



LMS/RUL/S11973  
Task Order LM00-502  
Control Number 14-0697

June 26, 2014

U.S. Department of Energy  
Office of Legacy Management  
ATTN: Art Kleinrath  
Site Manager  
2597 Legacy Way  
Grand Junction, CO 81503

**SUBJECT:** Contract No. DE-AM01-07LM00060, The S.M. Stoller Corporation, a wholly owned subsidiary of Huntington Ingalls Industries (Stoller)  
Task Order LM00-502 – Other Defense Activities – Other Sites  
First Quarter 2014 Production Water and Natural Gas Monitoring Report, Rulison, Colorado, Site

**REFERENCE:** Task Order LM00-502-07-619, Rulison, Colorado, Site

Dear Mr. Kleinrath:

The U.S. Department of Energy (DOE) Office of Legacy Management conducted quarterly production water and natural gas sampling at natural gas wells near the Rulison, Colorado, Site on December 19, 2013. The samples were shipped to the GEL Group Inc. laboratories in Charleston, South Carolina, for analysis. All requested analyses were successfully completed. Samples were analyzed for gamma-emitting radionuclides by high-resolution gamma spectrometry; tritium was analyzed using the conventional method with a detection limit on the order of 400 picocuries per liter and natural gas samples were analyzed using enriched tritium techniques.

### **Site Location and Background**

The Rulison site is located in Garfield County in western Colorado (see enclosed Figure 1). The Rulison test was designed and conducted to evaluate the use of a nuclear detonation to fracture the tight, gas-bearing formations in the Piceance Basin for enhanced natural gas production. A 40-kiloton device was detonated on September 10, 1969, at a depth of 8,426 feet below ground surface in the Williams Fork Formation of the Mesaverde Group.

To provide a more consolidated information package, the monitoring report now includes appendixes that consist of the associated trip report and the data validation package.

During the first-quarter sampling event conducted on December 19, 2013, monitoring activities were impacted by severe weather conditions at the Rulison site; natural gas valves at a local production station were frozen and not functioning properly. The intermittent closure of the production line valves caused significantly higher-than-normal wellhead pressures. At some wells, the high wellhead pressure prevented the production water plunger from traveling up the wells to purge production water. The higher wellhead pressures also contributed to a 10- to 15-degree increase in wellhead natural gas temperatures. Sampling locations are from natural gas wells that have bottom-hole locations near or within 1 mile of the detonation site.

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	BM36-13B
36B	Wellhead separator	BM36-13

Seven wells (Battlement Mesa [BM] 26-22B-D, BM 26-34A, BM 26-34C-D, and BM 26-13B) produced no production water, while well BM 26-33C produced only about 250 milliliters (mL) of production water. The 250 mL of production water provide enough sample volume for only tritium and chloride analyses. Produced-water samples, and one duplicate sample from well BM 26-33B, were collected from 13 gas wells identified in the sample plan.

## Conclusions

No liquid-phase or gas-phase tritium contamination was detected in the analysis of 13 gas-phase samples and 7 liquid-phase samples. Two carbon-14 natural gas-phase samples indicated a potential detect at just slightly above detection levels, but well below screening or action levels. Gross alpha activity was detected in one of the seven samples and gross beta activity was detected in six of the seven samples. The alpha and beta detections are from naturally occurring radionuclides. The results continue to verify that detonation-related contaminants have not impacted natural gas wells at the sampling locations.

Please contact me at (970) 248-6477 with any questions.

Sincerely,

**Rick Hutton**

Digitally signed by Rick Hutton  
DN: c=us, o=u.s. government, ou=department of  
energy, ou=Energy IT Services, ou=Legacy  
Management, ou=People, cn=Rick Hutton  
Date: 2014.07.08 15:45:13 -06'00'

Richard D. Hutton  
Project Manager

# **Monitoring Results Natural Gas Wells Near Project Rulison First Quarter 2014**

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

**Date Sampled**    December 19, 2013

### **Background**

Project Rulison was the second Plowshare Program test to stimulate natural gas recovery from deep and low-permeability formations. On September 10, 1969, a 40-kiloton-yield nuclear device was detonated 8,426 feet (1.6 miles) below the ground surface in the Williams Fork Formation at what is now the Rulison, Colorado, Site. Following the detonation, a series of production tests were conducted. Afterward, the site was shut down and then remediated, and the emplacement well (R-E) and the reentry well (R-Ex) were plugged.

### **Purpose**

As part of the U.S. Department of Energy (DOE) Office of Legacy Management (LM) mission to protect human health and the environment, LM is monitoring natural gas wells that are near the Rulison site for radionuclides associated with the detonation. Though the very low permeability of the Williams Fork Formation limits migration, institutional control restrictions limit subsurface access in the detonation zone. When 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**

Of the 13 wells sampled for gas and water, no analytical result exceeded the screening levels specified in the *Rulison Monitoring Plan*. The gas- and liquid-phase levels are reproduced in Table 3a and Table 3b, respectively.

During the first-quarter sampling event conducted on December 19, 2013, monitoring activities were impacted by severe weather conditions at the Rulison site; natural gas valves at a local production station were frozen and not functioning properly. The intermittent closure of the production line valves caused significantly higher-than-normal wellhead pressures. At some wells, the high wellhead pressure prevented the production water plunger from traveling up the wells to purge production water. The higher wellhead pressures also contributed to a 10- to 15-degree increase in wellhead natural gas temperatures. Seven wells (Battlement Mesa [BM] 26-22B-D, BM 26-34A, BM 26-34C-D, and BM 36-13B) produced no production water,

while well BM 26-33C produced only about 250 milliliters (mL) of production water. The 250 mL of production water provide enough sample volume for only tritium and chloride analyses. Produced-water samples, and one duplicate sample from well BM 26-33B, were collected from 13 gas wells identified in the first-quarter sample plan.

The well on Pad 36N, BM 26-33C, produced approximately 250 milliliters (mL) of production water, which was enough sample volume for only gross alpha, gross beta, and tritium analyses. The 13 wells are listed in Table 1. Sequential sample collection information is listed in Table 2.

*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	BM36-13B
36B	Wellhead separator	BM36-13

*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 26-33D	15739	WL	NGSA	Yes	Yes	75.1	346
2	26N	BM 26-33C	15742	WL	NGSA	Yes	Yes <sup>1</sup>	77.1	348
3	26N	BM 26-33B	15743	WL	NGSA	Yes	Yes	72.7	344
DUP	26N	BM 26-33B	15743	WL	NGSA	No	Yes	72.7	344
4	26N	BM 26-34C	15741	WL	NGSA	Yes	None	77.9	281
5	26N	BM 26-34B	15745	WL	NGSA	Yes	Yes	75.6	344
6	26N	BM 26-34D	15748	WL	NGSA	Yes	None	76.8	346
7	26N	BM 26-34A	15744	WL	NGSA	Yes	None	79.4	347
8	26K	BM 26-22B	16086	WL	NGSA	Yes	None	76.9	420
9	26K	BM 26-22C	16087	WL	NGSA	Yes	None	71.4	398
10	26K	BM 26-22D	16074	WL	NGSA	Yes	None	73.6	397
11	35C	BM 35-32A	10919	WL	NGSV	Yes	Yes	55.2	374
12	36L	BM 36-13B	15469	WL	NGSV	Yes	None	67	427
13	36B	BM 36-13	10840	WL	NGSV	Yes	Yes	67.4	375

**Notes:**

<sup>1</sup>Approximately 250 mL of production water.

