

**SENSITIVE AREA DETERMINATION
RICE LEASE - SITE SPECIFIC
SUBSURFACE INVESTIGATION REPORT
REMEDATION #8461**

**CM PRODUCTION, LLC
CLIFF UNIT— RICE LEASE PRODUCED WATER PITS
SECTION 33, T12N, R54W, 6TH P.M.
LOGAN COUNTY, COLORADO**

PREPARED FOR

**CM PRODUCTION, LLC
390 UNION BOULEVARD, SUITE 620
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PREPARED BY

**OLSSON ASSOCIATES
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JANUARY 2015

OLSSON PROJECT No. 014-0704



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1.0 EXECUTIVE SUMMARY

CM Production, LLC (CM) retained Olsson Associates (Olsson) to conduct a subsurface investigation of CM Production's Rice Lease to assess the potential for groundwater and surface water impacts related to the use of three unlined earthen produced water storage pits at the Cliff Unit/ Rice Lease site. This report presents the observations and findings of the subsurface investigation performed on December 15 and December 16, 2014, and monitoring well measurements taken on January 2, 2015 for Colorado Oil and Gas Conservation Commission (COGCC) Remediation #8461. **Figure 1** presents a general site location map. The monitoring well locations and the boring locations are shown on **Figure 2**.

On December 15, 2014 Olsson personnel arrived onsite and met with Mr. Rob Young Northeast Environmental Protection Specialist with the COGCC. Olsson attempted to hand auger two locations near the head of the east-west lateral drainage down slope from the north pit. The first hand auger boring location, HA-1, was on the south bank near the head of an east-west lateral channel proximal to the north produced water evaporation pit. Hand auger boring, HA-1, encountered refusal at approximately one foot below surface grade (bsg).

A second hand auger boring was attempted out in a 'septa' of soil where several smaller channels came together to form the head of the east-west lateral channel. This second hand auger boring, HA-2, met with refusal at approximately 4.5 feet bsg which was approximately the same elevation as the base of the lateral channel. Moisture was observed in the bottom of HA-2, but there was insufficient water accumulation to obtain a sample. This moisture may have been snow melt water contained within the low permeability soils of the lateral drainage.

A third hand auger boring, HA-3, was advanced to the north of the site at a location approximately four feet above the base of the main channel. Auger refusal occurred at a depth of approximately three feet bsg and the boring was dry to the bottom.

Site Services of Golden, Colorado advanced test holes using a direct-push 7730 DT Geoprobe® rig capable of drilling with three inch diameter solid stem augers. The test holes were completed as groundwater monitoring wells. Groundwater was not encountered during the site specific subsurface investigation down to depths of more than 40 feet bsg in any of the Geoprobe® test holes advanced on December 15 and December 16, 2014. Observations were that the siltstone, claystone and sand lithologies were dry to the terminus of the borings in the up gradient and down gradient test holes subsequently completed as monitoring wells MW-2 and MW-3.

A moist to wet interval observed in the test hole for MW-1 from 5 feet to 7 feet bsg appears to be the result of seepage from the south pit to the shallow subsurface. Lithologies in MW-1 below 10 feet bsg were dry and no ground water was encountered.

A Geoprobe® soil boring, SB-1, placed on the north side of the lateral drainage and to the north of the north pit, encountered refusal at 9 feet. Lithologies of the boring were dry to bottom and the bottom interval consisted of hard silty clay.

On January 2, 2015, Olsson gauged all three monitoring wells and found all three wells dry. MW-1 had moisture at bottom, but no water, believed to be residual moisture left from water seepage at a depth of 7' bsg.

Olsson gauged piezometer, PZ-1, on January 2, previously on December 15, 2014 and July 2014 and during all occasions the piezometer was dry.

The site is not in a sensitive area as defined in the COGCC 100 Series Rules, and Rule 901.e. based on the following:

- The site specific data obtained from the hand auger borings and monitoring well test holes during the subsurface investigation conducted on December 15 and December 16, 2014;
- The absence of groundwater in the three onsite monitoring wells gauged on January 2, 2015;
- The absence of water in piezometer PZ-1 gauged on July 23, 2014, December 15, 2014, and on January 2, 2015; and
- The information presented in the Sensitive Area Determination Assessment Report in April 2014.

2.0 SITE SPECIFIC SENSITIVE AREA EVALUATION

The COGCC requested that CM Production perform a site specific sensitive area evaluation to determine if produced water was leaking from the pits and impacting surface water or shallow groundwater at the site. In April 2014 Olsson prepared a Sensitive Area Determination Assessment Report based on previously submitted data and a review of published data for the area. The report concluded that the site was in a non-sensitive area based on the review of this information. The COGCC required CM Production to perform a site specific evaluation to determine if there was evidence of impacts to surface water or shallow groundwater at the site.

2.1 Project and Site Description

The site is located in northwestern Logan County, Colorado near the Colorado - Nebraska Border. The site is located in the southwest quarter of the northwest quarter, Section 33, Township 12 North, Range 54 West. CM Production operates three produced water storage pits at the Rice Lease located adjacent to an intermittent drainage that flows to the south from the Chimney Canyons and Chalk Bluffs. The general site location is shown on **Figure 1**.

