0 - 0	38.4	U		#	60	37.3
Gross Beta	pCi/L	09/09/2015	N001	0 - 0	169			#	42	38.7
Lead-212	pCi/L	09/09/2015	N001	0 - 0	0.631	U		#	16	9.43
Potassium-40	pCi/L	09/09/2015	N001	0 - 0	122	U		#	210	129
Promethium-144	pCi/L	09/09/2015	N001	0 - 0	3.79	U		#	9.5	5.74
Promethium-146	pCi/L	09/09/2015	N001	0 - 0	-1.1	U		#	8.9	5.15
Ruthenium-106	pCi/L	09/09/2015	N001	0 - 0	-1.79	U		#	80	46.5
Thorium-234	pCi/L	09/09/2015	N001	0 - 0	43.8	U		#	170	103
Tritium	pCi/L	09/09/2015	N001	0 - 0	-105	U		#	260	154
Uranium-235	pCi/L	09/09/2015	N001	0 - 0	-13.4	U		#	51	30.2
Yttrium-88	pCi/L	09/09/2015	N001	0 - 0	-1.06	U		#	15	8.55

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 12/30/2015
Location: 05-045-16086 WELL BM 26-22B

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)	Result	Qualifiers Lab	Data	QA	Detection Limit	Uncertainty
Tritium	pCi/L	09/09/2015	N001	0 - 0	-125	U		#	240	143

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

REPORT DATE: 12/30/2015

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

Parameter	Units	Sample Date	Sample ID	Depth Range (Ft BLS)	Result	Qualifiers		Detection Limit	Uncertainty
						Lab	Data QA		
Actinium-228	pCi/L	09/09/2015	N001	0 - 0	15	U	#	27	14
Americium-241	pCi/L	09/09/2015	N001	0 - 0	0	U	#	56	32.6
Antimony-125	pCi/L	09/09/2015	N001	0 - 0	1.15	U	#	18	10.5
Cerium-144	pCi/L	09/09/2015	N001	0 - 0	12.9	U	#	21	13.3
Cesium-134	pCi/L	09/09/2015	N001	0 - 0	3.38	U	#	6.7	3.16
Cesium-137	pCi/L	09/09/2015	N001	0 - 0	0.725	U	#	6.6	3.88
Cobalt-60	pCi/L	09/09/2015	N001	0 - 0	1.41	U	#	7.1	4.12
Europium-152	pCi/L	09/09/2015	N001	0 - 0	-2.67	U	#	38	21.3
Europium-154	pCi/L	09/09/2015	N001	0 - 0	-5.58	U	#	38	21.5
Europium-155	pCi/L	09/09/2015	N001	0 - 0	0.466	U	#	18	10.7
Gross Alpha	pCi/L	09/09/2015	N001	0 - 0	39.6	U	#	51	32.5
Gross Beta	pCi/L	09/09/2015	N001	0 - 0	107		J #	43	32.5
Lead-212	pCi/L	09/09/2015	N001	0 - 0	1.33	U	#	12	7.25
Potassium-40	pCi/L	09/09/2015	N001	0 - 0	-8.6	U	#	180	106
Promethium-144	pCi/L	09/09/2015	N001	0 - 0	1.04	U	#	7.7	4.55
Promethium-146	pCi/L	09/09/2015	N001	0 - 0	-0.887	U	#	7.7	4.47
Ruthenium-106	pCi/L	09/09/2015	N001	0 - 0	-25	U	#	65	36.7
Thorium-234	pCi/L	09/09/2015	N001	0 - 0	65	U	#	92	57
Tritium	pCi/L	09/09/2015	N001	0 - 0	20.1	U	#	260	155
Uranium-235	pCi/L	09/09/2015	N001	0 - 0	0.831	U	#	28	16.4
Yttrium-88	pCi/L	09/09/2015	N001	0 - 0	0.976	U	#	7.9	4.58

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.

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Attachment 2 Trip Report

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Trip Report
Natural Gas Wells near Project Rulison
Fourth Quarter 2015

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

Date Sampled

September 9, 2015

Background

Project Rulison was the second Plowshare Program test to investigate using a nuclear detonation 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 ground surface in the Williams Fork Formation, at what is now the Rulison, Colorado, Site. A series of production tests followed the detonation, and the site was subsequently shut down, the emplacement well (R-E) and reentry well (R-Ex) were plugged, and the surface soils were remediated.