**Abbreviations:**

API American Petroleum Institute  
 DUP duplicate  
 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 are between 0.75 mile 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 that of the Rulison detonation point.

## Sample Collection

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.

When a gas sample is collected, the 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 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	$5.183 \times 10^{-6}$ pCi/cc/TU
<sup>14</sup> Carbon	pMC	2 pMC	5 pMC	$6.54 \times 10^{-5}$ pCi/cc and $16.4 \times 10^{-5}$ pCi/cc, respectively

### Abbreviations:

pCi/cc	picocuries per cubic centimeter
pCi/cc/TU	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 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	3x background	TBD	
Gross beta	pCi/L	3x 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**

As scheduled, 13 gas samples were collected from 13 producing gas wells near the Rulison site. Due to severe weather conditions at the site, which caused downstream production valves to not operate, wellhead pressures were significantly higher than normal. The higher line pressure at the wellhead caused several production water plungers to not operate properly. As a result, no production water was transported to the surface. Therefore, only six wells produced enough water for total analysis and well BM 26-33C produced only enough water—approximately 250mL—for tritium and chloride analyses. Two gas samples indicated levels of carbon-14 slightly above detection limits of 0.2 percent modern carbon (pMC), but well below the screening level of 2.0 pMC for carbon-14 in natural gas. No other Rulison-related contamination was present in the gas samples. Since the carbon-14 levels were higher than the detection level, and no other Rulison-related contamination was detected, natural gas sampling will continue in accordance with the normal schedule (i.e., the next sampling event will occur in June 2014).

Production water analytical results are tabulated by well in Appendix A.

**Laboratory Qualifiers**

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

A “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 3 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, in addition to those for gas-phase pMC, are summarized in Table 4a. Liquid-phase results for gross alpha and gross 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) Collected	Tritium Results (gas phase)			Tritium Results (liquid phase)			Carbon-14 (gas phase)		
		Detect	Non-detect	NA	Detect	Non-detect	NA	Detect	Non-detect	NA
Natural gas wells	13/07	0	13	0	0	7	7	2	11	0

**Notes:**

A duplicate sample was collected at well BM 26-33B and is included in the total of seven liquid-phase samples. BM 36-33C produced approximately 250 mL of production water, enough for only chloride and tritium analyses. NA was assigned to seven samples because an insufficient amount of production water for analysis was collected from well BM 26-33C, and no production water was collected at wells BM 26-22B–D, BM 26-34A, BM 26-34C–D, and BM 36-13B.

*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	Non-detect	NA	Detect	Non-detect	NA
Natural gas wells	7	1	5	7	6	0	7

**Notes:**

Data validation assigned a J qualifier to five of the six gross-alpha detect results. Data validation assigned a J qualifier to 5 of the 10 gross-beta detect results. A duplicate sample was collected at well BM 26-33B and is included in the total of seven liquid-phase samples. NA was assigned to seven samples because an insufficient amount of production water for analysis was collected from well BM 26-33C, and no production water was collected from wells BM 26-22B–D, BM 26-34A, BM 26-34C–D, and BM 36-13B.

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

Collection Location	Total Liquid Samples Collected	Potassium-40 Results		
		Detect	Non-detect	NA
Natural gas wells	7	1	5	7

**Notes:**

Data validation assigned a J qualifier to two of the seven potassium-40 detect results.

A duplicate sample was collected at well BM 26-33B and is included in the total of seven liquid-phase samples.

NA was assigned to seven samples because an insufficient amount of production water for analysis was collected from well BM 26-33C, and no production water was collected from wells BM 26-22B-D, BM 26-34A, BM 26-34C-D, and BM 36-13B.



## **Data Review and Validation Report**

This page intentionally left blank

# Data Validation Package

---

**December 2013  
Natural Gas and Produced Water  
Sampling at the  
Rulison, Colorado, Site**

**April 2014**



U.S. DEPARTMENT OF  
**ENERGY**

Legacy  
Management

---

This page intentionally left blank

# 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 .....	18
Certification .....	20

## **Attachment 1—Data Presentation**

Natural Gas Data  
Produced Water Data

This page intentionally left blank

# Sampling Event Summary

**Site:** Rulison, Colorado, Site

**Sampling Period:** December 19, 2013

The U.S. Department of Energy Office of Legacy Management conducted sampling at the Rulison, Colorado, Site on December 19, 2013, 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. Natural gas and 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:

- Natural gas samples were submitted under requisition 13125803 to Isotech Laboratories in Champaign, Illinois, for the determination of carbon-14 and tritium.
- Produced water samples were submitted under requisition 13125804 to ALS Laboratory Group in Fort Collins, Colorado, for the determination of chloride, gross alpha/beta, gamma emitting nuclides, and tritium.

Sampling and analysis 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 produced water sample was collected at location 05-045-15743.

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 13 wells sampled during this event exceeded the screening levels specified in the Monitoring Plan. The natural gas and produced water sample results are presented in Attachment 1.



Rick Hutton

Site Lead

The S.M. Stoller Corporation,  
a wholly owned subsidiary of Huntington Ingalls Industries

5-12-14

Date



M:\LTS\111\0082\03\000\S09396\S0939600.mxd smithw 09/26/2012 3:10:22 PM

Rulison, Colorado, Site Sample Location Map



# Data Assessment Summary

This page intentionally left blank

### Water Sampling Field Activities Verification Checklist

<b>Project</b>	<u>Rulison, Colorado</u>	<b>Date(s) of Water Sampling</b>	<u>December 19, 2013</u>
<b>Date(s) of Verification</b>	<u>April 4, 2014</u>	<b>Name of Verifier</b>	<u>Stephen Donovan</u>

	<b>Response (Yes, No, NA)</b>	<b>Comments</b>
1. Is the SAP the primary document directing field procedures? List any Program Directives or other documents, SOPs, instructions.	Yes	Program Directive RUL-2013-01.
2. Were the sampling locations specified in the planning documents sampled?	No	Only 7 wells of the 13 planned produced enough production water for analysis.
3. Were calibrations conducted as specified in the above-named documents?	NA	Field measurements were not required.
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?	NA	This sampling event did not include groundwater.
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?	NA	This sampling event did not include groundwater.

### 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 05-045-15743.
10. Were equipment blanks taken at a frequency of one per 20 samples that were collected with non-dedicated equipment?	NA	An equipment blank was not required.
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	A limited volume of produced water was available at well 05-045-15742; only a tritium sample was submitted for analysis.
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 (RIN): 13125803  
Sample Event: December 19, 2013  
Site(s): Rulison, Colorado  
Laboratory: Isotech Laboratories  
Work Order No.: 23941  
Analysis: Radiochemistry  
Validator: Stephen Donovan  
Review Date: March 27, 2014

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 1, Data Deliverables Examination. The data were examined to assess the completeness of the deliverables, identify any reporting errors, and assess the usability of the data based on the results of the field duplicate and the laboratory’s evaluation of their data, as described in the narrative provided. The data are acceptable as received. 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
Natural Gas Analysis	LMG-01	NA	Gas Chromatography
Carbon-14 and Tritium	LMG-03	Combustion	Liquid Scintillation Counting

### Data Qualifier Summary

None of the analytical results required qualification.

