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**Terrace Pit
Groundwater Monitoring Report - Fourth Quarter 2017
Remediation Project #7392**

January 8, 2018

Prepared By:

Talon/LPE
1811 East Mulberry Street
Fort Collins, CO 80524

Prepared For:

Whiting Petroleum Corporation

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1 Introduction

Talon/LPE (Talon) was contracted by Whiting Petroleum Corporation (Whiting) to conduct groundwater monitoring in an area associated with a former pit identified west of the Terrace Gas Plant (Site) in Weld County, Colorado. The site is located at the northwest quarter of the northeast quarter of Section 18, Township 10 North, Range 58 West, 6th Principal Meridian. The Terrace Compressor tin horn pit (COGCC facility #100035 - Remediation #7392) is located approximately one-eighth (1/8) of a mile to the west of the Terrace Gas Plant. The site is located at 40°50'44.22"N and 103°54'48.34"W. The Site Plan is shown on Figure 1 and the general site location is shown on Figure 5.

2 Objective

The primary objective of this document is to report on Site activities completed during Fourth Quarter 2017 which included groundwater monitoring.

3 Regulatory Framework

The COGCC has regulatory jurisdiction over oil and natural gas industry operations in the State of Colorado. Section 900 of the COGCC Rules is for Exploration and Production Waste Management. More specifically, Section 910 details the Concentrations and Sampling for Soil and Groundwater rules. The regulatory limits for specific analytes in soil and groundwater are detailed in Table 910-1 and are summarized below.

Compound	COGCC Table 910-1 Groundwater Concentrations
Benzene	0.005 mg/L
Toluene	1.0 mg/L
Ethylbenzene	0.7 mg/L
Xylenes (total)	10 mg/L

4 Site Characteristics

4.1 Geography

The site is located in the Pawnee Grasslands in Weld County, which is the northeastern part of Colorado. The Grasslands are part of the Colorado Eastern Plains and are relatively flat with the exception of the Pawnee Creek which drains into the South Platte River.

4.2 Geologic Summary

Geology in this area consists of Oligocene age soils of the White River Group comprised of the Brule Formation and Chadron Formation. The Brule Formation consists of interbedded claystones, mudstones, and siltstones of grayish green color. Underlying the Brule Formation is the Chadron Formation comprised of sandstones, claystones, and conglomerates; color varies from yellowish-brown to olive-gray.

4.3 Groundwater

According to the Colorado Division of Water Resources Website, there are no water wells within 1,000-foot radius of the Site.

Depth to groundwater levels as measured on December 13, 2017, in the three (3) groundwater monitoring wells range from 44.84 to 52.72 feet below top of casing (Table 3), which are above-ground by approximately three (3) feet (ft). No wells had measurable amounts of phase-separated hydrocarbons (PSH) during the gauging and sampling activities. The groundwater gradient has been calculated to be approximately 0.003 feet/foot to the southeast as shown in Figure 4.

5 Groundwater Monitoring

On December 13, 2017, Talon personnel gauged all three (3) monitoring wells for depth to water (Table 3). The three (3) wells were purged of three (3) casing volumes, or until the wells became dry. The water levels were allowed to recover within the wells and groundwater samples were collected. The collected groundwater samples were submitted to Summit Scientific in Golden, Colorado (Summit) for analysis of benzene, toluene, ethylbenzene, and total xylenes (BTEX) via method SW8260. Purge water generated during sampling activities was placed into 55-gallon steel drums pending off-site disposal.

Table 1 in Attachment 2 summarizes the well completion and survey information, and Table 2 summarizes the groundwater laboratory analytical results, and Table 3 includes well gauging data. A copy of the laboratory reports and chain of custody documentation is included in Attachment 3.

Analytical results for benzene in groundwater were above COGCC Table 910-1 concentration levels in MW-1 (3.2 mg/L) and MW-2 (0.036 mg/L) and below laboratory detection limits in MW-3 (Table 2). The analytical result for toluene was above COGCC Table 910-1 concentration level in MW-1 (9.8 mg/L). All remaining groundwater analytical results were below COGCC Table 910-1 concentration levels or below laboratory detection limits (Figure 2). Figure 3 shows the isoconcentration contours of dissolved-phase benzene analytical results. Talon will continue to monitor the wells during quarterly monitoring events.