Purpose

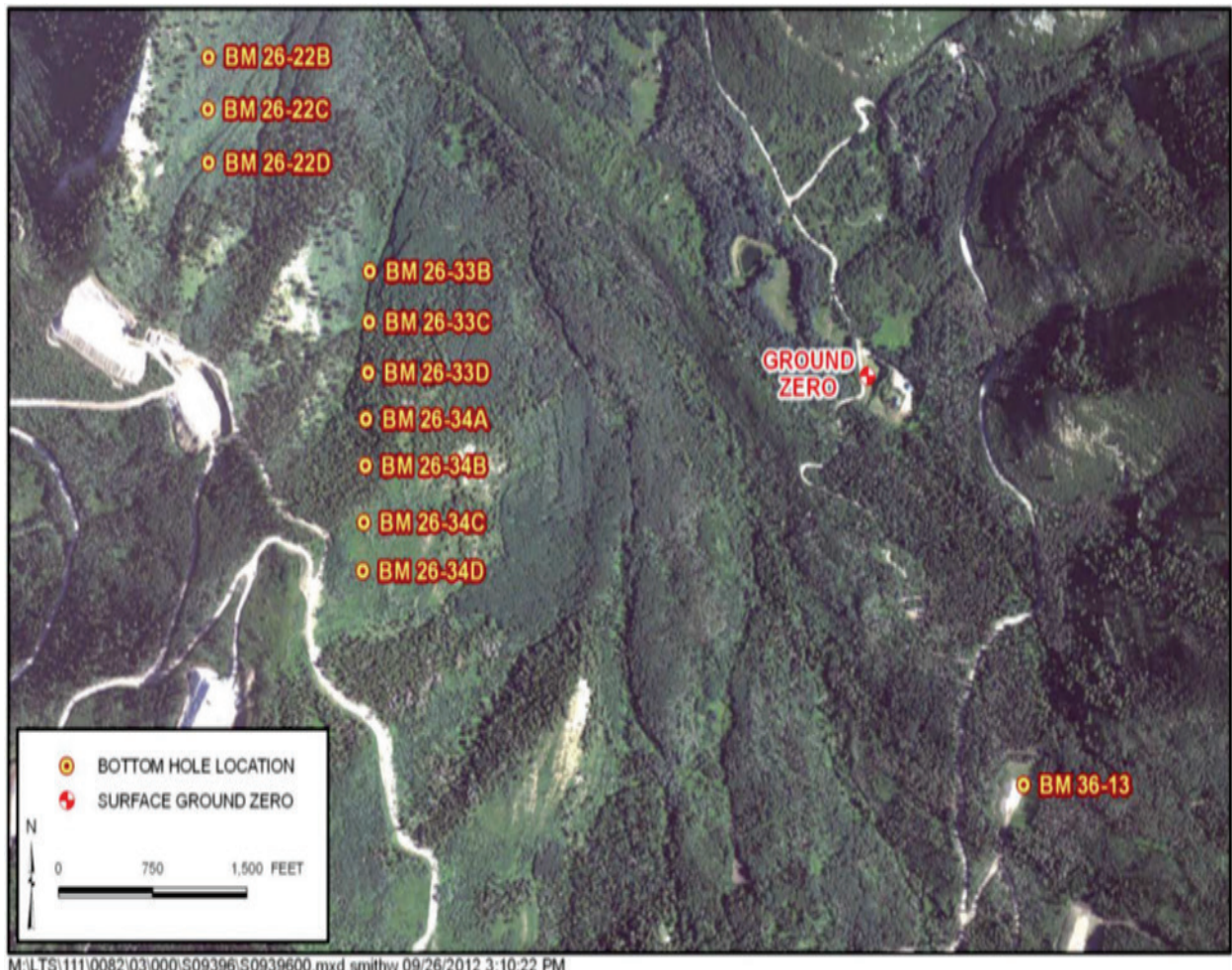
As part of the U.S. Department of Energy (DOE) Office of Legacy Management (LM) mission to protect human health and the environment, LM is monitoring natural gas wells near the Rulison site for radionuclides associated with the detonation. The very low permeability of the Williams Fork Formation limits contaminant migration in the subsurface and institutional controls limit subsurface access near the detonation zone. The Colorado Oil and Gas Conservation Commission notifies DOE of any drilling permit activity within 3 miles of the site. The State and DOE review drilling permits and gas well development practices within this boundary to ensure that drilling activities maintain a safe distance from the detonation zone. 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. The purpose of this trip was to collect natural gas and production water from producing natural gas wells in the Battlement Mesa (BM) field. The sampled wells collect natural gas from the formation horizon where the Project Rulison detonation occurred. The well locations are within 1.5 miles of the detonation location (surface ground zero on Figure 1).

Summary of Results

The water volume in the collection tanks for most of the wells had increased significantly from the previous quarters sampling; allowing for a 1 gallon sample to be collected from 9 of 13 wells. A 1 gallon duplicate production water sample was collected during the September sampling event at well BM 26-33C. At well BM 26-22B approximately 450 mL was collected which may provide enough sample for tritium analysis. Three wells (BM 26-34B, 34D, and BM-13)

produced no production water sample. Well BM-13 was undergoing a gas line repair and was not operating at the time of our sampling. The sampling team is planning to return to the BM-13 well in early October to collect the production water for this site.

For the 10 wells sampled on Pads 26N and 26K, the bottom-hole locations are between 0.76 mile and 1.1 miles from the Project Rulison vertical emplacement well 25-95 (R-E). Wells on Pads 35C and 36L are approximately 0.95 mile from the detonation point. The well on Pad 36B is approximately 0.55 mile southeast of well 25-95 (R-E). Surface projections of the bottom-hole well locations and Project Rulison surface ground zero, at well 25-95 (R-E) (i.e., the detonation point), are shown in Figure 1.



