Monitoring Results
Natural Gas Wells
Near Project Rulison
Third Quarter 2014

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

Date Sampled: July 1, 2014

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 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. The very low permeability of the Williams Fork Formation limits contaminant migration, and institutional controls restrict 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

Analytical results of production water samples and natural gas samples collected in July 2014 were all below the screening levels specified in the *Rulison Monitoring Plan*.

The July sampling effort consisted of sampling a total of 13 natural gas wells. Nine wells (Battlement Mesa [BM] 26-33C, 26-34A, 26-34B, 26-34D, 26-22C, 26-22D, 35-32A, 36-13B, and 36-13) produced enough production water volume to conduct all scheduled analyses. Wells BM 26-33B and BM 26-34C produced enough production water for chloride and tritium analysis and two wells, BM 26-33D and BM 26-22B, generated no production water for analysis. At all wells, natural gas was collected and analyzed for tritium and carbon-14.

Table 1 lists the 13 wells, and Table 2 lists the sequential sample collection information.

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 26-33B	15743	WL	NGSA	Yes	Yes[1]	68.8	262
2	26N	BM 26-33C	15742	WL	NGSA	Yes	Yes	68.1	286
3	26N	BM 26-33D	15739	WL	NGSA	Yes	No	69.1	288
4	26N	BM 26-34A	15744	WL	NGSA	Yes	Yes	62.9	280
5	26N	BM 26-34B	15745	WL	NGSA	Yes	Yes	62.3	284
Duplicate	26N	BM 26-34B	15745	WL	NGSA	No	Yes	62.3	284
6	26N	BM 26-34C	15741	WL	NGSA	Yes	Yes[1]	61.9	281
7	26N	BM 26-34D	15748	WL	NGSA	Yes	Yes	63.9	267
8	26K	BM 26-22B	16086	WL	NGSA	Yes	No	69.3	257
9	26K	BM 26-22C	16087	WL	NGSA	Yes	Yes	68.1	260
10	26K	BM 26-22D	16074	WL	NGSA	Yes	Yes	68.8	260
11	35C	BM 35-32A	10919	WL	NGSA	Yes	Yes	74.6	268
12	36L	BM 36-13B	15469	WL	NGSV	Yes	Yes	78	282
13	36B	BM 36-13	10840	WL	NGSV	Yes	Yes	80	279

[1]During production, water sampling wells only produced enough sample for analysis of chloride and tritium

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 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.

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 the suite of radionuclides identified by high-resolution gamma spectrometry.

Table 3a. Gas-Phase Concentrations for Tritium Sample Results

Analyte	Reporting Units	Screening Concentration	Action Concentration	Comment
Tritium	TU	19,293	TBD	5.183×10^{-6} pCi cc^{-1} TU^{-1}
^{14}Carbon	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

Eleven of the total 13 sampling locations produced enough production water to analyze for some or all of the Rulison-related contaminants.

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 "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	13/12	0	13	0	0	12	2	0	0	0

Notes:
Natural gas samples were successfully collected from all 13 wells associated with the sampling plan. Well BM26-34B was selected as a duplicate sampling location where duplicate production water was collected but no duplicate natural gas sample was collected.
At wells BM 36-33D and BM 26-22B, no production water was produced during sampling operations. Historically, BM 36-33D and BM 26-22B have typically produced no or very small amounts of production water. Wells BM 26-33B and BM 26-34C produced approximately 250 milliliters of production water, which is enough for only chloride and tritium analyses.

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	12	1	9	4	10	0	4

Notes:
Data validation assigned a J qualifier to one gross-alpha detect result.
Data validation assigned a J qualifier to one gross-beta detect result.
Two sample locations (BM 26-33B and BM 26-34C) provided insufficient amounts of production water for gross alpha, gross beta, and potassium-40 analysis. No production water was collected from wells BM 26-33D and BM 26-22B.

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	12	2	8	4

Notes:
Data validation assigned a J qualifier to both potassium-40 detect results. Two sample locations (BM 26-34C and BM 26-22B) produced insufficient amounts of production water for potassium-40 analysis. No production water was collected from wells BM 26-33D and BM 26-22B.

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Data Review and Validation Report

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Data Validation Package

July 2014
Natural Gas and Produced Water Sampling at the Rulison, Colorado, Site

November 2014

U.S. DEPARTMENT OF ENERGY | Legacy Management

Available for sale to the public from:

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5301 Shawnee Road
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Contents

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Sampling Event Summary

Site: Rulison, Colorado, Site

Sampling Period: July 14, 2014

The U.S. Department of Energy Office of Legacy Management conducted sampling at the Rulison, Colorado, Site on July 14, 2014, 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 14066310 to Isotech Laboratories in Champaign, Illinois, for the determination of carbon-14 and tritium.
- Produced water samples were submitted under requisition 14066311 to ALS Laboratory Group in Fort Collins, Colorado, for the determination of chloride, gross alpha/beta, gamma-emitting nuclides, and tritium.

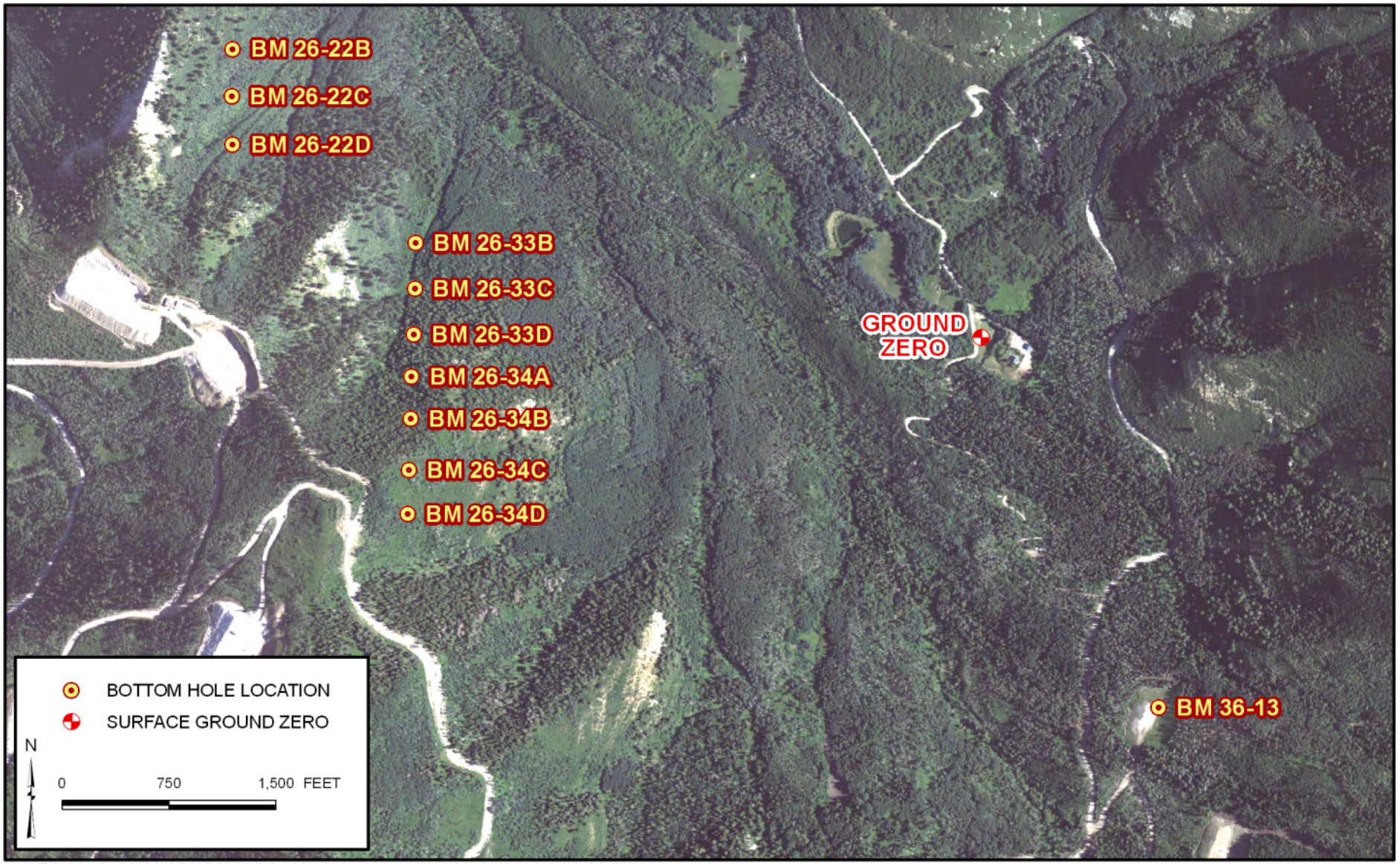
Sampling and analyses were conducted as specified in the *Sampling and Analysis Plan for U.S. Department of Energy Office of Legacy Management Sites* (LMS/PRO/S04351, continually updated). A duplicate produced water sample was collected at location 05-045-15745.