### Sample Shipping/Receiving

Isotech Laboratories received 13 natural gas samples on January 2, 2014, accompanied by a Chain of Custody (COC) form. The COC 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. The COC form was complete with no errors or omissions with the following exception. There was no relinquishment signature on the form.

### Summary

Thirteen natural gas samples were received at Isotech Laboratories and analyzed by gas chromatography to determine the natural gas composition. The samples were then combusted with the resulting water collected for analysis. Carbon-14 and tritium were measured in the water collected by liquid scintillation counting. There were no analytical difficulties noted by the laboratory.

## Completeness

The results of the gas chromatography analysis were reported in volume percent showing the average sample composition of 90 percent methane.

The carbon-14 results were reported in percent modern carbon (pMC). The tritium results were reported in tritium units. Carbon-14 was detected in two samples at 0.5 pMC with a detection limit of 0.4 pMC.

## General Information

Requisition No. (RIN): 13125804  
Sample Event: December 19, 2013  
Site(s): Rulison Site  
Laboratory: ALS Laboratory Group, Fort Collins, Colorado  
Work Order No.: 1401001  
Analysis: Radiochemistry and Wet Chemistry  
Validator: Stephen Donivan  
Review Date: March 27, 2014

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 2.

*Table 2. Analytes and Methods*

Analyte	Line Item Code	Prep Method	Analytical Method
Chloride	WCH-B-011	EPA 300.0	EPA 300.0
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 3. Refer to the sections below for an explanation of the data qualifiers applied.

*Table 3. Data Qualifier Summary*

Sample Number	Location	Analyte	Flag	Reason
1401001-1	BM 26-33B Duplicate	Gross Beta	J	Less than the determination limit
1401001-2	BM 26-33B	Gross Beta	J	Less than the determination limit
1401001-4	BM 26-33D	Gross Beta	J	Less than the determination limit
1401001-5	BM 26-34B	Gross Beta	J	Less than the determination limit
1401001-5	BM 26-34B	Yttrium-88	U	Nuclide identification criteria
1401001-6	BM 35-32A	Actinium-228	U	Nuclide identification criteria
1401001-6	BM 35-32A	Potassium-40	J	Less than the determination limit
1401001-7	BM 36-13	Gross Alpha	J	Less than the determination limit

## Sample Shipping/Receiving

ALS Laboratory Group in Fort Collins, Colorado, received seven water samples on January 2, 2014, accompanied by a COC form. The COC 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 COC 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 MDLs for the wet chemical analyte and MDCs for radiochemical analytes met the detection limits 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 demonstrates that the instrument is capable of acceptable performance in the beginning of the analytical run and of producing a linear curve. 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.

#### *Method EPA 300.0, Chloride*

Calibration for chloride was performed using five calibration standards on December 16, 2013. The calibration curve correlation coefficient values were greater than 0.995 and the absolute values of the intercepts were less than 3 times the MDL. Initial and continuing calibration verification checks were made at the required frequency with all calibration checks meeting the laboratory's acceptance criteria.

#### 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 January 17, 2014. 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 was 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: 13125804 Lab Code: PAR Validator: Stephen Donovan Validation Date: 03/27/2014

Project: Rulison Site Analysis Type:  Metals  General Chem  Rad  Organics

# of Samples: 7 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

All analyses were completed within the applicable holding times.

Detection Limits

There are 12 detection limit failures.

Field/Trip Blanks

Field Duplicates

There was 1 duplicate evaluated.

**SAMPLE MANAGEMENT SYSTEM**

RIN: 13125804      Lab Code: PAR

**Non-Compliance Report: Detection Limits**

Project: Rulison Site

Validation Date: 03/27/2014

Ticket	Location	Lab Sample ID	Method Code	Lab Method	Analyte Name	Result	Qualifier	Reported Detection Limit	Required Detection Limit	Units
LNT 716	2559	1401001-1	GPC-A-001	724R11	GROSS BETA	68.7		24	4	pCi/L
LNT 716	2559	1401001-1	GPC-A-001	724R11	GROSS ALPHA	11.6	U	25	2	pCi/L
LNT 703	BM 26-33B	1401001-2	GPC-A-001	724R11	GROSS ALPHA	21.3	U	29	2	pCi/L
LNT 703	BM 26-33B	1401001-2	GPC-A-001	724R11	GROSS BETA	60.3		24	4	pCi/L
LNT 705	BM 26-33D	1401001-4	GPC-A-001	724R11	GROSS BETA	110		47	4	pCi/L
LNT 705	BM 26-33D	1401001-4	GPC-A-001	724R11	GROSS ALPHA	9.68	U	42	2	pCi/L
LNT 706	BM 26-34B	1401001-5	GPC-A-001	724R11	GROSS BETA	98.1		44	4	pCi/L
LNT 706	BM 26-34B	1401001-5	GPC-A-001	724R11	GROSS ALPHA	17	U	35	2	pCi/L
LNT 710	BM 35-32A	1401001-6	GPC-A-001	724R11	GROSS BETA	172		43	4	pCi/L
LNT 710	BM 35-32A	1401001-6	GPC-A-001	724R11	GROSS ALPHA	19.5	U	31	2	pCi/L
LNT 711	BM 36-13	1401001-7	GPC-A-001	724R11	GROSS BETA	88.1		21	4	pCi/L
LNT 711	BM 36-13	1401001-7	GPC-A-001	724R11	GROSS ALPHA	30.6		19	2	pCi/L

**SAMPLE MANAGEMENT SYSTEM**  
**Radiochemistry Data Validation Worksheet**

**RIN:** 13125804                      **Lab Code:** PAR                      **Date Due:** 01/30/2014  
**Matrix:** Water                      **Site Code:** RUL01                      **Date Completed:** 01/20/2014

Sample	Analyte	Date Analyzed	Result	Flag	Tracer %R	LCS %R	MS %R	Duplicate
BM 36-13	Actinium-228	01/09/2014						1.47
Blank_Spike	Americium-241	01/08/2014				99.70		
BM 36-13	Americium-241	01/09/2014						0.78
BM 36-13	Antimony-125	01/09/2014						0.26
BM 36-13	Cerium-144	01/09/2014						1.06
BM 36-13	Cesium-134	01/09/2014						0.67
Blank_Spike	Cesium-137	01/08/2014				101.00		
BM 36-13	Cesium-137	01/09/2014						0.64
Blank_Spike	Cobalt-60	01/08/2014				98.50		
BM 36-13	Cobalt-60	01/09/2014						1.02
BM 36-13	Europium-152	01/09/2014						1.00
BM 36-13	Europium-154	01/09/2014						0.30
BM 36-13	Europium-155	01/09/2014						1.75
BM 26-34B	GROSS ALPHA	01/15/2014						0.93
Blank_Spike	GROSS ALPHA	01/16/2014				90.20		
BM 35-32A	GROSS ALPHA	01/16/2014					117.0	
Blank	GROSS ALPHA	01/16/2014	-0.4400	U				
BM 26-34B	GROSS BETA	01/15/2014						0.68
Blank	GROSS BETA	01/16/2014	-0.5400	U				
BM 35-32A	GROSS BETA	01/16/2014					103.0	
Blank_Spike	GROSS BETA	01/16/2014				91.70		
BM 35-32A	H-3	01/06/2014						0.97
Blank_Spike	H-3	01/07/2014				106.00		
BM 35-32A	H-3	01/07/2014					98.3	
Blank	H-3	01/07/2014	125.0000	U				
BM 36-13	Lead-212	01/09/2014						0.58
BM 36-13	Potassium-40	01/09/2014						0.20
BM 36-13	Promethium-144	01/09/2014						0.15
BM 36-13	Promethium-146	01/09/2014						0.06
BM 36-13	Ruthenium-106	01/09/2014						1.51
BM 36-13	Thorium-234	01/09/2014						0.70
BM 36-13	Uranium-235	01/09/2014						0.65