In July 2014, Olsson personnel use a hand auger to advance a test hole downslope from the southeast produced water pit at a location that was approximately three feet above the base of the main drainage channel. The boring was advanced to ten feet below surface grade (bsg) and was completed as a temporary piezometer, PZ-1, using one-inch diameter schedule 40 polyvinyl chloride (PVC) casing and slip caps. The bottom eight feet of the PVC casing of PZ-1 was slotted using a hand saw. The location of PZ-1 is shown on **Figure 2**.

2.2 Scope of Work

On December 5, 2014 Olsson prepared a Form 27 Work Plan that was submitted to the COGCC for approval. The Work Plan outlined the proposed Scope of Work for the subsurface investigation. The COGCC conditionally approved the work plan on December 8, 2014. The conditions were as follows:

- 1. The maximum depth of each boring was to be determined based on specific observations of lithology and moisture content during the advancement of each boring. If unconsolidated alluvium was encountered below 30-feet from surface grade, the boring was to be advanced to either auger/probe refusal or a minimum of 40-feet below surface grade (bsg). Depending on moisture content and lithologic conditions, a determination of final total depth would be made in the field in consultation with the COGCC*
- 2. The proposed piezometer location at the north produced water pit shall be installed at the head of the east/west lateral channel directly below the pit. The modified location was shown on the diagram from Olsson's Work Plan.*

3. *The previously installed piezometer, PZ-1, shall be checked during the site investigation activities to determine if it is still dry. If water is present, collect a sample and submit for the proposed analyses.*

This scope of work was developed in response to John Noto's (the previous Northeast Environmental Protection Specialist) May 1, 2014 request for a Form 27 in response to the Notice of Alleged Violation (NOAV) #200399090; John Axelson's (East Environmental Supervisor) October 30, 2014 letter and a response letter from Jeremy Ferrin, COGCC Compliance Office, sent to Kirk Mueller at Davis Graham and Stubbs on December 5, 2014.

2.3 Sensitive Area Definition

According to the definition provided in the COGCC 100 Series Rules:

A Sensitive Area is an area vulnerable to potential significant adverse groundwater impacts due to factors such as the presence of shallow groundwater or pathways for communication with deeper groundwater; proximity to surface water, including lakes, rivers, perennial or intermittent streams, creeks, irrigation canals, and wetlands. Additionally, areas classified for domestic use by the Water Quality Control Commission, local (water supply) wellhead protection areas, areas within 1/8 mile of a domestic water well, areas within 1/4 mile of a public water supply well, ground water basins designated by the Colorado Ground Water Commission, and surface water supply areas are sensitive areas.

2.4 Sensitive Area Determination (Rule 901)

The COGCC 900 Series rules and regulations establish the permitting, construction, operating, and closure requirements for pits, methods of exploration and production (E&P) waste management, procedures for spill/release response and reporting, and sampling and analysis for remediation activities. The 900 Series rules are applicable only to E&P waste as defined in § 34-60-103(4.5), C.R.S, and other solid waste where the Colorado Department of Public Health and Environment has allowed remediation oversight by the COGCC.

According to the COGCC Rule 901.e:

A sensitive area determination is to be performed when the operator or Director has data that indicate an impact or threat of impact to ground water or surface water, the Director may require the operator to make a sensitive area determination and that determination shall be subject to the Director's approval. The sensitive area determination shall be made using appropriate geologic and hydrogeologic data to evaluate the potential for impact to ground water and surface water, such as appropriate percolation tests that demonstrate that seepage will not reach underlying ground water or waters of the State and impact current or future uses of these waters. Operators shall submit data evaluated and analysis used in the determination to the Director.

According to Rule 901.f sensitive area operations shall incorporate adequate measures and controls to prevent significant adverse environmental impacts and ensure compliance with the concentration levels in Table 910-1, with consideration to Colorado Department of Public Health and Environment Water Quality Control Commission (WQCC) standards and classifications.

2.5 Site Geology

The site is underlain by the Tertiary age Brule Formation of the White River Group. The Brule Formation consists primarily of massive siltstone with localized beds of sandstone, volcanic ash, claystone, and fine sand. The Brule Formation ranges from 200 feet to 500 feet in thickness, is relatively impermeable, and is not considered part of the High Plains Aquifer except in areas where it is extensively fractured or where zones of significant secondary permeability zones are present. According to a University of Idaho doctoral thesis titled Hydrostratigraphy and Hydraulic Behavior of Fractured Brule Formation in Sidney Draw, Cheyenne County, Nebraska, (Barrash, 1986) the Brule Formation is dominantly siltstone; sandstone lenses and stringers occur but are not extensive. Sidney Draw is located a few miles to the northeast of the site. The horizontal hydraulic conductivity of the Brule Formation ranges from 10^{-5} to 10^{-6} meters/second (m/s) and vertical hydraulic conductivity ranges from 10^{-6} m/s to 10^{-7} m/s. **Figure 3** presents the site geology.