6 Conclusions & Recommendations

During the Fourth Quarter 2017, Talon collected groundwater samples from all three (3) groundwater monitoring wells at the Site. Analytical results for benzene in groundwater were above COGCC Table 910-1 concentration levels in MW-1 (3.2 mg/L) and MW-2 (0.036 mg/L) and below laboratory detection limits in MW-3. The analytical result for toluene was above COGCC Table 910-1 concentration level in MW-1 (9.8 mg/L). All remaining groundwater analytical results were below COGCC Table 910-1 concentration levels or below laboratory detection limits.

The extent of groundwater impacts remains unknown. Talon recommends installing more soil borings and groundwater monitoring wells to further define the extent of impacts at the site.

Talon will continue quarterly monitoring at the Site. The next groundwater sampling event is anticipated to occur in March 2018.

Attachment 1
Figures

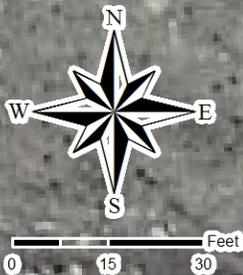


COUNTY RD 118

MW-2

MW-1

MW-3



Legend
Monitor Wells



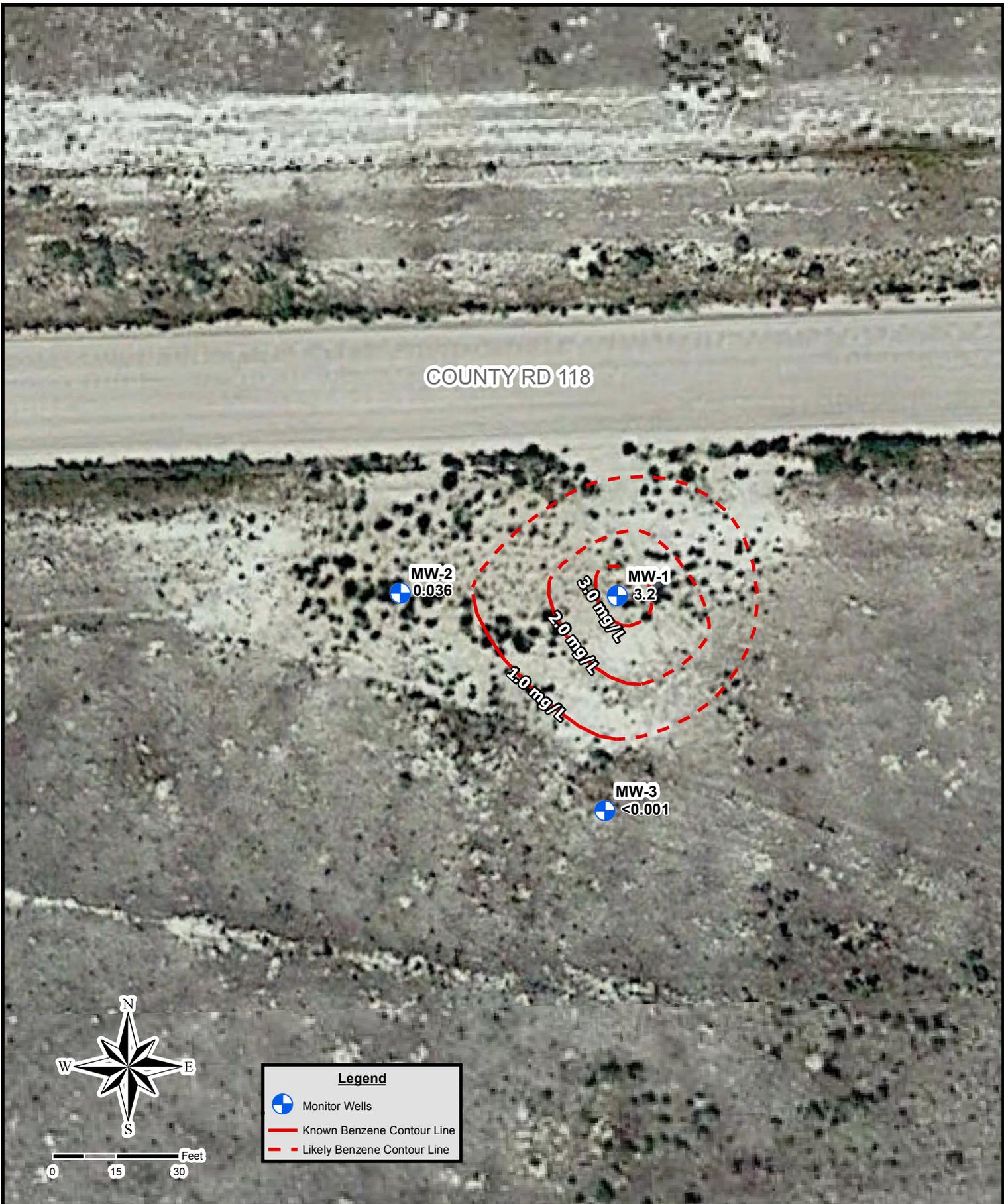
Drafted: 8/2/2017
1 in = 30 ft
Drafted By: IJM