**SAMPLE MANAGEMENT SYSTEM**  
**Radiochemistry Data Validation Worksheet**

**RIN:** 13125804                      **Lab Code:** PAR                      **Date Due:** 01/30/2014  
**Matrix:** Water                      **Site Code:** RUL01                      **Date Completed:** 01/20/2014

Sample	Analyte	Date Analyzed	Result	Flag	Tracer %R	LCS %R	MS %R	Duplicate
BM 36-13	Yttrium-88	01/09/2014						0.89

**SAMPLE MANAGEMENT SYSTEM**  
**Wet Chemistry Data Validation Worksheet**

**RIN:** 13125804      **Lab Code:** PAR      **Date Due:** 01/30/2014  
**Matrix:** Water      **Site Code:** RUL01      **Date Completed:** 01/20/2014

Analyte	Date Analyzed	CALIBRATION				Method Blank	LCS %R	MS %R	MSD %R	DUP RPD	Serial Dil. %R
		Int.	R^2	CCV	CCB						
CHLORIDE	01/03/2014	0.000	1.0000	OK	OK	OK	103.00	94.0	100.0	2.00	

## **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.

Natural gas samples were collected as specified in Program Directive RUL-2013-01 in an evacuated 17.8-liter gas cylinder provided by Isotech Laboratories, Inc. Each sampling container was filled to approximately 25 pounds per square inch with natural gas from each well.

### Equipment Blank Assessment

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 05-045-15743. For non-radiochemical measurements, the relative percent difference for duplicate results that are greater than 5 times the PQL should be less than 20 percent. For results less than 5 times the PQL, the range should be no greater than the PQL. 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: 13125804      Lab Code: PAR      Project: Rulison Site      Validation Date: 03/27/2014

Duplicate: 2559

Sample: BM 26-33B

Analyte	Sample				Duplicate				RPD	RER	Units
	Result	Flag	Error	Dilution	Result	Flag	Error	Dilution			
Actinium-228	9.3	U	29.2	1	24.9	U	17.5	1		0.9	pCi/L
Americium-241	2.45	U	5.27	1	0.543	U	4.7	1		0.5	pCi/L
Antimony-125	-4.4	U	10.2	1	3.96	U	9.42	1		1.2	pCi/L
Cerium-144	-9.28	U	15.4	1	-0.325	U	14.5	1		0.8	pCi/L
Cesium-134	-2.4	U	5.44	1	-4.91	U	3.95	1		0.7	pCi/L
Cesium-137	3.34	U	4.59	1	-3.45	U	4.01	1		2.2	pCi/L
CHLORIDE	8600			1000	8700			1000	1.16		MG/L
Cobalt-60	1.03	U	5.56	1	1.66	U	4.55	1		0.2	pCi/L
Europium-152	-7.73	U	24.5	1	-4.13	U	21.8	1		0.2	pCi/L
Europium-154	6.62	U	25.6	1	-14.4	U	23	1		1.2	pCi/L
Europium-155	1.72	U	7.42	1	0.973	U	6.2	1		0.2	pCi/L
GROSS ALPHA	21.3	U	18.3	1	11.6	U	15.3	1		0.8	pCi/L
GROSS BETA	60.3		18.3	1	68.7		18.8	1		0.6	pCi/L
H-3	46	U	212	1	-30.8	U	209	1		0.5	pCi/L
Lead-212	1.65	U	8.98	1	3.9	U	7.7	1		0.4	pCi/L
Potassium-40	-1.29	U	95.1	1	-5	U	80.1	1		0.1	pCi/L
Promethium-144	1.59	U	5	1	1.75	U	4.67	1		0	pCi/L
Promethium-146	-4.43	U	4.61	1	0.656	U	4.44	1		1.6	pCi/L
Ruthenium-106	-2.7	U	39.5	1	-18.1	U	37.1	1		0.6	pCi/L
Thorium-234	20.8	U	53.6	1	6.03	U	49.7	1		0.4	pCi/L
Uranium-235	5.11	U	22.9	1	7.62	U	14.4	1		0.2	pCi/L
Yttrium-88	-5.76	U	8.77	1	4.09	U	4.86	1		1.9	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 5-12-2014  
Stephen Donovan Date

Data Validation Lead: Stephen Donovan 5-12-2014  
Stephen Donovan Date

# **Attachment 1**

## **Data Presentation**

This page intentionally left blank

## **Natural Gas Data**

This page intentionally left blank

---

**Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site**

**REPORT DATE: 04/04/2014**

**Location: 05-045-10840 WELL, Natural Gas Well - Angle, BM 36-13**

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)		Matrix Subtype	Result	Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	12/19/2013	N001	LNT 701	8683	- 8683		0.2	U		#	0.2	
Tritium	pCi/L	12/19/2013	N001	LNT 701	8683	- 8683		0.0514	U		#	0.0514	

---

**Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site**

**REPORT DATE: 04/04/2014**

**Location: 05-045-10919 WELL, Natural Gas Well - Angle, BM 35-32A**

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)		Matrix Subtype	Result	Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	12/19/2013	N001	LNT 700	9236	- 9236		0.2	U		#	0.2	
Tritium	pCi/L	12/19/2013	N001	LNT 700	9236	- 9236		0.0514	U		#	0.0514	



---

**Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site**

**REPORT DATE: 04/04/2014**

**Location: 05-045-15469 WELL, Natural Gas Well - Angle, BM 36-13B**

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)		Matrix Subtype	Result	Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	12/19/2013	N001	LNT 702	8901	- 8901		0.5			#		
Tritium	pCi/L	12/19/2013	N001	LNT 702	8901	- 8901		0.0514	U		#	0.0514	

---

**Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site**

**REPORT DATE: 04/04/2014**

**Location: 05-045-15739 WELL, Natural Gas Well - Angle, BM 26-33D**

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	12/19/2013	N001	LNT 692	8963.5 - 8963.5		0.2	U		#	0.2	
Tritium	pCi/L	12/19/2013	N001	LNT 692	8963.5 - 8963.5		0.0632	U		#	0.0632	

---

**Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site**

**REPORT DATE: 04/04/2014**

**Location: 05-045-15741 WELL, Natural Gas Well - Angle, BM 26-34C**

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	12/19/2013	N001	LNT 695	8963.5 - 8963.5		0.2	U		#	0.2	
Tritium	pCi/L	12/19/2013	N001	LNT 695	8963.5 - 8963.5		0.0514	U		#	0.0514	