2.6 Soil

According to the COGCC GIS database and the Logan County Colorado Soil Survey, the soils in the vicinity of the site consist of the Mitchell – Keota loams (Soil unit #70) which occupy 3 percent to 9 percent slopes to the west of the site, and Badland (Soil unit #13) to the east of the site along the main drainage. The Badland soil unit consists of very steep barren land dissected by many intermittent drainage channels that have entrenched into the soft shale and siltstone of the Brule Formation and the overlying algal limestone of the Ogallala Formation. The Ogallala Formation and Arikaree Formation lie stratigraphically above the Brule Formation and are exposed in the Chimney Canyons and Chalk Bluffs to the north and northwest of the site.

The unit is barren or nearly barren and is too steep or inaccessible for livestock. These soils are droughty and are susceptible to wind and water erosion. Water for livestock is difficult to locate in these areas. Windbreaks and environmental plantings are difficult to establish on these soils.

2.7 Hydrologic Setting

There is a north to south intermittent drainage located east of the three Rice produced water evaporation pits. The southeast pit is approximately 75 feet west of the main drainage. An intermittent, east-west lateral drainage, proximal to the northeast corner of the north pit, joins the main channel at a point approximately 170 feet to the east-northeast of the north pit.

There are no lakes, rivers, creeks, ponds, irrigation canals, or wetlands within one mile of the Rice produced water evaporation pits. The nearest named stream is an intermittent creek named George Creek located approximately six and half miles to the south.

The High Plains aquifer is comprised of the Tertiary Ogallala Formation and the Arikaree Formation of the White River Group. These formations lie topographically and stratigraphically above the site and form the Chalk Bluffs and Chimney Canyons located north of the site. The Brule Formation is a confining layer at the base of the High Plains aquifer, and yields limited

water to wells only in areas where it has been extensively fractured or in zones where there is highly conductive secondary porosity.

A review of the Division of Water Resources website indicates that there are no permitted water wells within a one-mile radius of the site. Information from wells outside the mile radius reported static water levels from 100 feet to more than 200 feet bsg. According to the water well records these wells produce from "All Unnamed Aquifers."

There are two windmill towers located approximately one and a half miles to the south of the site on the Chimney Canyons Grazing Association ranch property. The windmills no longer have blades and the wells do not appear to be in use. The Division of Water Resources records show a well that is permitted to the Chimney Canyons Grazing Association that reportedly has a total depth of 112 feet and a static water level of 75 feet. Permitted water wells outside a mile radius are shown on **Figure 4**.

3.0 SENSITIVE AREA SUBSURFACE ASSESSMENT

Olsson met with Mr. Rob Young, COGCC Northeast Environmental Protection Specialist on December 15 and December 16, 2014 to oversee the subsurface investigation. Olsson retained Site Services to provide drilling services for the subsurface investigation.

3.1 Site Specific Subsurface Investigation Preparation

Olsson personnel contacted the Utility Notification Center of Colorado (UNCC) to locate buried utilities on the site. Olsson prepared a site specific health and safety plan (HASP) for the subsurface investigation including emergency contact information and a route to the Sterling Regional MedCenter in Sterling, Colorado.

Olsson contracted with Site Services to perform the subsurface investigation and construct the monitoring wells. Olsson requested that Site Services bring materials to construct temporary one-inch diameter piezometers down to at least 10 feet bsg in the event that hand auger test holes could be advanced to those depths. This was in addition to the scope of work presented to Site Services for three monitoring wells completed to a minimum depth of 40 feet bsg.

3.2 Hand Auger Boring Observations

Olsson personnel used a hand auger to advance three borings at the top of the east-west lateral channel close to the base of the northeast corner of the north pit. The purpose of these borings was to install a temporary piezometer to assess seepage from the north pit and potential impacts to surface water. Hand auger boring locations are shown on **Figure 2**.

On December 15, 2014 Olsson attempted to hand auger two locations near the head of the east-west lateral drainage down slope from the north pit. Hand auger refusal was encountered in the first boring, HA-1, at approximately one foot bsg. A second hand auger boring, HA-2, was attempted out in a 'septa' of soil where several smaller channels came together to form the east-west channel.

The lithologies encountered in hand auger boring HA-2 consisted of silts, clays, and weathered siltstone similar to that exposed in the sides of the drainage. Hand auger refusal was encountered at a depth of approximately 4.5 feet bsg, which was at the elevation of the bottom of the lateral channel. Water was encountered at the bottom of the boring, but there was not sufficient water volume to enable a sample to be collected. Several attempts to obtain a grab water sample were attempted using a ¾-inch diameter disposable bailer, but there was not any water in the bailer. Moisture or water in the bottom of the boring may be related to snow melt seeping through the lateral drainage.

A hand auger boring (HA-3) was also advanced to the north of the site at a point approximately four feet above the elevation of the main north to south channel. Hand auger refusal was encountered at a depth of approximately three feet bsg. Lithologies consisted of silt and clay. Soils were dry in the hand auger boring to refusal depth.