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 — 11-7-14

Rick Hutton
Site Lead
The S.M. Stoller Corporation,
a wholly owned subsidiary of Huntington Ingalls Industries

Date



Rulison, Colorado, Site Sample Location Map

Data Assessment Summary

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Water Sampling Field Activities Verification Checklist

Project	Rulison, Colorado	**Date(s) of Water Sampling**	July 14, 2014
Date(s) of Verification	October 6, 2014	**Name of Verifier**	Stephen Donivan

	Response (Yes, No, NA)	Comments
1. Is the SAP the primary document directing field procedures?	Yes	
List any Program Directives or other documents, SOPs, instructions.		Program Directive RUL-2013-01.
2. Were the sampling locations specified in the planning documents sampled?	No	Limited volume of produced water was available from four of the wells.
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?	NA	This sampling event did not include groundwater.
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?		

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?	NA	This sampling event did not include groundwater.
Was one pump/tubing volume removed prior to sampling?		
9. Were duplicates taken at a frequency of one per 20 samples?	Yes	A duplicate sample was collected at location 05-045-15745.
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	Limited volume of produced water was available.
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):	14066310
Sample Event:	July 14, 2014
Site(s):	Rulison, Colorado
Laboratory:	Isotech Laboratories
Work Order No.:	25901
Analysis:	Radiochemistry
Validator:	Stephen Donivan
Review Date:	October 6, 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 July 17, 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 and tritium were not detected in any of the samples.

General Information

Requisition No. (RIN): 14066311
Sample Event: July 14, 2014
Site(s): Rulison Site
Laboratory: ALS Laboratory Group, Fort Collins, Colorado
Work Order No.: 1407289
Analysis: Radiochemistry and Wet Chemistry
Validator: Stephen Donivan
Review Date: October 6, 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
1407289-2	BM 26-22C	Actinium-228	J	Less than the determination limit
1407289-3	BM 26-22D	Actinium-228	U	Nuclide identification criteria
1407289-5	BM 26-33C	Gross Alpha	J	Less than the determination limit
1407289-6	BM 26-34A	Potassium-40	J	Less than the determination limit
1407289-7	BM 26-34B	Uranium-235	U	Nuclide identification criteria
1407289-7	BM 26-34B	Gross Beta	J	Less than the determination limit
1407289-10	BM 35-32A	Actinium-228	U	Nuclide identification criteria
1407289-10	BM 35-32A	Potassium-40	J	Less than the determination limit
1407289-11	BM 36-13	Actinium-228	U	Nuclide identification criteria
1407289-12	BM 36-13B	Actinium-228	U	Nuclide identification criteria

Sample Shipping/Receiving

ALS Laboratory Group in Fort Collins, Colorado, received 12 water samples on July 16, 2014, 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 MDLs for the wet chemical analyte and 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 elevated dissolved solids levels 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 June 15, 2014. The calibration curve correlation coefficient values were greater than 0.995 and the absolute values of the intercepts were less than three 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 four 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 August 12, 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: 14066311 **Lab Code:** PAR **Validator:** Stephen Donivan **Validation Date:** 10/06/2014

Project: Rulison Site **Analysis Type:** ☐ Metals ☑ General Chem ☑ Rad ☐ Organics

# of Samples: 12 **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 20 detection limit failures.
☐ Field/Trip Blanks	
☑ Field Duplicates	There was 1 duplicate evaluated.

SAMPLE MANAGEMENT SYSTEM

RIN: 14066311 Lab Code: PAR

Non-Compliance Report: Detection Limits

Project: Rulison Site

Validation Date: 10/06/2014

Ticket	Location	Lab Sample ID	Method Code	Lab Method	Analyte Name	Result	Qualifier	Reported Detection Limit	Required Detection Limit	Units
MIZ 162	2657	1407289-1	GPC-A-001	724R11	GROSS ALPHA	3.5	U	30	2	pCi/L
MIZ 162	2657	1407289-1	GPC-A-001	724R11	GROSS BETA	66.3		21	4	pCi/L
MHW 502	BM 26-22C	1407289-2	GPC-A-001	724R11	GROSS BETA	170		42	4	pCi/L
MHW 502	BM 26-22C	1407289-2	GPC-A-001	724R11	GROSS ALPHA	19.4	U	43	2	pCi/L
MHW 503	BM 26-22D	1407289-3	GPC-A-001	724R11	GROSS ALPHA	29.4	U	38	2	pCi/L
MHW 503	BM 26-22D	1407289-3	GPC-A-001	724R11	GROSS BETA	195		41	4	pCi/L
MHW 498	BM 26-33C	1407289-5	GPC-A-001	724R11	GROSS ALPHA	36.2		26	2	pCi/L
MHW 498	BM 26-33C	1407289-5	GPC-A-001	724R11	GROSS BETA	123		21	4	pCi/L
MHW 508	BM 26-34A	1407289-6	GPC-A-001	724R11	GROSS BETA	368		110	4	pCi/L
MHW 508	BM 26-34A	1407289-6	GPC-A-001	724R11	GROSS ALPHA	-31	U	120	2	pCi/L
MHW 500	BM 26-34B	1407289-7	GPC-A-001	724R11	GROSS BETA	64.7		22	4	pCi/L
MHW 500	BM 26-34B	1407289-7	GPC-A-001	724R11	GROSS ALPHA	25.9	U	26	2	pCi/L
MHW 501	BM 26-34D	1407289-9	GPC-A-001	724R11	GROSS BETA	134		44	4	pCi/L
MHW 501	BM 26-34D	1407289-9	GPC-A-001	724R11	GROSS ALPHA	18.6	U	44	2	pCi/L
MHW 504	BM 35-32A	1407289-10	GPC-A-001	724R11	GROSS ALPHA	25.8	U	38	2	pCi/L
MHW 504	BM 35-32A	1407289-10	GPC-A-001	724R11	GROSS BETA	199		43	4	pCi/L
MHW 505	BM 36-13	1407289-11	GPC-A-001	724R11	GROSS BETA	164		42	4	pCi/L
MHW 505	BM 36-13	1407289-11	GPC-A-001	724R11	GROSS ALPHA	20.7	U	38	2	pCi/L
MHW 506	BM 36-13B	1407289-12	GPC-A-001	724R11	GROSS BETA	170		44	4	pCi/L
MHW 506	BM 36-13B	1407289-12	GPC-A-001	724R11	GROSS ALPHA	25.1	U	43	2	pCi/L

SAMPLE MANAGEMENT SYSTEM
Radiochemistry Data Validation Worksheet

RIN: 14066311 **Lab Code:** PAR **Date Due:** 08/13/2014

Matrix: Water **Site Code:** RUL01 **Date Completed:** 08/13/2014

Sample	Analyte	Date Analyzed	Result	Flag	Tracer %R	LCS %R	MS %R	Duplicate RER
BM 26-34A	Actinium-228	08/08/2014						0.07
BM 26-34A	Americium-241	08/08/2014						0.34
Blank_Spike	Americium-241	08/08/2014				97.80		
BM 26-34A	Antimony-125	08/08/2014						0.27
BM 26-34A	Cerium-144	08/08/2014						0.87
BM 26-34A	Cesium-134	08/08/2014						1.10
BM 26-34A	Cesium-137	08/08/2014						0.62
Blank_Spike	Cesium-137	08/08/2014				103.00		
BM 26-34A	Cobalt-60	08/08/2014						0.07
Blank_Spike	Cobalt-60	08/08/2014				98.90		
BM 26-34A	Europium-152	08/08/2014						1.76
BM 26-34A	Europium-154	08/08/2014						1.88
BM 26-34A	Europium-155	08/08/2014						1.51
BM 26-34D	GROSS ALPHA	07/24/2014						0.39
Blank_Spike	GROSS ALPHA	07/24/2014				115.00		
2657	GROSS ALPHA	07/24/2014					112.0	
Blank	GROSS ALPHA	07/24/2014	0.0080	U				
BM 26-34D	GROSS BETA	07/24/2014						0.46
Blank_Spike	GROSS BETA	07/24/2014				109.00		
2657	GROSS BETA	07/24/2014					106.0	
Blank	GROSS BETA	07/24/2014	0.7800	U				
BM 26-34A	H-3	07/23/2014						0.41
Blank_Spike	H-3	07/23/2014				107.00		
BM 26-34D	H-3	07/23/2014					107.0	
Blank	H-3	07/23/2014	15.0000	U				
BM 26-34A	Lead-212	08/08/2014						0.54
BM 26-34A	Potassium-40	08/08/2014						0.60
BM 26-34A	Promethium-144	08/08/2014						0.20
BM 26-34A	Promethium-146	08/08/2014						0.39
BM 26-34A	Ruthenium-106	08/08/2014						2.31
BM 26-34A	Thorium-234	08/08/2014						0.28
BM 26-34A	Uranium-235	08/08/2014						2.22