Whiting Oil and Gas Corporation
Terrace Pit
Weld County, CO
Figure 1 - Site Map



Drafted: 12/28/2017
 1 in = 30 ft
 Drafted By: IJM

Whiting Oil and Gas Corporation
 Terrace Pit
 Weld County, CO
 Figure 2 - Groundwater Concentrntion Map 12/13/2017



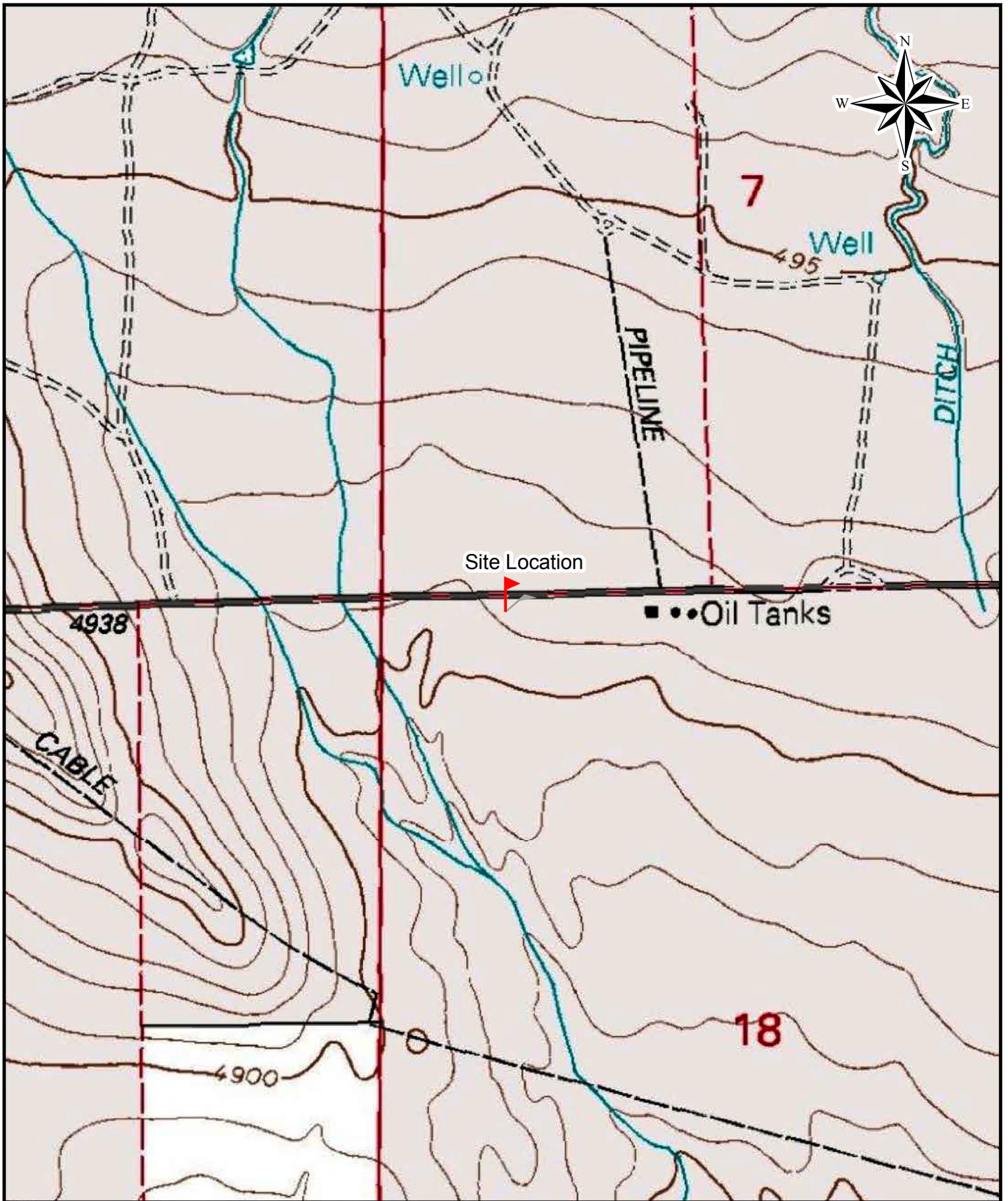
Drafted: 12/28/2017
 1 in = 30 ft
 Drafted By: IJM