---

**Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site**

**REPORT DATE: 04/04/2014**

**Location: 05-045-15742 WELL, Natural Gas Well - Angle, BM 26-33C**

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	12/19/2013	N001	LNT 691	8963.5 - 8963.5		0.2	U		#	0.2	
Tritium	pCi/L	12/19/2013	N001	LNT 691	8963.5 - 8963.5		0.0514	U		#	0.0514	

---

**Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site**

**REPORT DATE: 04/04/2014**

**Location: 05-045-15743 WELL, Natural Gas Well - Angle, BM 26-33B**

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	12/19/2013	N001	LNT 690	8963.5 - 8963.5		0.2	U		#	0.2	
Tritium	pCi/L	12/19/2013	N001	LNT 690	8963.5 - 8963.5		0.0514	U		#	0.0514	

---

**Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site**

**REPORT DATE: 04/04/2014**

**Location: 05-045-15744 WELL, Natural Gas Well - Angle, BM 26-34A**

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	12/19/2013	N001	LNT 693	8963.5 - 8963.5		0.2	U		#	0.2	
Tritium	pCi/L	12/19/2013	N001	LNT 693	8963.5 - 8963.5		0.0514	U		#	0.0514	

---

**Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site**

**REPORT DATE: 04/04/2014**

**Location: 05-045-15745 WELL, Natural Gas Well - Angle, BM 26-34B**

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	12/19/2013	N001	LNT 694	8963.5 - 8963.5		0.2	U		#	0.2	
Tritium	pCi/L	12/19/2013	N001	LNT 694	8963.5 - 8963.5		0.0514	U		#	0.0514	

---

**Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site**

**REPORT DATE: 04/04/2014**

**Location: 05-045-15748 WELL, Natural Gas Well - Angle, BM 26-34D**

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	12/19/2013	N001	LNT 696	8963.5 - 8963.5		0.5			#		
Tritium	pCi/L	12/19/2013	N001	LNT 696	8963.5 - 8963.5		0.0514	U		#	0.0514	



---

**Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site**

**REPORT DATE: 04/04/2014**

**Location: 05-045-16074 WELL, Natural Gas Well - Angle, BM 26-22D**

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	12/19/2013	N001	LNT 699	8983.5 - 8983.5		0.2	U		#	0.2	
Tritium	pCi/L	12/19/2013	N001	LNT 699	8983.5 - 8983.5		0.0514	U		#	0.0514	

---

**Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site**

**REPORT DATE: 04/04/2014**

**Location: 05-045-16086 WELL, Natural Gas Well - Angle, BM 26-22B**

Parameter	Units	Sample Date	Sample ID	Ticket Number	Elev. Range (Ft)	Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	12/19/2013	N001	LNT 697	8983.5 - 8983.5		0.2	U		#	0.2	
Tritium	pCi/L	12/19/2013	N001	LNT 697	8983.5 - 8983.5		0.0514	U		#	0.0514	

**Gas Matrix Chemistry Data by Location (U5EE510) FOR SITE RUL01, Rulison Site**

**REPORT DATE: 04/04/2014**

**Location: 05-045-16087 WELL, Natural Gas Well - Angle, BM 26-22C**

Parameter	Units	Sample		Ticket Number	Elev. Range (Ft)		Matrix Subtype	Result	Qualifiers		Detection Limit	Uncertainty
		Date	ID		Lab	Data			QA			
Carbon-14	pMC	12/19/2013	N001	LNT 698	8983.5	- 8983.5		0.2	U	#	0.2	
Tritium	pCi/L	12/19/2013	N001	LNT 698	8983.5	- 8983.5		0.0514	U	#	0.0514	

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.
- L Less than 3 bore volumes purged prior to sampling.
- U Parameter analyzed for but was not detected.
- G Possible grout contamination, pH > 9.
- Q Qualitative result due to sampling technique.
- X Location is undefined.
- J Estimated value.
- R Unusable result.

**QA QUALIFIER:**

- # Validated according to quality assurance guidelines.

This page intentionally left blank

## **Produced Water Data**

This page intentionally left blank

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

**REPORT DATE: 04/04/2014**

**Location: 05-045-10840 WELL BM 36-13**

Parameter	Units	Sample		Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID		Lab	Data	QA		
Actinium-228	pCi/L	12/19/2013	N002	24.3	U		#	28	18.3
Americium-241	pCi/L	12/19/2013	N002	14.6	U		#	50	30.9
Antimony-125	pCi/L	12/19/2013	N002	2.5	U		#	16	9.1
Cerium-144	pCi/L	12/19/2013	N002	22	U		#	37	22.7
Cesium-134	pCi/L	12/19/2013	N002	-1.24	U		#	7.2	4.12
Cesium-137	pCi/L	12/19/2013	N002	-2.18	U		#	7.8	4.32
Chloride	mg/L	12/19/2013	N002	7000			#	100	
Cobalt-60	pCi/L	12/19/2013	N002	0.687	U		#	8.1	4.65
Europium-152	pCi/L	12/19/2013	N002	-3.22	U		#	40	22.4
Europium-154	pCi/L	12/19/2013	N002	-10.1	U		#	45	24.7
Europium-155	pCi/L	12/19/2013	N002	10.3	U		#	17	10.3
Gross Alpha	pCi/L	12/19/2013	N002	30.6		J	#	19	13.8
Gross Beta	pCi/L	12/19/2013	N002	88.1			#	21	19.9
Lead-212	pCi/L	12/19/2013	N002	5.07	U		#	16	9.94
Potassium-40	pCi/L	12/19/2013	N002	57.3	U		#	130	76.6
Promethium-144	pCi/L	12/19/2013	N002	-1.64	U		#	8.3	4.75
Promethium-146	pCi/L	12/19/2013	N002	-.572	U		#	8.1	4.64
Ruthenium-106	pCi/L	12/19/2013	N002	-42.5	U		#	72	39.4

---

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

**REPORT DATE: 04/04/2014**

**Location: 05-045-10840 WELL BM 36-13**

<b>Parameter</b>	<b>Units</b>	<b>Sample Date</b>	<b>Sample ID</b>	<b>Result</b>	<b>Lab</b>	<b>Qualifiers Data</b>	<b>QA</b>	<b>Detection Limit</b>	<b>Uncertainty</b>
Thorium-234	pCi/L	12/19/2013	N002	-34.8	U		#	150	86.8
Tritium	pCi/L	12/19/2013	N002	14.3	U		#	390	231
Uranium-235	pCi/L	12/19/2013	N002	12.4	U		#	21	13.1
Yttrium-88	pCi/L	12/19/2013	N002	0.745	U		#	12	7.13