SAMPLE MANAGEMENT SYSTEM
Radiochemistry Data Validation Worksheet

RIN: 14066311 **Lab Code:** PAR **Date Due:** 08/13/2014

Matrix: Water **Site Code:** RUL01 **Date Completed:** 08/13/2014

Sample	Analyte	Date Analyzed	Result	Flag	Tracer %R	LCS %R	MS %R	Duplicate RER
BM 26-34A	Yttrium-88	08/08/2014						0.85

SAMPLE MANAGEMENT SYSTEM

Wet Chemistry Data Validation Worksheet

RIN: 14066311 **Lab Code:** PAR **Date Due:** 08/13/2014

Matrix: Water **Site Code:** RUL01 **Date Completed:** 08/13/2014

Analyte	Date Analyzed	CALIBRATION				Method Blank	LCS %R	MS %R	MSD %R	DUP RPD	Serial Dil. %R
		Int.	R^2	CCV	CCB						
CHLORIDE	07/21/2014	0.000	1.0000	OK	OK	OK	98.00				

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 Analysis

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 BM 26-34B. For non-radiochemical measurements, the relative percent difference for duplicate results that are greater than five times the practical quantitation limit (PQL) should be less than 20 percent. For results less than five 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: 14066311 **Lab Code:** PAR **Project:** Rulison Site **Validation Date:** 10/06/2014

Duplicate: 2657 **Sample:** BM 26-34B

Analyte	Sample				Duplicate				RPD	RER	Units
	Result	Flag	Error	Dilution	Result	Flag	Error	Dilution			
Actinium-228	4.12	U	19.6	1	15.6	U	17.1	1		0.9	pCi/L
Americium-241	3.2	U	18.4	1	17.5	U	31.2	1		0.8	pCi/L
Antimony-125	0.0052	U	6.81	1	11.2	U	7.63	1		2.1	pCi/L
Cerium-144	-1.66	U	14.4	1	0.407	U	15.3	1		0.2	pCi/L
Cesium-134	-1.23	U	3.22	1	-2.04	U	3.41	1		0.3	pCi/L
Cesium-137	0.921	U	2.81	1	2.88	U	3.26	1		0.9	pCi/L
CHLORIDE	8200			500	8500			500	3.59		MG/L
Cobalt-60	-0.16	U	3.25	1	1.28	U	3.41	1		0.6	pCi/L
Europium-152	-0.132	U	15.9	1	-5.64	U	17	1		0.5	pCi/L
Europium-154	10.8	U	16.8	1	-3.92	U	18.5	1		1.2	pCi/L
Europium-155	8.18	U	7.28	1	-0.766	U	9.08	1		1.5	pCi/L
GROSS ALPHA	25.9	U	17.4	1	3.5	U	17.8	1		1.8	pCi/L
GROSS BETA	64.7		17.9	1	66.3		17.2	1		0.1	pCi/L
H-3	-84.3	U	194	1	-23.8	U	201	1		0.4	pCi/L
Lead-212	-0.289	U	8.41	1	-0.0942	U	8.06	1		0	pCi/L
Potassium-40	80.1	U	77	1	84.7	U	101	1		0.1	pCi/L
Promethium-144	2.07	U	3.31	1	4.36	U	3.64	1		0.9	pCi/L
Promethium-146	-0.21	U	3.3	1	-0.695	U	3.61	1		0.2	pCi/L
Ruthenium-106	3.82	U	26.8	1	-13.2	U	31.2	1		0.8	pCi/L
Thorium-234	13.6	U	81.4	1	5.1	U	106	1		0.1	pCi/L
Uranium-235	22.1		13.6	1	-7.74	U	26.5	1		2.0	pCi/L
Yttrium-88	4.14	U	3.92	1	-0.115	U	3.92	1		1.5	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 Donivan — Stephen Donivan — 11-7-2014 — Date

Data Validation Lead: Stephen Donivan — Stephen Donivan — 11-7-2014 — Date

Attachment 1
Data Presentation

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Natural Gas Data

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Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/28/2014
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	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Carbon-14	pMC	07/14/2014	N002	MHW 495	8683	-	8683		0.2	U		#		
Tritium	pCi/L	07/14/2014	N002	MHW 495	8683	-	8683		0.0514	U		#		

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/28/2014
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	07/14/2014	N002	MHW 494	9236	-	9236		0.2	U	#		
Tritium	pCi/L	07/14/2014	N002	MHW 494	9236	-	9236		0.0514	U	#		

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/28/2014
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	Qualifiers Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	07/14/2014	N002	MHW 496	8901	-	8901		0.2	U		#		
Tritium	pCi/L	07/14/2014	N002	MHW 496	8901	-	8901		0.0514	U		#		

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/28/2014
Location: 05-045-15739 WELL, Natural Gas Well - Angle, BM 26-33D

Parameter	Units	Sample Date	ID	Ticket Number	Elev. Range		(Ft)	Matrix Subtype	Result	Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	07/14/2014	N001	MHW 486	8963.5	-	8963.5		0.2	U		#		
Tritium	pCi/L	07/14/2014	N001	MHW 486	8963.5	-	8963.5		0.0514	U		#		

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/28/2014
Location: 05-045-15741 WELL, Natural Gas Well - Angle, BM 26-34C

Parameter	Units	Sample Date	ID	Ticket Number	Elev. Range		(Ft)	Matrix Subtype	Result	Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	07/14/2014	N002	MHW 489	8963.5	-	8963.5		0.2	U		#		
Tritium	pCi/L	07/14/2014	N002	MHW 489	8963.5	-	8963.5		0.0514	U		#		

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/28/2014
Location: 05-045-15742 WELL, Natural Gas Well - Angle, BM 26-33C

Parameter	Units	Sample Date	ID	Ticket Number	Elev. Range (Ft)			Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	07/14/2014	N002	MHW 485	8963.5	-	8963.5		0.2	U		#		
Tritium	pCi/L	07/14/2014	N002	MHW 485	8963.5	-	8963.5		0.0514	U		#		

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/28/2014
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	07/14/2014	N002	MHW 484	8963.5	-	8963.5		0.2	U		#		
Tritium	pCi/L	07/14/2014	N002	MHW 484	8963.5	-	8963.5		0.0514	U		#		

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/28/2014
Location: 05-045-15744 WELL, Natural Gas Well - Angle, BM 26-34A

Parameter	Units	Sample Date	ID	Ticket Number	Elev. Range (Ft)			Matrix Subtype	Result	Qualifiers Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	07/14/2014	N002	MHW 487	8963.5	-	8963.5		0.2	U		#		
Tritium	pCi/L	07/14/2014	N002	MHW 487	8963.5	-	8963.5		0.0514	U		#		

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/28/2014
Location: 05-045-15745 WELL, Natural Gas Well - Angle, BM 26-34B

Parameter	Units	Sample Date	ID	Ticket Number	Elev. Range (Ft)			Matrix Subtype	Result	Lab	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	07/14/2014	N003	MHW 488	8963.5	-	8963.5		0.2	U		#		
Tritium	pCi/L	07/14/2014	N003	MHW 488	8963.5	-	8963.5		0.0514	U		#		

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/28/2014
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	Qualifiers Data	QA	Detection Limit	Uncertainty
Carbon-14	pMC	07/14/2014	N002	MHW 490	8963.5	-	8963.5		0.2	U		#		
Tritium	pCi/L	07/14/2014	N002	MHW 490	8963.5	-	8963.5		0.0514	U		#		

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/28/2014
Location: 05-045-16074 WELL, Natural Gas Well - Angle, BM 26-22D