Whiting Oil and Gas Corporation
 Terrace Pit
 Weld County, CO
 Figure 3 - Benzene Isoconcentration Map (12/13/2017)



Drafted: 12/28/2017
 1 in = 30 ft
 Drafted By: IJM

Whiting Oil and Gas Corporation
 Terrace Pit
 Weld County, CO
 Figure 4 - Groundwater Gradient Map 12/22/2017



Drafted: 12/28/2017
 Map Scale 1:10,000
 Drafted By: IJM

Whiting Oil and Gas Corporation
 Terrace Pit
 Weld County, CO
 Figure 5 - Topographic Map

**Attachment 2
Tables**



Table 1 - Well Information

**Whiting Oil and Gas Corporation
Terrace Pit
Weld County, Colorado**

Well ID	Latitude	Longitude	Ground Surface Elevation (ft amsl)	TOC Elevation (ft amsl)	Screen Interval (ft bgs)	Total Depth (ft)
MW-1	40.845630	-103.913390	4909.7	4912.9	44-74	77.25
MW-2	40.845634	-103.913576	4909.9	4912.9	45-65	67.07
MW-3	40.845490	-103.913404	4909.6	4912.5	40-60	59.97

TOC - Top of Casing
ft bgs - Feet Below Ground Surface
ft amsl - Feet Above Mean Sea Level



Table 2 - Groundwater Analytical Data

**Whiting Oil and Gas Corporation
Terrace Pit
Weld County, Colorado**

Sample ID	Lab ID	Date	Concentration (mg/L)			
			Benzene	Toluene	Ethyl-Benzene	Xylenes
COGCC Table 910-1 Concentration Levels			0.005	1	0.7	10
MW-1	1706314-01	06/29/17	0.99	5.1	0.66	4.1
	1709242-01	09/25/17	2.4	7.2	0.0072	6.7
	1712178-01	12/13/17	3.2	9.8	0.041	7.5
MW-2	1706314-02	06/29/17	0.053	0.48	0.06	0.33
	1709242-02	09/25/17	0.066	0.5	0.0029	0.22
	1712178-02	12/13/17	0.036	0.0088	0.0056	0.019
MW-3	1706314-03	06/29/17	0.03	0.067	0.0047	0.027
	1709242-03	09/25/17	<0.001	<0.001	<0.001	<0.002
	1712178-03	12/13/17	<0.001	1	<0.001	<0.002