3.3 Monitoring Well Test Hole Observations

Site Services used a 7730 DT Series rubber track-mounted Geoprobe® direct push/drill rig which is capable of driving a two-inch diameter Macro-Core® barrel and turning three-inch diameter solid stem auger. Site Services used the Geoprobe® to drive five foot length Macro-Core® barrels containing polyacetate sleeves in which the soil samples were contained.

Lithologies encountered included light brown to grayish or yellowish brown silty clay, silty sand, and weathered siltstone and claystone bedrock. The Geoprobe® sampling was continued until the point of refusal in each of the test holes advanced for the construction of groundwater monitoring wells, at which point Site Services switched over to the three-inch diameter solid stem augers and continued boring to a depth of 40 feet bsg. The details can be found in the lithologic logs for each monitoring well test hole included in Appendix A, and the well completion logs presented in Appendix B. Site photographs are presented as Appendix C.

Monitoring Well MW-1 Test Hole

MW-1 was located adjacent to the southeast corner of the south produced water evaporation pit (Figure 2). Geoprobe® refusal occurred at 18 feet and solid stem auger was used to drill to a total depth of 43.50 feet bsg. Soil samples were collected continuously in five foot intervals from the surface down to 18 feet bsg.

Moist sediment was encountered at 5 feet and became wet at 7 feet. The upper foot was wet in the interval from 10 feet to 14 feet; however, the remainder of the boring was dry, as based on observed in the Geoprobe® soil sample intervals and the auger cuttings. This moisture and water appeared to be related to seepage from the pit and not groundwater.

Lithology consisted of clay and silty clay from ground surface to 16 feet bsg; silt and very fine grained sand from 16 feet bsg to 18 feet bsg at the point of Geoprobe® refusal. Once Site Services switched over to solid stem augers soil samples could not be collected, but cuttings were observed to consist of silty clay to very fine sand to the bottom of the test hole.

Monitoring Well MW-2 Test Hole MW-2 was bored up gradient and approximately 87 feet north northwest of the north produced water evaporation pit. Geoprobe® refusal occurred at 3 feet bsg and Site Services used the 3-inch diameter solid stem augers to drill to a depth of 8 feet; at which point Olsson requested that they remove the augers and use the Geoprobe® to collect a soil sample from 8 feet to 12 feet. Refusal occurred again at 12 feet and the boring was continued using solid stem auger to a total depth of 40.00 feet. Soils were observed to be dry.

Siltstone and claystone subcrop was noted at the surface near the MW-2 test hole location. The sediments observed in the first sample sleeve from 0 to 3 feet, consisted of silty clay that hyperaccumulated in the sleeve and the polyacetate sleeve was twisted at the bottom. Subangular blocky parting was noted in the bottom part of the 0 to 3 feet sample interval.

The sediment in the interval from 8 feet to 12 feet consisted of clay and clayey silt, that was massive and dry to slightly moist. The interval from 10 feet to 12 feet in the second sleeve consisted of clay to silty clay with a sand lens at 11 feet to 11.5 feet. Refusal was encountered again at 12 feet bsg. Site Services switched over to three-inch diameter solid stem augers and drilled to 40 feet bsg. The cuttings were observed to consist primarily of yellowish-brown to gray brown silty clay to the terminus of the test hole. The cuttings were dry to slightly moist to the terminus of the boring.

Monitoring Well MW-3 Test Hole

MW-3 was located down gradient, east-southeast of the east produced water evaporation pit, on the north side of the well pad for the Rice #2 oil well (Figure 2). The lithologies encountered in the test hole for MW-3 contained more silt and sand than the other two test holes. Geoprobe® refusal occurred at 33 feet at which time a 3-inch diameter solid stem auger was used to drill to a total depth of 43.00 feet. The bottom of the test hole collapsed back to a depth of 40.00 feet bsg, where monitoring well MW-3 was set.

Sediments consisted of clayey silt and silt. Weak platy parting was observed in the interval from 10 feet to 15 feet. Platy parting and shale fragments were observed in the interval from 15 feet to 20 feet and from 20 feet to 25 feet bsg which consisted of fissile clayey silty shale and shale fragments. The interval from 25 feet to 30 feet bsg consisted of clayey silt that changed to a very fine grained sand and friable silty sand. The interval from 30 feet to 33 feet consisted of a dry medium to coarse-grained sand. Geoprobe® refusal was encountered at 33 feet bsg. The sediment in all of the sample intervals was dry.

Soil Boring SB-1

SB-1 was located adjacent to the northeast corner of the north produced water evaporation pit on the north side of the east -west lateral drainage. Geoprobe® refusal occurred at a depth of nine feet. The purpose of soil boring SB-1 was to assess the potential for seepage from the north pit to the lateral drainage, since the hand auger borings in the lateral drainage encountered refusal at shallow depth.

Sediments encountered in the sample sleeves from 0 to 6 feet consisted of clay and clayey silt, that was massive and contained shale and rock fragments in the bottom two feet of the interval. The interval from 6 feet to 9 feet bsg consisted of moderate yellowish brown shale, clay, and silty clay that became hard and dry at the bottom of the interval. The sediment in both Geoprobe® sample intervals was dry.