Parameter	Units	Sample Date	ID	Ticket Number	Elev. Range (Ft)			Matrix Subtype	Result	Lab Qualifiers	Data QA	Detection Limit	Uncertainty
Carbon-14	pMC	07/14/2014	N002	MHW 493	8983.5	-	8983.5		0.2	U	#		
Tritium	pCi/L	07/14/2014	N002	MHW 493	8983.5	-	8983.5		0.0514	U	#		

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/28/2014
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	07/14/2014	N001	MHW 491	8983.5	-	8983.5		0.2	U		#		
Tritium	pCi/L	07/14/2014	N001	MHW 491	8983.5	-	8983.5		0.0514	U		#		

Gas Matrix Chemistry Data by Location (USEE510) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/28/2014
Location: 05-045-16087 WELL, Natural Gas Well - Angle, BM 26-22C

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	07/14/2014	N002	MHW 492	8983.5	-	8983.5		0.2	U		#		
Tritium	pCi/L	07/14/2014	N002	MHW 492	8983.5	-	8983.5		0.0514	U		#		

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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Produced Water Data

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General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-10840 WELL BM 36-13

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	07/14/2014	N001	20.8		U	#	19	8.44
Americium-241	pCi/L	07/14/2014	N001	0.307	U		#	25	14.9
Antimony-125	pCi/L	07/14/2014	N001	-1.95	U		#	13	7.68
Cerium-144	pCi/L	07/14/2014	N001	7.21	U		#	22	13.6
Cesium-134	pCi/L	07/14/2014	N001	-6.27	U		#	5.9	3.36
Cesium-137	pCi/L	07/14/2014	N001	-1.66	U		#	6.1	3.53
Chloride	mg/L	07/14/2014	N001	11000			#	200	
Cobalt-60	pCi/L	07/14/2014	N001	-0.753	U		#	7.6	4.37
Europium-152	pCi/L	07/14/2014	N001	3.92	U		#	32	18.6
Europium-154	pCi/L	07/14/2014	N001	-1.78	U		#	33	19.1
Europium-155	pCi/L	07/14/2014	N001	-2.92	U		#	13	7.6
Gross Alpha	pCi/L	07/14/2014	N001	20.7	U		#	38	23.5
Gross Beta	pCi/L	07/14/2014	N001	164			#	42	38.3
Lead-212	pCi/L	07/14/2014	N001	-3.01	U		#	14	8.51
Potassium-40	pCi/L	07/14/2014	N001	160	U		#	170	106
Promethium-144	pCi/L	07/14/2014	N001	-1.66	U		#	29	17.3
Promethium-146	pCi/L	07/14/2014	N001	0.739	U		#	5.8	3.47
Ruthenium-106	pCi/L	07/14/2014	N001	1.1	U		#	56	33.1
Thorium-234	pCi/L	07/14/2014	N001	53.4	U		#	140	79.5
Tritium	pCi/L	07/14/2014	N001	-23.5	U		#	350	205
Uranium-235	pCi/L	07/14/2014	N001	7.94	U		#	14	8.31

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-10840 WELL BM 36-13

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Yttrium-88	pCi/L	07/14/2014	N001	2.22	U		#	7.1	4.25

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-10919 WELL BM 35-32A

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	07/14/2014	N001	21.9		U	#	21	11.1
Americium-241	pCi/L	07/14/2014	N001	0.0753	U		#	4.5	2.67
Antimony-125	pCi/L	07/14/2014	N001	3.02	U		#	10	5.21
Cerium-144	pCi/L	07/14/2014	N001	-4.88	U		#	24	14.1
Cesium-134	pCi/L	07/14/2014	N001	1.63	U		#	2.8	1.75
Cesium-137	pCi/L	07/14/2014	N001	-1.72	U		#	4.1	2.32
Chloride	mg/L	07/14/2014	N001	10000			#	200	
Cobalt-60	pCi/L	07/14/2014	N001	-0.814	U		#	4.5	2.59
Europium-152	pCi/L	07/14/2014	N001	12.5	U		#	20	12.3
Europium-154	pCi/L	07/14/2014	N001	-1.29	U		#	23	13.4
Europium-155	pCi/L	07/14/2014	N001	1.22	U		#	6.1	3.66
Gross Alpha	pCi/L	07/14/2014	N001	25.8	U		#	38	24.2
Gross Beta	pCi/L	07/14/2014	N001	199			#	43	43
Lead-212	pCi/L	07/14/2014	N001	0.515	U		#	11	6.46
Potassium-40	pCi/L	07/14/2014	N001	162		J	#	110	73.1
Promethium-144	pCi/L	07/14/2014	N001	2.68	U		#	2.8	1.8
Promethium-146	pCi/L	07/14/2014	N001	-1.31	U		#	4.4	2.57
Ruthenium-106	pCi/L	07/14/2014	N001	-25.9	U		#	39	22.4
Thorium-234	pCi/L	07/14/2014	N001	19.2	U		#	72	43.6
Tritium	pCi/L	07/14/2014	N001	-14	U		#	310	185
Uranium-235	pCi/L	07/14/2014	N001	17	U		#	18	10.3

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-10919 WELL BM 35-32A

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Yttrium-88	pCi/L	07/14/2014	N001	-1.84	U		#	10	6.07

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-15469 WELL BM 36-13B

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	07/14/2014	N001	35		U	#	23	12
Americium-241	pCi/L	07/14/2014	N001	-9.9	U		#	110	64.4
Antimony-125	pCi/L	07/14/2014	N001	1.69	U		#	11	6.25
Cerium-144	pCi/L	07/14/2014	N001	0.525	U		#	26	15.8
Cesium-134	pCi/L	07/14/2014	N001	-1.32	U		#	4.7	2.76
Cesium-137	pCi/L	07/14/2014	N001	-1.38	U		#	4.5	2.62
Chloride	mg/L	07/14/2014	N001	12000			#	200	
Cobalt-60	pCi/L	07/14/2014	N001	-1.38	U		#	4.4	2.5
Europium-152	pCi/L	07/14/2014	N001	10.5	U		#	22	13.1
Europium-154	pCi/L	07/14/2014	N001	-2.49	U		#	23	13.5
Europium-155	pCi/L	07/14/2014	N001	0	U		#	17	10.1
Gross Alpha	pCi/L	07/14/2014	N001	25.1	U		#	43	26.5
Gross Beta	pCi/L	07/14/2014	N001	170			#	44	39.7
Lead-212	pCi/L	07/14/2014	N001	3.04	U		#	13	8.06
Potassium-40	pCi/L	07/14/2014	N001	110	U		#	120	73
Promethium-144	pCi/L	07/14/2014	N001	0.0605	U		#	4.5	2.69
Promethium-146	pCi/L	07/14/2014	N001	0.0462	U		#	4.9	2.93
Ruthenium-106	pCi/L	07/14/2014	N001	11.3	U		#	41	24.6
Thorium-234	pCi/L	07/14/2014	N001	30.4	U		#	200	120
Tritium	pCi/L	07/14/2014	N001	-105	U		#	340	197
Uranium-235	pCi/L	07/14/2014	N001	3.07	U		#	25	14.8

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-15469 WELL BM 36-13B

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Yttrium-88	pCi/L	07/14/2014	N001	2.62	U		#	4.2	2.59

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-15741 WELL BM 26-34C

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Chloride	mg/L	07/14/2014	N001	8200			#	100	
Tritium	pCi/L	07/14/2014	N001	-115	U		#	330	195

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-15742 WELL BM 26-33C

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	07/14/2014	N001	19	U		#	38	17.3
Americium-241	pCi/L	07/14/2014	N001	18.3	U		#	44	26.7
Antimony-125	pCi/L	07/14/2014	N001	5.18	U		#	13	7.35
Cerium-144	pCi/L	07/14/2014	N001	3.42	U		#	26	15.4
Cesium-134	pCi/L	07/14/2014	N001	3.82	U		#	7.9	4.9
Cesium-137	pCi/L	07/14/2014	N001	3.01	U		#	5.4	3.31
Chloride	mg/L	07/14/2014	N001	8600			#	100	
Cobalt-60	pCi/L	07/14/2014	N001	1.46	U		#	6.4	3.8
Europium-152	pCi/L	07/14/2014	N001	18.9	U		#	28	17.6
Europium-154	pCi/L	07/14/2014	N001	0.521	U		#	31	18.1
Europium-155	pCi/L	07/14/2014	N001	2	U		#	15	9.11
Gross Alpha	pCi/L	07/14/2014	N001	36.2		J	#	26	18.4
Gross Beta	pCi/L	07/14/2014	N001	123			#	21	24.5
Lead-212	pCi/L	07/14/2014	N001	-2.87	U		#	14	8.08
Potassium-40	pCi/L	07/14/2014	N001	66.6	U		#	150	89.7
Promethium-144	pCi/L	07/14/2014	N001	2.03	U		#	5.6	3.4
Promethium-146	pCi/L	07/14/2014	N001	-2.91	U		#	6.8	3.91
Ruthenium-106	pCi/L	07/14/2014	N001	-14.6	U		#	53	30.8
Thorium-234	pCi/L	07/14/2014	N001	4.3	U		#	130	80.3
Tritium	pCi/L	07/14/2014	N001	10.6	U		#	300	177
Uranium-235	pCi/L	07/14/2014	N001	1.08	U		#	25	14.8