mg/L -milligrams per liter

< - Analytical result is less than the reporting limit

COGCC - Colorado Oil and Gas Conservation Commission

NS - Not Sampled

PSH - Phase-Separated Hydrocarbons



Table 3 - Gauging Data

**Whiting Oil and Gas Corporation
Terrace Pit
Weld County, Colorado**

Well ID	Top of Casing Elevation (ft amsl)	Date Gauged	Depth to Product (ft btoc)	DTW (ft btoc)	Total Depth (ft)	Product Thickness (ft)	Potentiometric Surface Elevation (ft)
MW-1	4912.9	6/29/2017	NA	54.21	77.25	0.00	4858.69
		8/3/2017	NA	53.99	76.80	0.00	4858.91
		9/25/2017	NA	53.27	76.72	0.00	4859.63
		12/22/2017	NA	52.20	77.15	0.00	4860.7
MW-2	4912.9	6/29/2017	NA	46.31	67.07	0.00	4866.59
		8/3/2017	NA	46.49	67.02	0.00	4866.41
		9/25/2017	NA	45.69	67.04	0.00	4867.21
		12/22/2017	NA	44.84	67.10	0.00	4868.06
MW-3	4912.5	6/29/2017	NA	55.77	59.97	0.00	4856.73
		8/3/2017	NA	54.40	60.92	0.00	4858.1
		9/25/2017	NA	53.12	60.11	0.00	4859.38
		12/22/2017	NA	52.72	60.03	0.00	4859.78

NA - Not Applicable

DTW - Depth to Water

ft btoc - Feet Below Top of Casing

ft amsl - Feet Above Mean Sea Level

Attachment 3
Analytical Reports

Summit Scientific

741 Corporate Circle – Suite I ♦ Golden, Colorado 80401

303.277.9310 - laboratory ♦ 303.277.9531 - fax

December 26, 2017

Jennifer Galles
Talon/LPE
1811 E Mulberry
Ft Collins, CO 80524
RE: Terrace

Enclosed are the results of analyses for samples received by Summit Scientific on 12/13/17 16:03. If you have any questions concerning this report, please feel free to contact me.

Sincerely,



Paul Shrewsbury For Ben Shrewsbury
Laboratory Manager



Talon/LPE
1811 E Mulberry
Ft Collins CO, 80524

Project: Terrace

Project Number: 701530.22.06
Project Manager: Jennifer Galles

Reported:
12/26/17 08:28

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
MW-1	1712178-01	Water	12/13/17 11:30	12/13/17 16:03
MW-3	1712178-02	Water	12/13/17 12:25	12/13/17 16:03
MW-2	1712178-03	Water	12/13/17 12:35	12/13/17 16:03

Summit Scientific

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Sample Receipt Checklist

S2 Work Order: 1712178

Client: Talon Client Project ID: Terrace

Shipped Via: P.U. Airbill #: _____
(UPS, FedEx, Hand Delivered, Pick-up, etc.)

Matrix (check all that apply): Air Soil/Solid Water Other: _____
(Describe)

Cooler ID				
Temp (°C)	1.4			

Thermometer ID: 61857155-K

	Yes	No	N/A	Comments (if any)
If samples require cooling, was the temperature at 4°C +/- 2°C ⁽¹⁾ ?				
NOTE: If samples are delivered the same day of sampling, this requirement is met provided that there is evidence that cooling has begun.	✓			
Were all samples received intact ⁽¹⁾ ?	x			
Was adequate sample volume provided ⁽¹⁾ ?	x			
If custody seals are present, are they intact ⁽¹⁾ ?			x	
Are short holding time analytes or samples with HTs due within 48 hours present?			x	
Is a chain-of-custody (COC) form present and filled out completely ⁽¹⁾ ?	x			
Does the COC agree with the number and type of sample bottles received ⁽¹⁾ ?	x			
Do the sample IDs on the bottle labels match the COC ⁽¹⁾ ?	x			
Is the COC properly relinquished by the client w/ date and time recorded ⁽¹⁾ ?	x			
For volatiles in water – is there headspace present? If yes, contact client and note in narrative.		x		
Are samples preserved that require preservation (excluding cooling) ⁽¹⁾ ? Note the type of preservative in the Comments column – HCl, H2SO4, NaOH, HNO3, ect	x			HCL
If samples are acid preserved for metals, is the pH ≤ 2 ⁽¹⁾ ? Record the pH in Comments.			x	
If dissolved metals are requested, were samples field filtered?			x	
Additional Comments (if any):				
⁽¹⁾ If NO, then contact the client before proceeding with analysis and note in case narrative.				