3.4 Monitoring Well Completions

Well completion diagrams are included in Appendix B. Site Services completed the monitoring wells using two-inch diameter Schedule 40 PVC casing and two-inch diameter 0.010-inch factory slotted PVC Screen. A 10-20 silica sand pack was placed in the annular space around

the PVC screen section from total depth of the well to a minimum depth of two feet above the top of the screened interval in each well.

Above the sand pack, 1 foot to 2 feet of bentonite crumbles were placed in the annular space of each well and hydrated with potable water to form a seal. The remaining annular space was filled with bentonite chips to a depth of approximately 1 foot to 2 feet bsg to prevent surface water infiltration into the well.

The wells were completed as 'stick-ups' with a protective steel riser surrounding the blank PVC casing. Each riser was grouted in place using Quikrete® concrete, the riser was filled with 10-20 silica sand and equipped with locking covers. Expandable and locking plugs were placed in the top of the solid casing of each well prior to riser covers being locked.

Monitoring well MW-1 was completed with fifteen feet of screen due to the moist to wet interval observed at approximately seven feet bsg. Lithologies below this depth were observed to be dry. The drillers reported that there was approximately 16 feet of water in MW-1 at the end of the day on December 15, 2014, but that this was seepage from up above and they could hear it coming into the well.

Monitoring wells, MW-2 and MW-3 were each completed with ten feet of screen. The wells were set at depths of approximately 40 feet where auger refusal was encountered or where the soil boring had collapsed. Water was not encountered in the test holes for MW-2 and MW-3.

3.5 Monitoring Well and Water Level Measurements

On January 2, 2015, Olsson personnel returned to the site to measure groundwater levels in the three monitoring wells and PZ-1. The intent was to gauge fluid levels using an oil/water interface probe and develop the monitoring wells prior to sampling. All three monitoring wells and PZ-1 were dry. Piezometer, PZ-1, was gauged and found to be dry; and PZ-1 was previously gauged after installation in July 2014 and on December 15, 2014, and was dry both times.

Monitoring wells MW-2 and MW-3 were dry without any water detected by the oil/water interface probe. There was no moisture observed on the oil/water interface probe or tape. The oil/water interface probe indicated water in monitoring well MW-1 at a depth of 40.26 feet. Mud was observed on the probe which resulted in a false positive reading for water. A disposable bailer was lowered into MW-1 to total depth. The outside of the bailer had mud on it, but there was no water inside the bailer. Several attempts were made to bail the well, but no water was recovered.

The presence of moisture at the bottom of MW-1 is believed due to residual water that seeped into the hole during the boring operation from a depth of 7 feet bsg and not representative of groundwater. This is supported by the absence of water in the well on January 2, 2015, which Olsson confirmed this with a disposable bailer.

4.0 CONCLUSIONS




The site is not in a sensitive area as defined by the definition contained in the COGCC 100 Series Rules, and Rule 901.e. Groundwater was not encountered in the three onsite monitoring wells, advanced to depths of 40 feet bsg or deeper.