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

**REPORT DATE: 04/04/2014**

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

Parameter	Units	Sample		Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID		Lab	Data	QA		
Actinium-228	pCi/L	12/19/2013	N002	26.6		U	#	20	12.1
Americium-241	pCi/L	12/19/2013	N002	0.329	U		#	5.1	3.06
Antimony-125	pCi/L	12/19/2013	N002	1.32	U		#	9.6	5.28
Cerium-144	pCi/L	12/19/2013	N002	-1.99	U		#	16	9.37
Cesium-134	pCi/L	12/19/2013	N002	-2.46	U		#	7	4.15
Cesium-137	pCi/L	12/19/2013	N002	-1.64	U		#	4.4	2.54
Chloride	mg/L	12/19/2013	N002	7800			#	200	
Cobalt-60	pCi/L	12/19/2013	N002	0.368	U		#	5.2	3.05
Europium-152	pCi/L	12/19/2013	N002	-7.34	U		#	26	14.3
Europium-154	pCi/L	12/19/2013	N002	-5.9	U		#	26	14.8
Europium-155	pCi/L	12/19/2013	N002	7.01	U		#	7.2	4.52
Gross Alpha	pCi/L	12/19/2013	N002	19.5	U		#	31	19.5
Gross Beta	pCi/L	12/19/2013	N002	172			#	43	39.6
Lead-212	pCi/L	12/19/2013	N002	0.519	U		#	14	8.21
Potassium-40	pCi/L	12/19/2013	N002	130		J	#	130	80.8
Promethium-144	pCi/L	12/19/2013	N002	-.734	U		#	5.2	3.04
Promethium-146	pCi/L	12/19/2013	N002	0.0531	U		#	4.5	2.67
Ruthenium-106	pCi/L	12/19/2013	N002	3.85	U		#	42	24.7

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 04/04/2014**  
**Location: 05-045-10919 WELL BM 35-32A**

Parameter	Units	Sample		Result	Qualifiers		Detection Limit	Uncertainty
		Date	ID		Lab	Data QA		
Thorium-234	pCi/L	12/19/2013	N002	9.9	U	#	69	41.8
Tritium	pCi/L	12/19/2013	N002	-9.53	U	#	390	233
Uranium-235	pCi/L	12/19/2013	N002	-8.53	U	#	31	18.5
Yttrium-88	pCi/L	12/19/2013	N002	-.762	U	#	12	7.44

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

**REPORT DATE: 04/04/2014**

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

Parameter	Units	Sample		Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID		Lab	Data	QA		
Actinium-228	pCi/L	12/19/2013	N002	24.1	U		#	25	11.5
Americium-241	pCi/L	12/19/2013	N002	-39.6	U		#	130	79
Antimony-125	pCi/L	12/19/2013	N002	-6.73	U		#	17	8.13
Cerium-144	pCi/L	12/19/2013	N002	-8.86	U		#	25	14.6
Cesium-134	pCi/L	12/19/2013	N002	-3.03	U		#	4	2.26
Cesium-137	pCi/L	12/19/2013	N002	1.29	U		#	3.8	2.32
Chloride	mg/L	12/19/2013	N002	12000			#	200	
Cobalt-60	pCi/L	12/19/2013	N002	-1.58	U		#	4.3	2.46
Europium-152	pCi/L	12/19/2013	N002	3.06	U		#	19	11
Europium-154	pCi/L	12/19/2013	N002	-2.48	U		#	20	11.7
Europium-155	pCi/L	12/19/2013	N002	-6.78	U		#	17	9.92
Gross Alpha	pCi/L	12/19/2013	N002	9.68	U		#	42	24.7
Gross Beta	pCi/L	12/19/2013	N002	110		J	#	47	34.6
Lead-212	pCi/L	12/19/2013	N002	3.48	U		#	12	7.05
Potassium-40	pCi/L	12/19/2013	N002	21.4	U		#	130	78.9
Promethium-144	pCi/L	12/19/2013	N002	-1.07	U		#	4.2	2.46
Promethium-146	pCi/L	12/19/2013	N002	-0.0766	U		#	4.8	2.85
Ruthenium-106	pCi/L	12/19/2013	N002	-0.793	U		#	38	22.6

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 04/04/2014**  
**Location: 05-045-15739 WELL BM 26-33D**

Parameter	Units	Sample		Result	Qualifiers		Detection Limit	Uncertainty
		Date	ID		Lab	Data QA		
Thorium-234	pCi/L	12/19/2013	N002	4.05	U	#	200	122
Tritium	pCi/L	12/19/2013	N002	52.2	U	#	350	210
Uranium-235	pCi/L	12/19/2013	N002	3.97	U	#	22	13.5
Yttrium-88	pCi/L	12/19/2013	N002	3.38	U	#	4.7	2.91

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 04/04/2014**  
**Location: 05-045-15742 WELL BM 26-33C**

Parameter	Units	Sample		Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID		Lab	Data	QA		
Chloride	mg/L	12/19/2013	N002	6100			#	100	
Tritium	pCi/L	12/19/2013	N002	-59.7	U		#	350	207

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

**REPORT DATE: 04/04/2014**

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

Parameter	Units	Sample		Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID		Lab	Data	QA		
Actinium-228	pCi/L	12/19/2013	N002	24.9	U		#	27	17.5
Actinium-228	pCi/L	12/19/2013	N003	9.3	U		#	49	29.2
Americium-241	pCi/L	12/19/2013	N002	0.543	U		#	8	4.7
Americium-241	pCi/L	12/19/2013	N003	2.45	U		#	8.8	5.27
Antimony-125	pCi/L	12/19/2013	N002	3.96	U		#	16	9.42
Antimony-125	pCi/L	12/19/2013	N003	-4.4	U		#	18	10.2
Cerium-144	pCi/L	12/19/2013	N002	-3.25	U		#	25	14.5
Cerium-144	pCi/L	12/19/2013	N003	-9.28	U		#	27	15.4
Cesium-134	pCi/L	12/19/2013	N002	-4.91	U		#	7.2	3.95
Cesium-134	pCi/L	12/19/2013	N003	-2.4	U		#	9.5	5.44
Cesium-137	pCi/L	12/19/2013	N002	-3.45	U		#	7.3	4.01
Cesium-137	pCi/L	12/19/2013	N003	3.34	U		#	7.6	4.59
Chloride	mg/L	12/19/2013	N002	8700			#	200	
Chloride	mg/L	12/19/2013	N003	8600			#	200	
Cobalt-60	pCi/L	12/19/2013	N002	1.66	U		#	7.8	4.55
Cobalt-60	pCi/L	12/19/2013	N003	1.03	U		#	9.7	5.56
Europium-152	pCi/L	12/19/2013	N002	-4.13	U		#	39	21.8
Europium-152	pCi/L	12/19/2013	N003	-7.73	U		#	45	24.5

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

**REPORT DATE: 04/04/2014**

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

Parameter	Units	Sample		Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID		Lab	Data	QA		
Europium-154	pCi/L	12/19/2013	N002	-14.4	U		#	42	23
Europium-154	pCi/L	12/19/2013	N003	6.62	U		#	44	25.6
Europium-155	pCi/L	12/19/2013	N002	0.973	U		#	10	6.2
Europium-155	pCi/L	12/19/2013	N003	1.72	U		#	12	7.42
Gross Alpha	pCi/L	12/19/2013	N002	11.6	U		#	25	15.3
Gross Alpha	pCi/L	12/19/2013	N003	21.3	U		#	29	18.3
Gross Beta	pCi/L	12/19/2013	N002	68.7		J	#	24	18.8
Gross Beta	pCi/L	12/19/2013	N003	60.3		J	#	24	18.3
Lead-212	pCi/L	12/19/2013	N002	3.9	U		#	13	7.7
Lead-212	pCi/L	12/19/2013	N003	1.65	U		#	15	8.98
Potassium-40	pCi/L	12/19/2013	N002	-5	U		#	140	80.1
Potassium-40	pCi/L	12/19/2013	N003	-1.29	U		#	160	95.1
Promethium-144	pCi/L	12/19/2013	N002	1.75	U		#	7.8	4.67
Promethium-144	pCi/L	12/19/2013	N003	1.59	U		#	8.5	5
Promethium-146	pCi/L	12/19/2013	N002	0.656	U		#	7.6	4.44
Promethium-146	pCi/L	12/19/2013	N003	-4.43	U		#	8.4	4.61
Ruthenium-106	pCi/L	12/19/2013	N002	-18.1	U		#	66	37.1
Ruthenium-106	pCi/L	12/19/2013	N003	-2.7	U		#	69	39.5