Muri P.
Custodian Printed Name

MP 12-13-17
Signature or Initials of Custodian

17:30
Date/Time



Talon/LPE
 1811 E Mulberry
 Ft Collins CO, 80524

Project: Terrace
 Project Number: 701530.22.06
 Project Manager: Jennifer Galles

Reported:
 12/26/17 08:28

MW-1
1712178-01 (Water)

Summit Scientific

Volatile Organic Compounds by EPA Method 8260B

Date Sampled: **12/13/17 11:30**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Benzene	3200	100	ug/l	100	1712193	12/18/17	12/21/17	EPA 8260B	
Toluene	9800	100	"	"	"	"	"	"	
Ethylbenzene	41	1.0	"	1	"	"	12/21/17	"	
Xylenes (total)	7500	200	"	100	"	"	12/21/17	"	

Date Sampled: **12/13/17 11:30**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
<i>Surrogate: 1,2-Dichloroethane-d4</i>		103 %	37-154		"	"	12/21/17	"	
<i>Surrogate: Toluene-d8</i>		96.1 %	45-149		"	"	"	"	
<i>Surrogate: 4-Bromofluorobenzene</i>		113 %	45-146		"	"	"	"	

Summit Scientific

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Talon/LPE
 1811 E Mulberry
 Ft Collins CO, 80524

Project: Terrace
 Project Number: 701530.22.06
 Project Manager: Jennifer Galles

Reported:
 12/26/17 08:28

MW-3
1712178-02 (Water)

Summit Scientific

Volatile Organic Compounds by EPA Method 8260B

Date Sampled: **12/13/17 12:25**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Benzene	ND	1.0	ug/l	1	1712193	12/18/17	12/21/17	EPA 8260B	
Toluene	1.0	1.0	"	"	"	"	"	"	
Ethylbenzene	ND	1.0	"	"	"	"	"	"	
Xylenes (total)	ND	2.0	"	"	"	"	"	"	

Date Sampled: **12/13/17 12:25**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
<i>Surrogate: 1,2-Dichloroethane-d4</i>		79.7 %	37-154		"	"	"	"	
<i>Surrogate: Toluene-d8</i>		101 %	45-149		"	"	"	"	
<i>Surrogate: 4-Bromofluorobenzene</i>		92.3 %	45-146		"	"	"	"	

Summit Scientific

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Talon/LPE
 1811 E Mulberry
 Ft Collins CO, 80524

Project: Terrace
 Project Number: 701530.22.06
 Project Manager: Jennifer Galles

Reported:
 12/26/17 08:28

MW-2
1712178-03 (Water)

Summit Scientific

Volatile Organic Compounds by EPA Method 8260B

Date Sampled: **12/13/17 12:35**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
Benzene	36	1.0	ug/l	1	1712193	12/18/17	12/21/17	EPA 8260B	
Toluene	8.8	1.0	"	"	"	"	"	"	
Ethylbenzene	5.6	1.0	"	"	"	"	"	"	
Xylenes (total)	19	2.0	"	"	"	"	"	"	

Date Sampled: **12/13/17 12:35**

Analyte	Result	Reporting Limit	Units	Dilution	Batch	Prepared	Analyzed	Method	Notes
<i>Surrogate: 1,2-Dichloroethane-d4</i>		81.4 %	37-154		"	"	"	"	
<i>Surrogate: Toluene-d8</i>		98.6 %	45-149		"	"	"	"	
<i>Surrogate: 4-Bromofluorobenzene</i>		91.1 %	45-146		"	"	"	"	

Summit Scientific

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1811 E Mulberry
Ft Collins CO, 80524

Project: Terrace
Project Number: 701530.22.06
Project Manager: Jennifer Galles

Reported:
12/26/17 08:28

Volatile Organic Compounds by EPA Method 8260B - Quality Control
Summit Scientific

Analyte	Reporting			Spike	Source	%REC		RPD		Notes
	Result	Limit	Units	Level	Result	%REC	Limits	RPD	Limit	

Batch 1712193 - EPA 5030 Water MS

Blank (1712193-BLK1)