Notes:

All wells sampled have been previously sampled by DOE.
 The first two numerals in the well name designate the section number of the bottom-well location in the BM field.
 The Project Rulison emplacement well, 25-95 (R-E) (i.e., ground zero), is located in Lot 11, Section 25.

Figure 1. Wells Sampled and Well 25-95 (R-E)

Table 3 lists the wells by sample-collection sequence. Before sample collection occurs at each well, each well’s pressure and temperature (see Table 3) were read and recorded from surface

transducers in the wells. Latitude and longitude values (not shown in Table 3) were compiled from survey plats included with the applications for permits to drill and from Colorado Oil and Gas Conservation Commission scout cards.

Except for the BM-13 well all other planned wellheads were available for sampling, and wellhead pressures and temperatures were within the normal range. At 9 of the 13 sampling locations plus a duplicate from BM 26-33C a 1 gallon container of production water was collected.

Table 3. Samples Collected

Sample Collection Sequence	Pad	Well Name	Location			Sample Phase		Well	
			API # 05-045-	Type	Subtype	Gas	Liquid	T (°F)	P (psi)
1	26N	BM 26-33B	15739	WL	NGSA		Yes	237	56.5
2	26N	BM 26-33C	15742	WL	NGSA		Yes	233	58.5
Duplicate	26N	BM 26-33D	15743	WL	NGSA		Yes	241	57.5
3	26N	BM 26-33C	15743	WL	NGSV		Yes	241	57.5
4	26N	BM 26-34A	15744	WL	NGSA		Yes	238	55.0
5	26N	BM 26-34B	15745	WL	NGSA		No	245	58
6	26N	BM 26-34C	15741	WL	NGSA		Yes	248	57.1
7	26N	BM 26-34D	15748	WL	NGSA		No	250	57.5
8	26K	BM 26-22B	16086	WL	NGSA		Yes ¹	233	58.7
9	26K	BM 26-22C	16087	WL	NGSA		Yes	231	56.5
10	26K	BM 26-22D	16074	WL	NGSA		Yes	241	57.0
11	35C	BM 35-32A	10919	WL	NGSV		Yes	227	59.2
12	36L	BM 36-13B	15469	WL	NGSV		Yes	232	60.3
13	36B	BM 36-13	10840	WL	NGSV		No ²	NA	NA

Notes:

¹Approximately 450ML of production water was collected from the BM 26-22B well.

²The operator was repairing a gas line from the BM-13 wellhead and no production water was collected.

Abbreviations:

API American Petroleum Institute
 NGSA natural gas well-angle
 NGSV natural gas well-vertical
 P (psi) pressure in pounds per square inch
 T (°F) temperature in degrees Fahrenheit
 WL well

The produced-water samples were collected from a tap on a common line connecting the output of two separators (each servicing a well) and the nearby accumulation tanks. The collected water sample from one separator was isolated from the other separator by valves. Lines from each of the two separators were purged before sample collection.

The amount of water condensation in the condensation tank is variable and often not desired for the planned analytes. Collected sample volumes (Table 4) varied due to the water vapor concentration in the gas, temperature, age of the well, the cycle times of the well plunger, and

transfer to the accumulation tank. Analysis priorities are tritium, gross alpha/beta, technetium-99, and high-resolution gamma spectrometry.

If condensate was collected with a sample, which happens for most samples, the condensate naturally separated from water after a short time in the sample bottle. The condensate was decanted in the field and returned to the operator. Table 4 lists the estimated sample volumes (including the condensate).

Table 4. Collected Water Sample Volumes (Before Decanting)

Sample Ticket	Well Name	Planned Analytes	Sample Volume (L)
1	BM 26-33B	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	≈1 gallon
2	BM 26-33C	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	1 gallon
3	BM 26-33D	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	1 gallon
4	BM 26-34A	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	1 gallon
5	BM 26-34B	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	NA
6	BM 26-34C	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	1 gallon
7	BM 26-34D	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	NA
8	BM 26-22B	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	450 MI
9	BM 26-22C	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	1 gallon
10	BM 26-22D	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	1 gallon
11	BM 35-32A	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	1 gallon
12	BM 36-13B	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	1 gallon
13	BM 36-13	³ H, Gross α/β, Gamma spec, Cl ⁻ , ⁹⁹ Tc	NA

Notes:

Water sample information is listed in the order of collection.

Abbreviations:

Cl⁻ chloride
 Gamma spec high-resolution gamma spectrometry analysis
 Gross α/β gross alpha and beta analyses
³H tritium
 L liter
 NA not applicable
⁹⁹Tc technetium-99

Equipment

Each produced-water sample was collected in a new, 1-gallon plastic bottle. After decanting, each water sample was poured into white, high-density polyethylene bottles of appropriate volumes for analysis.

RIN

RIN 15097352 was assigned to these samples.
 Location 2657 is the duplicate for BM 26-33C.