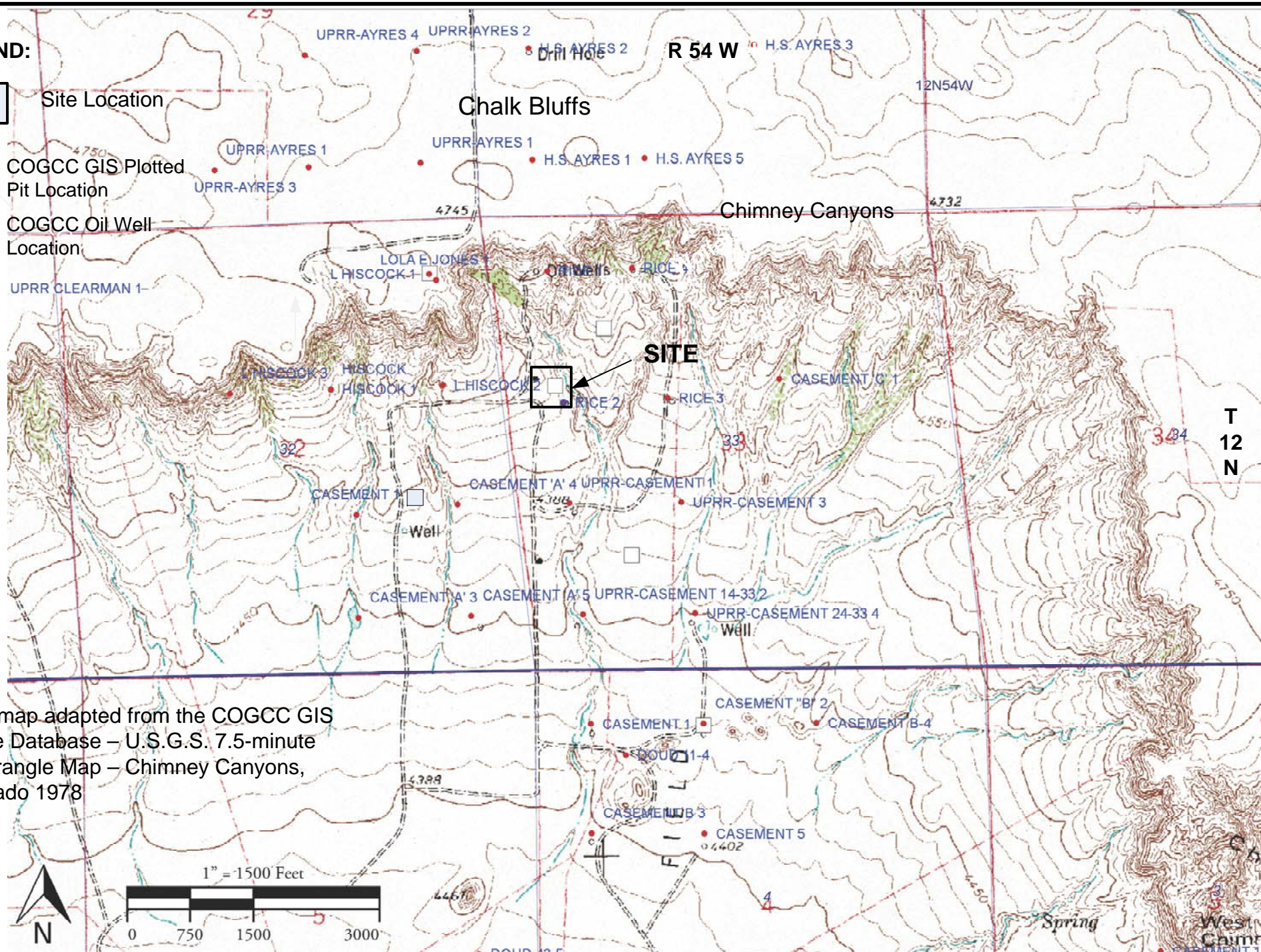
Surface water does not appear to be impacted by operation of the produced water pits since piezometer, PZ-1, has remained dry, hand auger borings near the top of the east-west lateral drainage met refusal at shallow depth and did not yield enough water to enable sample collection.

Soil boring, SB-1, advanced using the Geoprobe® to the northeast of the north pit down to a depth of nine feet bsg met with refusal. The lithologies were dry to the bottom of the SB-1 boring which terminated in hard silty clay.

FIGURES

LEGEND:

-  Site Location
-  COGCC GIS Plotted Pit Location
-  COGCC Oil Well Location



Base map adapted from the COGCC GIS
Online Database - U.S.G.S. 7.5-minute
Quadrangle Map - Chimney Canyons,
Colorado 1978

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DATE: 01/12/2015

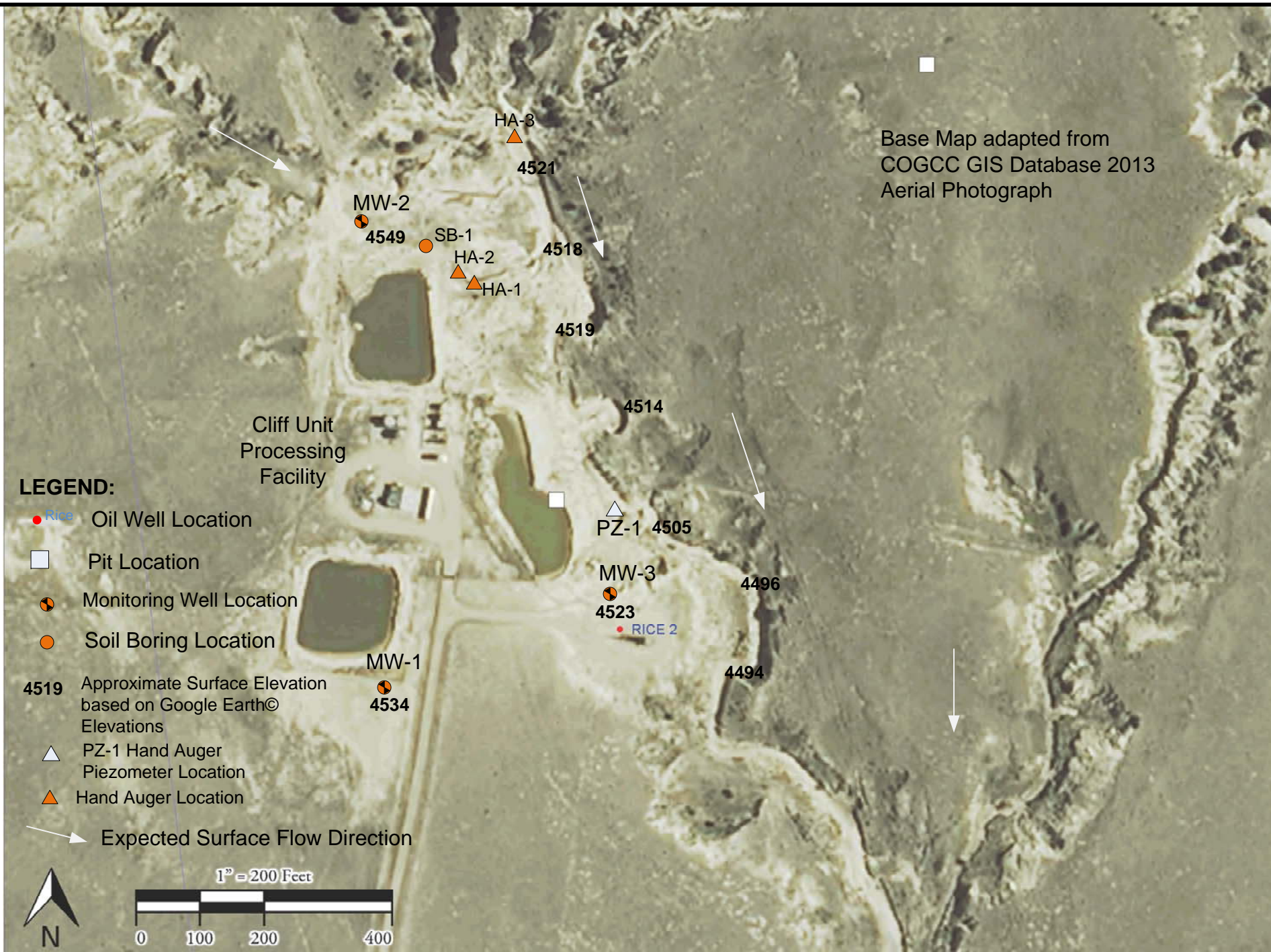
General Site Location Map
CM Production, LLC
Cliff Field, Rice Lease, Logan County, Colorado