Prepared: 12/18/17 Analyzed: 12/21/17

Benzene	ND	1.0	ug/l							
Toluene	ND	1.0	"							
Ethylbenzene	ND	1.0	"							
Xylenes (total)	ND	2.0	"							
Surrogate: 1,2-Dichloroethane-d4	8.68		"	13.3		65.1	37-154			
Surrogate: Toluene-d8	12.7		"	13.3		95.6	45-149			
Surrogate: 4-Bromofluorobenzene	12.7		"	13.3		95.6	45-146			

LCS (1712193-BS1)

Prepared: 12/18/17 Analyzed: 12/21/17

Benzene	29.0	1.0	ug/l	33.3		87.1	51-132			
Toluene	30.1	1.0	"	33.3		90.2	51-138			
Ethylbenzene	32.0	1.0	"	33.1		96.7	58-146			
m,p-Xylene	63.1	2.0	"	66.5		94.9	57-144			
o-Xylene	32.6	1.0	"	32.7		99.9	53-146			
Surrogate: 1,2-Dichloroethane-d4	9.23		"	13.3		69.2	37-154			
Surrogate: Toluene-d8	13.2		"	13.3		99.4	45-149			
Surrogate: 4-Bromofluorobenzene	12.6		"	13.3		94.6	45-146			

Matrix Spike (1712193-MS1)

Source: 1712149-05

Prepared: 12/18/17 Analyzed: 12/21/17

Benzene	30.4	1.0	ug/l	33.3	ND	91.2	34-141			
Toluene	31.2	1.0	"	33.3	ND	93.5	27-151			
Ethylbenzene	34.8	1.0	"	33.1	ND	105	29-160			
m,p-Xylene	68.3	2.0	"	66.5	211	NR	20-166			QM-07
o-Xylene	35.7	1.0	"	32.7	ND	109	33-159			
Surrogate: 1,2-Dichloroethane-d4	9.44		"	13.3		70.8	37-154			
Surrogate: Toluene-d8	13.0		"	13.3		97.5	45-149			
Surrogate: 4-Bromofluorobenzene	12.6		"	13.3		94.1	45-146			

Summit Scientific

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Talon/LPE
 1811 E Mulberry
 Ft Collins CO, 80524

Project: Terrace
 Project Number: 701530.22.06
 Project Manager: Jennifer Galles

Reported:
 12/26/17 08:28

Volatile Organic Compounds by EPA Method 8260B - Quality Control
Summit Scientific

Analyte	Reporting		Spike Level	Source Result	%REC		RPD		Notes
	Result	Limit			Units	%REC	Limits	RPD	

Batch 1712193 - EPA 5030 Water MS

Matrix Spike Dup (1712193-MSD1)	Source: 1712149-05			Prepared: 12/18/17		Analyzed: 12/21/17				
Benzene	30.8	1.0	ug/l	33.3	ND	92.5	34-141	1.37	32	
Toluene	32.1	1.0	"	33.3	ND	96.2	27-151	2.88	25	
Ethylbenzene	35.5	1.0	"	33.1	ND	107	29-160	2.08	50	
m,p-Xylene	69.6	2.0	"	66.5	211	NR	20-166	1.87	36	QM-07
o-Xylene	36.2	1.0	"	32.7	ND	111	33-159	1.36	26	
<i>Surrogate: 1,2-Dichloroethane-d4</i>	<i>9.70</i>		<i>"</i>	<i>13.3</i>		<i>72.8</i>	<i>37-154</i>			
<i>Surrogate: Toluene-d8</i>	<i>13.0</i>		<i>"</i>	<i>13.3</i>		<i>97.3</i>	<i>45-149</i>			
<i>Surrogate: 4-Bromofluorobenzene</i>	<i>12.5</i>		<i>"</i>	<i>13.3</i>		<i>94.1</i>	<i>45-146</i>			

Summit Scientific

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Talon/LPE
1811 E Mulberry
Ft Collins CO, 80524

Project: Terrace
Project Number: 701530.22.06
Project Manager: Jennifer Galles

Reported:
12/26/17 08:28

Notes and Definitions

- QM-07 The spike recovery was outside acceptance limits for the MS and/or MSD. The batch was accepted based on acceptable LCS/LCSD recovery.
- DET Analyte DETECTED
- ND Analyte NOT DETECTED at or above the reporting limit
- NR Not Reported
- dry Sample results reported on a dry weight basis
- RPD Relative Percent Difference