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-15742 WELL BM 26-33C

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Yttrium-88	pCi/L	07/14/2014	N001	-1.12	U		#	9.9	5.79

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-15743 WELL BM 26-33B

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Chloride	mg/L	07/14/2014	N001	9400			#	100	
Tritium	pCi/L	07/14/2014	N001	-44.7	U		#	340	199

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-15744 WELL BM 26-34A

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	07/14/2014	N001	19.3	U		#	20	13
Americium-241	pCi/L	07/14/2014	N001	10.8	U		#	29	17.7
Antimony-125	pCi/L	07/14/2014	N001	-0.734	U		#	16	9.47
Cerium-144	pCi/L	07/14/2014	N001	2.38	U		#	27	16
Cesium-134	pCi/L	07/14/2014	N001	0.924	U		#	9.2	5.51
Cesium-137	pCi/L	07/14/2014	N001	0.0375	U		#	6.6	3.88
Chloride	mg/L	07/14/2014	N001	30000			#	1000	
Cobalt-60	pCi/L	07/14/2014	N001	-3.64	U		#	9.3	5.24
Europium-152	pCi/L	07/14/2014	N001	20.1	U		#	39	24.1
Europium-154	pCi/L	07/14/2014	N001	26.9	U		#	37	23.1
Europium-155	pCi/L	07/14/2014	N001	6.62	U		#	15	9.01
Gross Alpha	pCi/L	07/14/2014	N001	-31	U		#	120	67.5
Gross Beta	pCi/L	07/14/2014	N001	368			#	110	93.2
Lead-212	pCi/L	07/14/2014	N001	-2.78	U		#	15	9.07
Potassium-40	pCi/L	07/14/2014	N001	425		J	#	180	127
Promethium-144	pCi/L	07/14/2014	N001	1.46	U		#	29	17.4
Promethium-146	pCi/L	07/14/2014	N001	-1.12	U		#	7	4.05
Ruthenium-106	pCi/L	07/14/2014	N001	-43	U		#	66	37.5
Thorium-234	pCi/L	07/14/2014	N001	31.2	U		#	140	84.5
Tritium	pCi/L	07/14/2014	N001	-22.2	U		#	300	180
Uranium-235	pCi/L	07/14/2014	N001	18.6	U		#	25	15.6

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-15744 WELL BM 26-34A

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Yttrium-88	pCi/L	07/14/2014	N001	0.6	U		#	8.6	5.02

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-15745 WELL BM 26-34B

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	07/14/2014	N001	4.12	U		#	33	19.6
Actinium-228	pCi/L	07/14/2014	N002	15.6	U		#	37	17.1
Americium-241	pCi/L	07/14/2014	N001	3.2	U		#	31	18.4
Americium-241	pCi/L	07/14/2014	N002	17.5	U		#	52	31.2
Antimony-125	pCi/L	07/14/2014	N001	0.0052	U		#	12	6.81
Antimony-125	pCi/L	07/14/2014	N002	11.2	U		#	13	7.63
Cerium-144	pCi/L	07/14/2014	N001	-1.66	U		#	24	14.4
Cerium-144	pCi/L	07/14/2014	N002	0.407	U		#	26	15.3
Cesium-134	pCi/L	07/14/2014	N001	-1.23	U		#	5.5	3.22
Cesium-134	pCi/L	07/14/2014	N002	-2.04	U		#	5.9	3.41
Cesium-137	pCi/L	07/14/2014	N001	0.921	U		#	4.7	2.81
Cesium-137	pCi/L	07/14/2014	N002	2.88	U		#	5.3	3.26
Chloride	mg/L	07/14/2014	N001	8200			#	100	
Chloride	mg/L	07/14/2014	N002	8500			#	100	
Cobalt-60	pCi/L	07/14/2014	N001	-0.16	U		#	5.7	3.25
Cobalt-60	pCi/L	07/14/2014	N002	1.28	U		#	5.8	3.41
Europium-152	pCi/L	07/14/2014	N001	-0.132	U		#	28	15.9
Europium-152	pCi/L	07/14/2014	N002	-5.64	U		#	30	17
Europium-154	pCi/L	07/14/2014	N001	10.8	U		#	28	16.8
Europium-154	pCi/L	07/14/2014	N002	-3.92	U		#	32	18.5
Europium-155	pCi/L	07/14/2014	N001	8.18	U		#	12	7.28

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-15745 WELL BM 26-34B

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Europium-155	pCi/L	07/14/2014	N002	-0.766	U		#	15	9.08
Gross Alpha	pCi/L	07/14/2014	N001	25.9	U		#	26	17.4
Gross Alpha	pCi/L	07/14/2014	N002	3.5	U		#	30	17.8
Gross Beta	pCi/L	07/14/2014	N001	64.7		J	#	22	17.9
Gross Beta	pCi/L	07/14/2014	N002	66.3			#	21	17.2
Lead-212	pCi/L	07/14/2014	N001	-0.289	U		#	14	8.41
Lead-212	pCi/L	07/14/2014	N002	-0.0942	U		#	14	8.06
Potassium-40	pCi/L	07/14/2014	N001	80.1	U		#	120	77
Potassium-40	pCi/L	07/14/2014	N002	84.7	U		#	160	101
Promethium-144	pCi/L	07/14/2014	N001	2.07	U		#	5.5	3.31
Promethium-144	pCi/L	07/14/2014	N002	4.36	U		#	5.8	3.64
Promethium-146	pCi/L	07/14/2014	N001	-0.21	U		#	5.6	3.3
Promethium-146	pCi/L	07/14/2014	N002	-0.695	U		#	6.2	3.61
Ruthenium-106	pCi/L	07/14/2014	N001	3.82	U		#	45	26.8
Ruthenium-106	pCi/L	07/14/2014	N002	-13.2	U		#	54	31.2
Thorium-234	pCi/L	07/14/2014	N001	13.6	U		#	140	81.4
Thorium-234	pCi/L	07/14/2014	N002	5.1	U		#	180	106
Tritium	pCi/L	07/14/2014	N001	-84.3	U		#	330	194
Tritium	pCi/L	07/14/2014	N002	-23.8	U		#	340	201
Uranium-235	pCi/L	07/14/2014	N001	22.1		U	#	22	13.6
Uranium-235	pCi/L	07/14/2014	N002	-7.74	U		#	44	26.5

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-15745 WELL BM 26-34B

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Yttrium-88	pCi/L	07/14/2014	N001	4.14	U		#	6.3	3.92
Yttrium-88	pCi/L	07/14/2014	N002	-0.115	U		#	6.8	3.92

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-15748 WELL BM 26-34D

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	07/14/2014	N001	19.3	U		#	19	9.33
Americium-241	pCi/L	07/14/2014	N001	0.94	U		#	5	2.97
Antimony-125	pCi/L	07/14/2014	N001	3.62	U		#	11	5.62
Cerium-144	pCi/L	07/14/2014	N001	3.06	U		#	23	13.9
Cesium-134	pCi/L	07/14/2014	N001	-1.17	U		#	4.6	2.67
Cesium-137	pCi/L	07/14/2014	N001	-1.42	U		#	4.5	2.57
Chloride	mg/L	07/14/2014	N001	12000			#	200	
Cobalt-60	pCi/L	07/14/2014	N001	-0.128	U		#	5	2.86
Europium-152	pCi/L	07/14/2014	N001	-1.9	U		#	25	14.2
Europium-154	pCi/L	07/14/2014	N001	-0.832	U		#	25	14.7
Europium-155	pCi/L	07/14/2014	N001	1.08	U		#	6.8	4.05
Gross Alpha	pCi/L	07/14/2014	N001	18.6	U		#	44	27
Gross Beta	pCi/L	07/14/2014	N001	134			#	44	35.6
Lead-212	pCi/L	07/14/2014	N001	3.42	U		#	11	6.45
Potassium-40	pCi/L	07/14/2014	N001	53.3	U		#	110	67.1
Promethium-144	pCi/L	07/14/2014	N001	-1.1	U		#	4.8	2.77
Promethium-146	pCi/L	07/14/2014	N001	0.602	U		#	4.8	2.86
Ruthenium-106	pCi/L	07/14/2014	N001	5.83	U		#	38	22.8
Thorium-234	pCi/L	07/14/2014	N001	20.6	U		#	70	42.6
Tritium	pCi/L	07/14/2014	N001	27.6	U		#	310	187
Uranium-235	pCi/L	07/14/2014	N001	7.57	U		#	16	8.73