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FIGURE

1



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DATE: 01/12/15

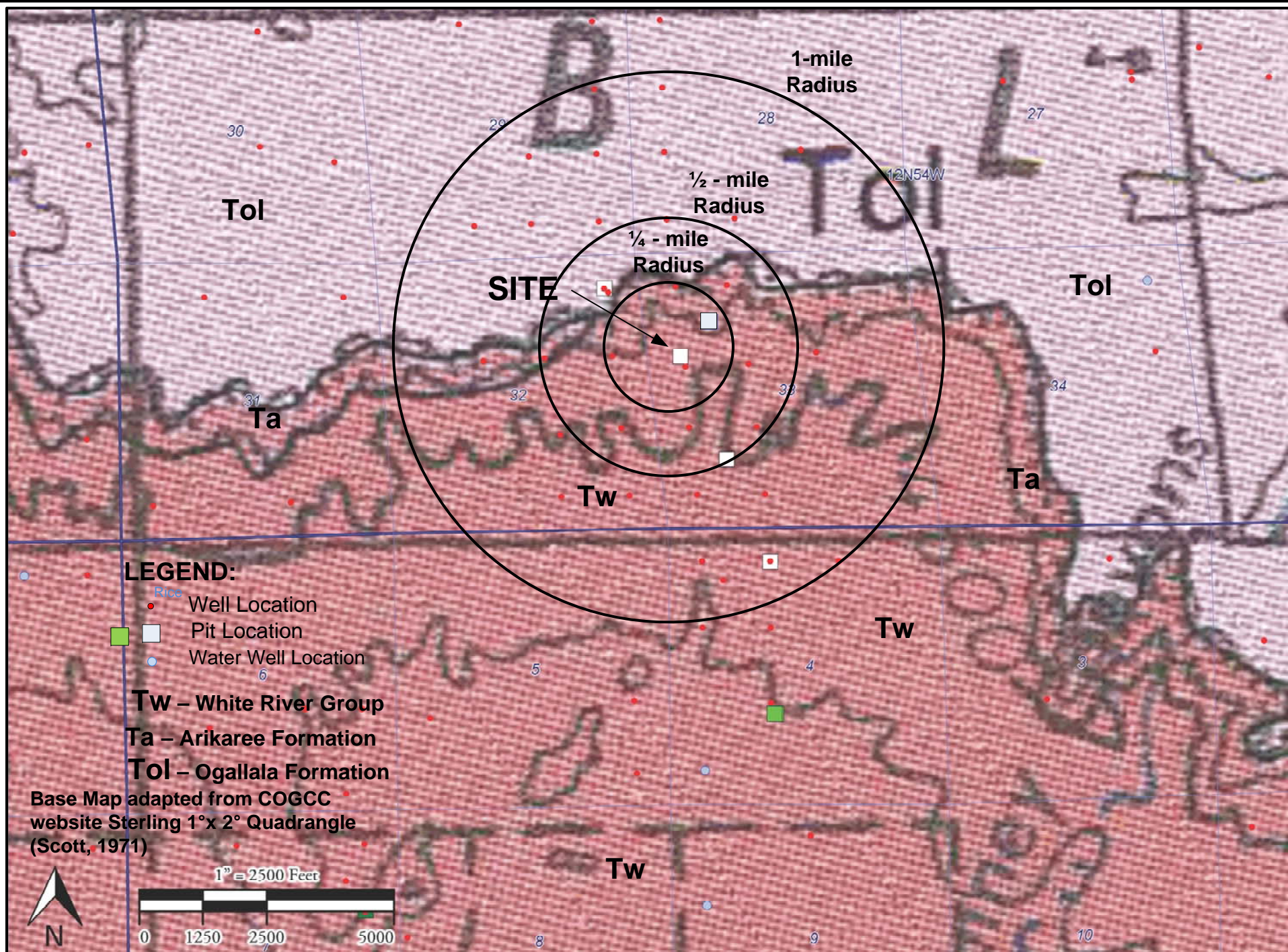
Monitoring Well and Boring Locations
CM Production, LLC
Cliff Unit, Rice Lease, Logan County, Colorado