**General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site**  
**REPORT DATE: 04/04/2014**  
**Location: 05-045-15743 WELL BM 26-33B**

Parameter	Units	Sample		Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID		Lab	Data	QA		
Thorium-234	pCi/L	12/19/2013	N002	6.03	U		#	83	49.7
Thorium-234	pCi/L	12/19/2013	N003	20.8	U		#	89	53.6
Tritium	pCi/L	12/19/2013	N002	-30.8	U		#	350	209
Tritium	pCi/L	12/19/2013	N003	46	U		#	360	212
Uranium-235	pCi/L	12/19/2013	N002	7.62	U		#	24	14.4
Uranium-235	pCi/L	12/19/2013	N003	5.11	U		#	38	22.9
Yttrium-88	pCi/L	12/19/2013	N002	4.09	U		#	7.9	4.86
Yttrium-88	pCi/L	12/19/2013	N003	-5.76	U		#	15	8.77



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

**REPORT DATE: 04/04/2014**

**Location: 05-045-15745 WELL BM 26-34B**

Parameter	Units	Sample		Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID		Lab	Data	QA		
Actinium-228	pCi/L	12/19/2013	N002	21.9	U		#	30	18.9
Americium-241	pCi/L	12/19/2013	N002	14.6	U		#	25	15.2
Antimony-125	pCi/L	12/19/2013	N002	2.45	U		#	11	6.05
Cerium-144	pCi/L	12/19/2013	N002	-4.67	U		#	20	12.1
Cesium-134	pCi/L	12/19/2013	N002	0.994	U		#	7.1	4.31
Cesium-137	pCi/L	12/19/2013	N002	-.151	U		#	4.8	2.81
Chloride	mg/L	12/19/2013	N002	11000			#	200	
Cobalt-60	pCi/L	12/19/2013	N002	-2.41	U		#	6.2	3.54
Europium-152	pCi/L	12/19/2013	N002	6.12	U		#	28	16.9
Europium-154	pCi/L	12/19/2013	N002	3.1	U		#	28	16.4
Europium-155	pCi/L	12/19/2013	N002	-6.48	U		#	13	7.5
Gross Alpha	pCi/L	12/19/2013	N002	17	U		#	35	21.7
Gross Beta	pCi/L	12/19/2013	N002	98.1		J	#	44	31.8
Lead-212	pCi/L	12/19/2013	N002	6.63	U		#	11	6.77
Potassium-40	pCi/L	12/19/2013	N002	0.951	U		#	140	83.9
Promethium-144	pCi/L	12/19/2013	N002	2.25	U		#	4.9	3.01
Promethium-146	pCi/L	12/19/2013	N002	0.775	U		#	5.3	3.14
Ruthenium-106	pCi/L	12/19/2013	N002	-7.31	U		#	48	28.1

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

**REPORT DATE: 04/04/2014**

**Location: 05-045-15745 WELL BM 26-34B**

Parameter	Units	Sample		Result	Qualifiers			Detection Limit	Uncertainty
		Date	ID		Lab	Data	QA		
Thorium-234	pCi/L	12/19/2013	N002	19.9	U		#	120	75.6
Tritium	pCi/L	12/19/2013	N002	117	U		#	350	212
Uranium-235	pCi/L	12/19/2013	N002	-3.48	U		#	42	25.6
Yttrium-88	pCi/L	12/19/2013	N002	6.79		U	#	5.7	3.69

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.
- L Less than 3 bore volumes purged prior to sampling.
- U Parameter analyzed for but was not detected.
- G Possible grout contamination, pH > 9.
- Q Qualitative result due to sampling technique.
- X Location is undefined.
- J Estimated value.
- R Unusable result.

**QA QUALIFIER:**

- # Validated according to quality assurance guidelines.

## **Trip Report**

This page intentionally left blank

**Trip Report  
Natural Gas Wells  
Near Project Rulison  
First Quarter 2014**

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

**Date Sampled:**

December 19, 2013

**Background:**

Project Rulison was the second Plowshare Program test to investigate using a nuclear device to stimulate natural gas recovery from deep and low-permeability formations. On September 10, 1969, a 40-kiloton-yield nuclear device was detonated 8,426 feet (1.6 miles) below the ground surface in the Williams Fork Formation at what is now the Rulison, Colorado, Site. Following the detonation, a series of production tests were conducted. Afterward, the site was shut down and later remediated, and the emplacement well (R-E) and reentry well (R-Ex) were plugged.