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-15748 WELL BM 26-34D

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Yttrium-88	pCi/L	07/14/2014	N001	1.73	U		#	9.7	5.81

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-16074 WELL BM 26-22D

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	07/14/2014	N001	26.5		U	#	20	11.9
Americium-241	pCi/L	07/14/2014	N001	-17.3	U		#	45	26.4
Antimony-125	pCi/L	07/14/2014	N001	-2.29	U		#	13	7.35
Cerium-144	pCi/L	07/14/2014	N001	13.2	U		#	25	15.4
Cesium-134	pCi/L	07/14/2014	N001	-3.74	U		#	5.8	3.37
Cesium-137	pCi/L	07/14/2014	N001	-0.319	U		#	5.3	3.1
Chloride	mg/L	07/14/2014	N001	11000			#	200	
Cobalt-60	pCi/L	07/14/2014	N001	-1.27	U		#	6.3	3.62
Europium-152	pCi/L	07/14/2014	N001	10.6	U		#	31	18.7
Europium-154	pCi/L	07/14/2014	N001	9.92	U		#	30	18.2
Europium-155	pCi/L	07/14/2014	N001	1.54	U		#	15	8.77
Gross Alpha	pCi/L	07/14/2014	N001	29.4	U		#	38	24.4
Gross Beta	pCi/L	07/14/2014	N001	195			#	41	42
Lead-212	pCi/L	07/14/2014	N001	-0.441	U		#	15	8.88
Potassium-40	pCi/L	07/14/2014	N001	89.3	U		#	160	97
Promethium-144	pCi/L	07/14/2014	N001	1.44	U		#	5.8	3.49
Promethium-146	pCi/L	07/14/2014	N001	-1.99	U		#	6.4	3.75
Ruthenium-106	pCi/L	07/14/2014	N001	-6.6	U		#	52	30.6
Thorium-234	pCi/L	07/14/2014	N001	-5.5	U		#	140	87
Tritium	pCi/L	07/14/2014	N001	7.49	U		#	300	177
Uranium-235	pCi/L	07/14/2014	N001	18.8	U		#	23	11.8

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-16074 WELL BM 26-22D

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Yttrium-88	pCi/L	07/14/2014	N001	-0.275	U		#	10	6.21

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-16087 WELL BM 26-22C

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Actinium-228	pCi/L	07/14/2014	N001	35.1		J	#	32	16.1
Americium-241	pCi/L	07/14/2014	N001	-17	U		#	78	46.3
Antimony-125	pCi/L	07/14/2014	N001	3.96	U		#	19	11.5
Cerium-144	pCi/L	07/14/2014	N001	-11.1	U		#	39	23
Cesium-134	pCi/L	07/14/2014	N001	-6.96	U		#	8.8	5.01
Cesium-137	pCi/L	07/14/2014	N001	-3.5	U		#	8.5	4.86
Chloride	mg/L	07/14/2014	N001	11000			#	200	
Cobalt-60	pCi/L	07/14/2014	N001	-3.88	U		#	8.9	4.92
Europium-152	pCi/L	07/14/2014	N001	-10.2	U		#	45	25.5
Europium-154	pCi/L	07/14/2014	N001	-2.81	U		#	46	26.6
Europium-155	pCi/L	07/14/2014	N001	3.4	U		#	22	13.3
Gross Alpha	pCi/L	07/14/2014	N001	19.4	U		#	43	26.3
Gross Beta	pCi/L	07/14/2014	N001	170			#	42	38.9
Lead-212	pCi/L	07/14/2014	N001	7.88	U		#	24	14.4
Potassium-40	pCi/L	07/14/2014	N001	35	U		#	280	167
Promethium-144	pCi/L	07/14/2014	N001	5.39	U		#	9.2	5.66
Promethium-146	pCi/L	07/14/2014	N001	-1.96	U		#	9.1	5.31
Ruthenium-106	pCi/L	07/14/2014	N001	-13.8	U		#	81	47

General Water Quality Data by Location (USEE105) FOR SITE RUL01, Rulison Site
REPORT DATE: 10/06/2014
Location: 05-045-16087 WELL BM 26-22C

Parameter	Units	Sample Date	Sample ID	Result	Qualifiers Lab	Qualifiers Data	Qualifiers QA	Detection Limit	Uncertainty
Thorium-234	pCi/L	07/14/2014	N001	68.3	U		#	300	183
Tritium	pCi/L	07/14/2014	N001	45.2	U		#	330	197
Uranium-235	pCi/L	07/14/2014	N001	0.39	U		#	74	44.3
Yttrium-88	pCi/L	07/14/2014	N001	6.71	U		#	8.1	5.15

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
Third Quarter 2014

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

Date Sampled

July 1, 2014

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

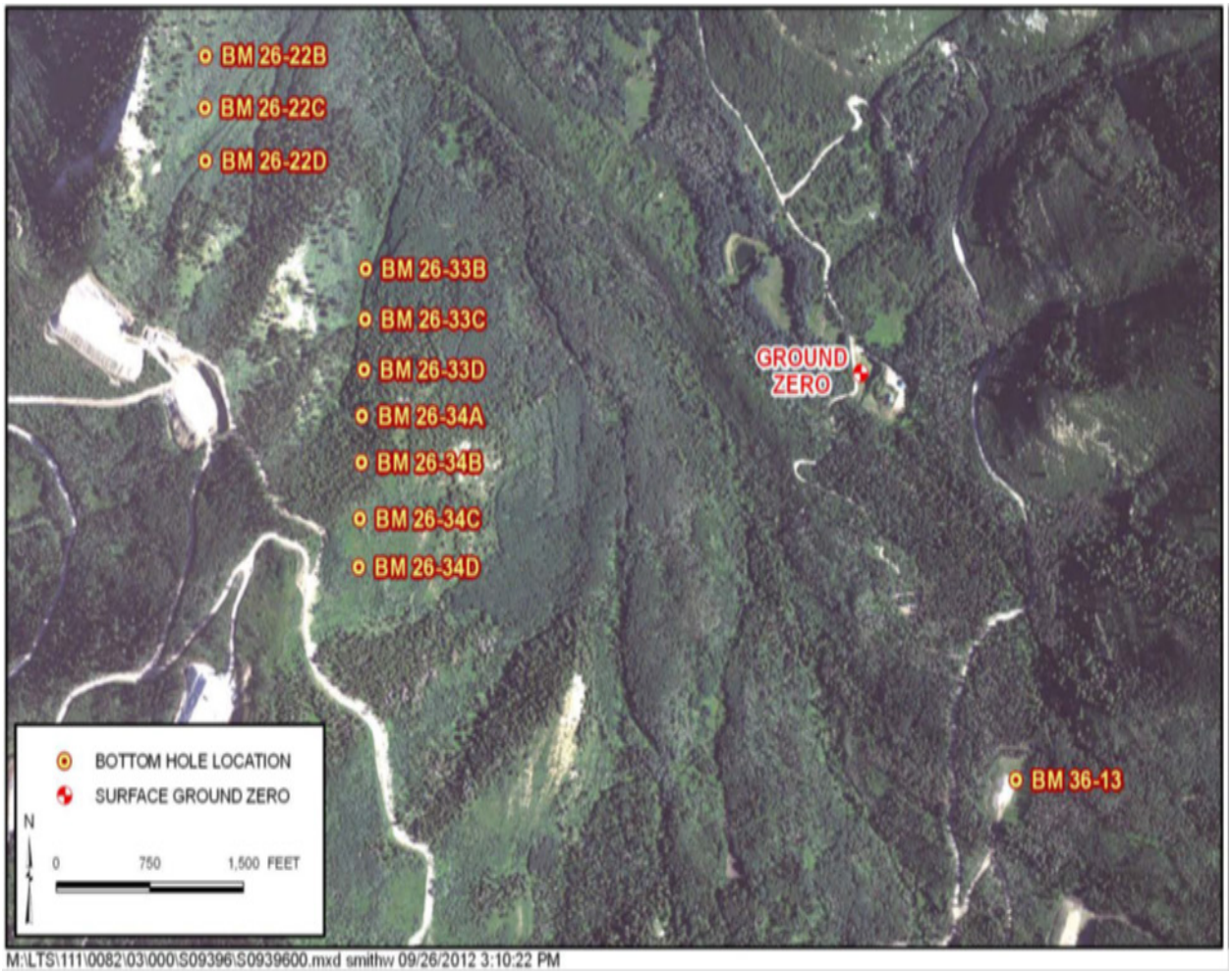
As part of the U.S. Department of Energy (DOE) Office of Legacy Management (LM) mission to protect human health and the environment, LM is monitoring natural gas wells near the Rulison site for radionuclides associated with the detonation. The very low permeability of the Williams Fork Formation limits 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 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 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 1 lists the wells by sample-collection sequence. Before sample collection occurs at each well, each 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.

All planned wellheads were available for sampling, and wellhead pressures and temperatures were within the normal range. A total of seven 1-gallon production-water samples were collected

for total analysis. At two locations, 26-33C and 26-22D, approximately 0.5–0.75 gallon of production water was collected. At four locations—26-33B, 26-33D, 26-34C, and 26-22B—no production water was collected. A duplicate sample was collected from 26-34B and is noted in Table 1. All other well functions were performing normally, so no impact to the analytical 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 (^{o}F)	P (psi)
1	26N	BM 26-33B	15739	WL	NGSA	Yes	No	68.8	262
2	26N	BM 26-33C	15742	WL	NGSA	Yes	Yes[a]	68.1	286
3	26N	BM 26-33D	15743	WL	NGSA	Yes	No	69.1	288
4	26N	BM 26-34A	15744	WL	NGSA	Yes	Yes	62.9	280
5	26N	BM 26-34B	15745	WL	NGSA	Yes	Yes	62.3	284
Duplicate	26N	BM 26-34B	15741	WL	NGSA	No	Yes	62.3	284
6	26N	BM 26-34C	15741	WL	NGSA	Yes	No	61.9	281
7	26N	BM 26-34D	15748	WL	NGSA	Yes	Yes	63.9	267
8	26K	BM 26-22B	16086	WL	NGSA	Yes	No	69.3	257
9	26K	BM 26-22C	16087	WL	NGSA	Yes	Yes	68.1	260
10	26K	BM 26-22D	16074	WL	NGSA	Yes	Yes[1]	68.8	260
11	35C	BM 35-32A	10919	WL	NGSV	Yes	Yes	74.6	268
12	36L	BM 36-13B	15469	WL	NGSV	Yes	Yes	78	282
13	36B	BM 36-13	10840	WL	NGSV	Yes	Yes	80	279

[a] BM 26-33C included approximately 0.75 gallon of produced water, and BM-22D included approximately 0.5 gallon of produced water, which should be enough sample volume for total analysis from both wells.

Abbreviations:

API	American Petroleum Institute
NGSA	natural gas well–angle
NGSV	natural gas well–vertical
P (psi)	pressure in pounds per square inch
T (^{o}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. 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 2 lists the estimated sample volumes (including the condensate).

Table 2. Collected Water Sample Volumes (Before Decanting)

Sample Ticket	Well Name	Planned Analytes	Sample Volume (L)
1	BM 26-33B	NA	No Sample
2	BM 26-33C	^{3}H, Gross α/β, Gamma spec, Cl^-, ^{99}Tc	≈ 2.0 L
3	BM 26-33D	NA	No Sample
4	BM 26-34A	^{3}H, Gross α/β, Gamma spec, Cl^-, ^{99}Tc	≈ 2.5 L
5	BM 26-34B	^{3}H, Gross α/β, Gamma spec, Cl^-, ^{99}Tc	≈ 2.5 L
Duplicate	BM 26-34B	^{3}H, Gross α/β, Gamma spec, Cl^-, ^{99}Tc	≈ 2.5 L
6	BM 26-34C	NA	No Sample
7	BM 26-34D	^{3}H, Gross α/β, Gamma spec, Cl^-, ^{99}Tc	≈ 2.5 L
8	BM 26-22B	NA	No Sample
9	BM 26-22C	^{3}H, Gross α/β, Gamma spec, Cl^-, ^{99}Tc	≈ 2.5 L
10	BM 26-22D	^{3}H, Gross α/β, Gamma spec, Cl^-, ^{99}Tc	≈ 1.75 L
11	BM 35-32A	^{3}H, Gross α/β, Gamma spec, Cl^-, ^{99}Tc	≈ 2.5 L
12	BM 36-13B	^{3}H, Gross α/β, Gamma spec, Cl^-, ^{99}Tc	≈ 2.5 L
13	BM 36-13	^{3}H, Gross α/β, Gamma spec, Cl^-, ^{99}Tc	≈ 2.5 L

Notes:
Water sample information is listed in the order of collection.
Wells BM 26-33B, BM 26-33D, BM 26-34C, and BM 26-22B did not produce water for laboratory analyses.

Abbreviations:

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

Isotech Analysis Report

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ANALYSIS REPORT

Lab #:	446533	Job #:	25901	IS-61901	Co. Job#:
Sample Name:	Ticket #MHW 491				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6053
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-22B				
Formation/Depth:					
Sampling Point:					
Date Sampled:	7/14/2014	Date Received:	7/17/2014		Date Reported: 9/11/2014

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide	nd				
Helium	nd				
Hydrogen	nd				
Argon	nd				
Oxygen	nd				
Nitrogen	0.091				
Carbon Dioxide	2.92				
Methane	91.15			< 0.2	< 10.0
Ethane	3.95				
Ethylene	nd				
Propane	0.960				
Propylene	nd				
Iso-butane	0.216				
N-butane	0.196				
Iso-pentane	0.0930				
N-pentane	0.0648				
Hexanes +	0.358				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1056
Specific gravity, calculated: 0.629

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
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ANALYSIS REPORT

Lab #:	446534	Job #:	25901	IS-61901	Co. Job#:
Sample Name:	Ticket #MHW 492				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6115
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-22C				
Formation/Depth:					
Sampling Point:					
Date Sampled:	7/14/2014	Date Received:	7/17/2014	Date Reported:	9/11/2014

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide	nd				
Helium	nd				
Hydrogen	nd				
Argon	0.408				
Oxygen	9.14				
Nitrogen	34.01				
Carbon Dioxide	1.83				
Methane	50.90			< 0.2	< 10.0
Ethane	2.48				
Ethylene	nd				
Propane	0.681				
Propylene	nd				
Iso-butane	0.144				
N-butane	0.143				
Iso-pentane	0.0593				
N-pentane	0.0429				
Hexanes +	0.166				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 598
Specific gravity, calculated: 0.795

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
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ANALYSIS REPORT

Lab #:	446535	Job #:	25901	IS-61901	Co. Job#:
Sample Name:	Ticket #MHW 493				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6041
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-22D				
Formation/Depth:					
Sampling Point:					
Date Sampled:	7/14/2014	Date Received:	7/17/2014		Date Reported: 9/11/2014

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide	nd				
Helium	nd				
Hydrogen	nd				
Argon	nd				
Oxygen	nd				
Nitrogen	0.081				
Carbon Dioxide	2.52				
Methane	90.59			< 0.2	< 10.0
Ethane	4.37				
Ethylene	nd				
Propane	1.32				
Propylene	nd				
Iso-butane	0.286				
N-butane	0.307				
Iso-pentane	0.126				
N-pentane	0.0893				
Hexanes +	0.309				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1073
Specific gravity, calculated: 0.633

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
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ANALYSIS REPORT

Lab #:	446536	Job #:	25901	IS-61901	Co. Job#:
Sample Name:	Ticket #MHW 484				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6036
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-33B				
Formation/Depth:					
Sampling Point:					
Date Sampled:	7/14/2014	Date Received:	7/17/2014		Date Reported: 9/11/2014

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide	nd				
Helium	nd				
Hydrogen	nd				
Argon	nd				
Oxygen	nd				
Nitrogen	0.086				
Carbon Dioxide	2.68				
Methane	90.24			< 0.2	< 10.0
Ethane	4.50				
Ethylene	nd				
Propane	1.33				
Propylene	nd				
Iso-butane	0.292				
N-butane	0.301				
Iso-pentane	0.129				
N-pentane	0.0892				
Hexanes +	0.353				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1074
Specific gravity, calculated: 0.636