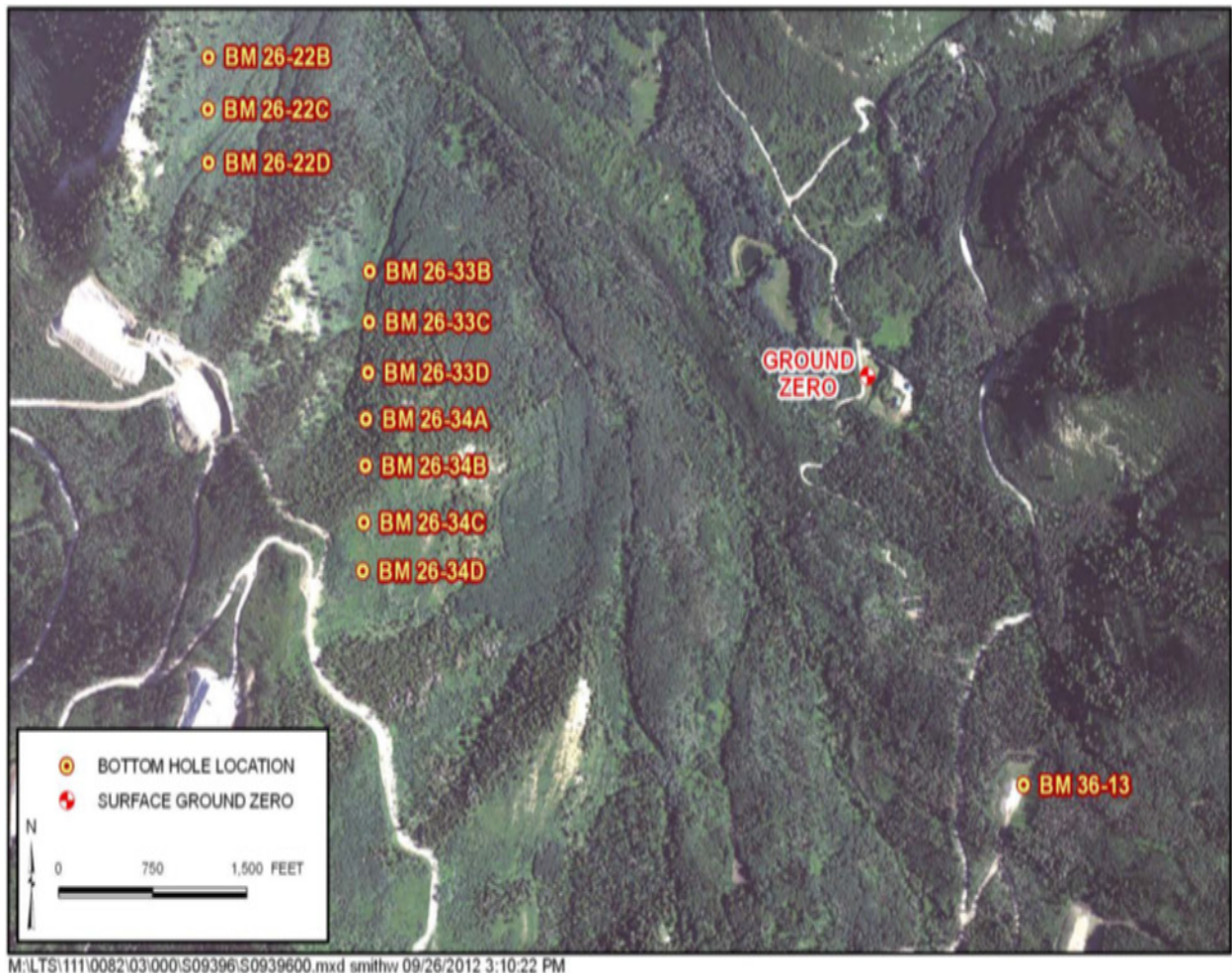
**Purpose:**

As part of the U.S. Department of Energy (DOE) Office of Legacy Management (LM) mission to protect human health and the environment, LM is monitoring natural gas wells that are near the Rulison site for radionuclides associated with the detonation. Even though the very low permeability of the 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 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. 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.

**Summary of Results:**

The following wells were sampled: seven producing gas wells on Pad 26N, three gas wells on Pad 26K, one well on Pad 35C, one well on Pad 36L, and one well on Pad 36B.

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 Battlement Mesa (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)*

The wells are listed by sample-collection sequence in Table 1. Before sample collection at each well, each individual well's pressure and temperature (see Table 1) were read and recorded from surface transducers in the wells. Latitude and longitude values (not shown in Table 1) were compiled from survey plats included with the applications for permits to drill and from Colorado Oil and Gas Conservation Commission scout cards.

Due to severe weather conditions at the Rulison site, natural gas valves at a local production station were frozen and not functioning properly. The intermittent closure of the production line valves caused significantly higher wellhead pressures than normal. At some wells the high wellhead pressure prohibited the production water plunger from traveling up the wells to purge production water. The higher wellhead pressures also contributed to 10 to 15 degrees higher wellhead natural gas temperatures. Seven wells (BM 26-22B–D, BM 26-34A, BM 26-34C, BM 26-34D, and BM 36-13B) produced no production water, while well BM 26-33C produced

only about 250 milliliters (mL). The 250 mL of production water collected provides enough sample volume for analysis of only tritium.

A total of 13 gas samples were collected and 6 wells produced enough production water for total analysis. A duplicate sample was collected from well BM 26-33B and is noted in Table 1. Well BM 26-33C provided only 250 mL of water, which is only enough for tritium analysis. All other well functions were performing normally, so no impact to contaminant analysis data is expected.

Table 1. 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 26-33D	15739	WL	NGSA	Yes	Yes	75.1	346
2	26N	BM 26-33C	15742	WL	NGSA	Yes	Yes <sup>1</sup>	77.1	348
3	26N	BM 26-33B	15743	WL	NGSA	Yes	Yes	72.7	344
Duplicate	26N	BM 26-33B	15743	WL	NGSA	No	Yes	72.7	344
4	26N	BM 26-34C	15741	WL	NGSA	Yes	None	77.9	281
5	26N	BM 26-34B	15745	WL	NGSA	Yes	Yes	75.6	344
6	26N	BM 26-34D	15748	WL	NGSA	Yes	None	76.8	346
8	26K	BM 26-22B	16086	WL	NGSA	Yes	None	76.9	420
9	26K	BM 26-22C	16087	WL	NGSA	Yes	None	71.4	398
10	26K	BM 26-22D	16074	WL	NGSA	Yes	None	73.6	397
11	35C	BM 35-32A	10919	WL	NGSV	Yes	Yes	55.2	374
12	36L	BM 36-13B	15469	WL	NGSV	Yes	None	67	427
13	36B	BM 36-13	10840	WL	NGSV	Yes	Yes	67.4	375

**Notes:**

<sup>1</sup> BM 26-33C produced approximately 250 mL of production water, which is enough sample volume for only tritium analysis.

**Abbreviations:**

API American Petroleum Institute  
 BM Battlement Mesa  
 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.

Water condensation is variable and often not desired for the planned analytes. Collected sample volumes (Table 2) 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. Analyses 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 2 lists the estimated sample volumes before decanting.

Table 2. Collected Water Sample Volumes (Before Decanting)

Sample Ticket	Well Name	Planned Analytes	Sample Volume (L)
	BM 26-33D	<sup>3</sup> H, Gross α/β, Gamma spec, Cl <sup>-</sup> , <sup>99</sup> Tc	≈ 2.5 L
	BM 26-33C	<sup>3</sup> H, Gross α/β, Gamma spec, Cl <sup>-</sup> , <sup>99</sup> Tc	≈ 250 mL
	BM 26-33B	<sup>3</sup> H, Gross α/β, Gamma spec, Cl <sup>-</sup> , <sup>99</sup> Tc	≈ 2.5 L
	BM 26-33B	<sup>3</sup> H, Gross α/β, Gamma spec, Cl <sup>-</sup> , <sup>99</sup> Tc	≈ 2.5 L Duplicate
	BM 26-34C	NA	No Sample
	BM 26-34B	<sup>3</sup> H, Gross α/β, Gamma spec, Cl <sup>-</sup> , <sup>99</sup> Tc	≈ 2.5 L
	BM 26-34D		No Sample
	BM 26-34A	NA	No Sample
	BM 26-22B	NA	No Sample
	BM 26-22C	NA	No Sample
	BM 26-22D	NA	No Sample
	BM 35-32A	<sup>3</sup> H, Gross α/β, Gamma spec, Cl <sup>-</sup> , <sup>99</sup> Tc	≈ 2.5 L
	BM 36-13B	NA	No Sample
	BM 36-13	<sup>3</sup> H, Gross α/β, Gamma spec, Cl <sup>-</sup> , <sup>99</sup> Tc	≈ 2.5 L

**Notes:**

Water sample information is listed in the order of collection.

The sample volume of water may include some condensate.

Wells BM 26-22B and BM 26-34A did not produce water for laboratory analyses; (historically these wells have not produced water during the sample collection).

**Abbreviations:**

Cl<sup>-</sup> chloride  
 Gamma spec high-resolution gamma spectrometry analysis  
 Gross α/β gross alpha and beta analyses  
<sup>3</sup>H tritium  
 L liter  
 NA not applicable  
<sup>99</sup>Tc 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. Natural gas was collected in an evacuated 17.8-liter gas cylinder provided by Isotech Laboratories, Inc. Each sampling container was filled to approximately 25 pounds per square inch with natural gas from each well.