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
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ANALYSIS REPORT

Lab #:	446537	Job #:	25901	IS-61901	Co. Job#:
Sample Name:	Ticket #MHW 485				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6110
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-33C				
Formation/Depth:					
Sampling Point:					
Date Sampled:	7/14/2014	Date Received:	7/17/2014		Date Reported: 9/11/2014

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide	nd				
Helium	nd				
Hydrogen	nd				
Argon	nd				
Oxygen	nd				
Nitrogen	0.067				
Carbon Dioxide	4.57				
Methane	89.44			< 0.2	< 10.0
Ethane	3.89				
Ethylene	nd				
Propane	1.01				
Propylene	nd				
Iso-butane	0.278				
N-butane	0.266				
Iso-pentane	0.108				
N-pentane	0.0774				
Hexanes +	0.297				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1041
Specific gravity, calculated: 0.646

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
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ANALYSIS REPORT

Lab #:	446538	Job #:	25901	IS-61901	Co. Job#:
Sample Name:	Ticket #MHW 486				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6042
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-33D				
Formation/Depth:					
Sampling Point:					
Date Sampled:	7/14/2014	Date Received:	7/17/2014		Date Reported: 9/11/2014

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide	nd				
Helium	nd				
Hydrogen	0.0115				
Argon	nd				
Oxygen	nd				
Nitrogen	0.081				
Carbon Dioxide	2.89				
Methane	89.87			< 0.2	< 10.0
Ethane	4.67				
Ethylene	nd				
Propane	1.34				
Propylene	nd				
Iso-butane	0.292				
N-butane	0.289				
Iso-pentane	0.121				
N-pentane	0.0879				
Hexanes +	0.347				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1073
Specific gravity, calculated: 0.639

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

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ANALYSIS REPORT

Lab #:	446539	Job #:	25901	IS-61901	Co. Job#:
Sample Name:	Ticket #MHW 487				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6022
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-34A				
Formation/Depth:					
Sampling Point:					
Date Sampled:	7/14/2014	Date Received:	7/17/2014		Date Reported: 9/11/2014

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide	nd				
Helium	nd				
Hydrogen	0.0152				
Argon	nd				
Oxygen	nd				
Nitrogen	0.074				
Carbon Dioxide	3.29				
Methane	89.85			< 0.2	< 10.0
Ethane	4.56				
Ethylene	nd				
Propane	1.20				
Propylene	nd				
Iso-butane	0.255				
N-butane	0.250				
Iso-pentane	0.105				
N-pentane	0.0864				
Hexanes +	0.314				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1062
Specific gravity, calculated: 0.638

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
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ANALYSIS REPORT

Lab #:	446540	Job #:	25901	IS-61901	Co. Job#:
Sample Name:	Ticket #MHW 488				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6090
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-34B				
Formation/Depth:					
Sampling Point:					
Date Sampled:	7/14/2014	Date Received:	7/17/2014		Date Reported: 9/11/2014

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide	nd				
Helium	nd				
Hydrogen	nd				
Argon	nd				
Oxygen	nd				
Nitrogen	0.073				
Carbon Dioxide	2.75				
Methane	89.22			< 0.2	< 10.0
Ethane	4.87				
Ethylene	nd				
Propane	1.77				
Propylene	nd				
Iso-butane	0.437				
N-butane	0.435				
Iso-pentane	0.120				
N-pentane	0.0678				
Hexanes +	0.260				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1085
Specific gravity, calculated: 0.644

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
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ANALYSIS REPORT

Lab #:	446541	Job #:	25901	IS-61901	Co. Job#:
Sample Name:	Ticket #MHW 489				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6071
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-34C				
Formation/Depth:					
Sampling Point:					
Date Sampled:	7/14/2014	Date Received:	7/17/2014		Date Reported: 9/11/2014

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide	nd				
Helium	nd				
Hydrogen	nd				
Argon	nd				
Oxygen	nd				
Nitrogen	0.073				
Carbon Dioxide	3.28				
Methane	90.01			< 0.2	< 10.0
Ethane	4.46				
Ethylene	nd				
Propane	1.19				
Propylene	nd				
Iso-butane	0.248				
N-butane	0.241				
Iso-pentane	0.0975				
N-pentane	0.0717				
Hexanes +	0.333				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1061
Specific gravity, calculated: 0.638

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
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ANALYSIS REPORT

Lab #:	446542	Job #:	25901	IS-61901	Co. Job#:
Sample Name:	Ticket #MHW 490				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6032
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 26-34D				
Formation/Depth:					
Sampling Point:					
Date Sampled:	7/14/2014	Date Received:	7/17/2014		Date Reported: 9/11/2014

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide	nd				
Helium	nd				
Hydrogen	nd				
Argon	nd				
Oxygen	nd				
Nitrogen	0.086				
Carbon Dioxide	3.68				
Methane	89.77			< 0.2	< 10.0
Ethane	4.47				
Ethylene	nd				
Propane	1.12				
Propylene	nd				
Iso-butane	0.238				
N-butane	0.210				
Iso-pentane	0.0822				
N-pentane	0.0581				
Hexanes +	0.283				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1052
Specific gravity, calculated: 0.638

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
ISOTECH LABORATORIES INC

ANALYSIS REPORT

Lab #:	446543	Job #:	25901	IS-61901	Co. Job#:
Sample Name:	Ticket #MHW 494				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6018
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 35-32A				
Formation/Depth:					
Sampling Point:					
Date Sampled:	7/14/2014	Date Received:	7/17/2014		Date Reported: 9/11/2014

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide	nd				
Helium	nd				
Hydrogen	nd				
Argon	nd				
Oxygen	nd				
Nitrogen	0.087				
Carbon Dioxide	3.94				
Methane	89.60			< 0.2	< 10.0
Ethane	4.50				
Ethylene	nd				
Propane	1.08				
Propylene	nd				
Iso-butane	0.227				
N-butane	0.199				
Iso-pentane	0.0774				
N-pentane	0.0538				
Hexanes +	0.234				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1047
Specific gravity, calculated: 0.639

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
ISOTECH LABORATORIES INC

ANALYSIS REPORT

Lab #:	446544	Job #:	25901	IS-61901	Co. Job#:
Sample Name:	Ticket #MHW 495				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6079
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 36-13				
Formation/Depth:					
Sampling Point:					
Date Sampled:	7/14/2014	Date Received:	7/17/2014		Date Reported: 9/11/2014

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide	nd				
Helium	nd				
Hydrogen	nd				
Argon	0.0237				
Oxygen	0.51				
Nitrogen	1.95				
Carbon Dioxide	1.36				
Methane	89.28			< 0.2	< 10.0
Ethane	4.61				
Ethylene	nd				
Propane	1.26				
Propylene	nd				
Iso-butane	0.256				
N-butane	0.259				
Iso-pentane	0.103				
N-pentane	0.0772				
Hexanes +	0.312				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1058
Specific gravity, calculated: 0.631

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.

ISOTECH
ISOTECH LABORATORIES INC

ANALYSIS REPORT

Lab #:	446545	Job #:	25901	IS-61901	Co. Job#:
Sample Name:	Ticket #MHW 496				Co. Lab#:
Company:	S.M. Stoller				Cylinder: 6057
API/Well:					
Container:	Isotech LP Tank				
Field/Site Name:	Rulison Site				
Location:	BM 36-13B				
Formation/Depth:					
Sampling Point:					
Date Sampled:	7/14/2014	Date Received:	7/17/2014		Date Reported: 9/11/2014

Component	Chemical mol. %	$\delta^{13}C$ ‰	δD ‰	^{14}C conc. pMC	Tritium TU
Carbon Monoxide	nd				
Helium	nd				
Hydrogen	nd				
Argon	nd				
Oxygen	nd				
Nitrogen	0.071				
Carbon Dioxide	5.39				
Methane	86.28			< 0.2	< 10.0
Ethane	6.01				
Ethylene	nd				
Propane	1.25				
Propylene	nd				
Iso-butane	0.292				
N-butane	0.201				
Iso-pentane	0.0819				
N-pentane	0.0567				
Hexanes +	0.365				

Total BTU/cu.ft. dry @ 60deg F & 14.73psia, calculated: 1053
Specific gravity, calculated: 0.666

nd = not detected. na = not analyzed. Isotopic composition of hydrogen is relative to VSMOW. Isotopic composition of carbon is relative to VPDB. Calculations for BTU and specific gravity per ASTM D3588. Chemical compositions are normalized to 100%. Mol. % is approximately equal to vol. %.