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FIGURE

2



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DATE: 01/15/15

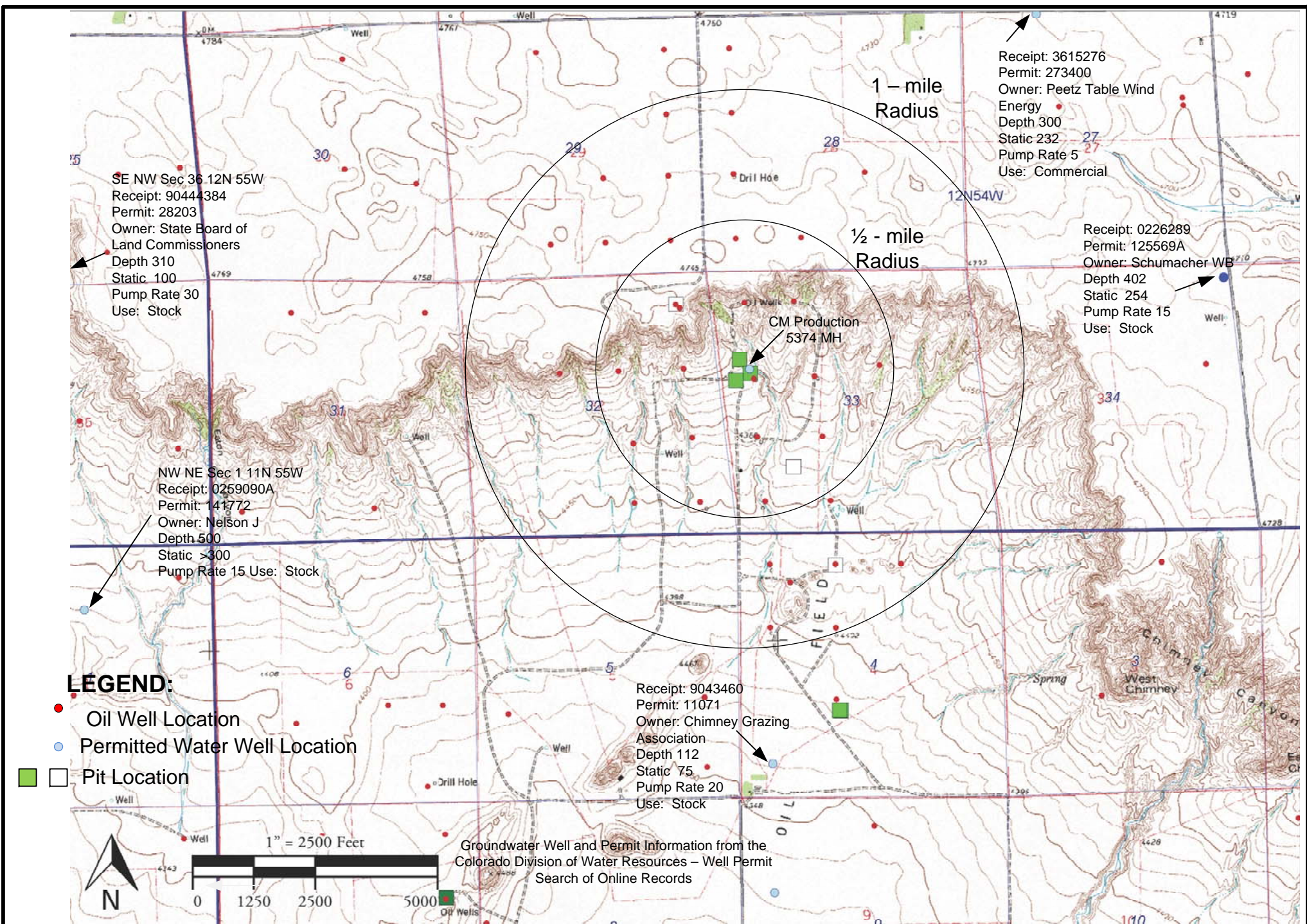
Cliff Field - Rice Lease Geologic Map
CM Production, LLC
Cliff Field, Rice Lease, Logan County, Colorado

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FIGURE

3



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DATE: 01/15/2015

Cliff Field - Rice Lease Permitted Water Well Map
 CM Production, LLC
 Cliff Field, Rice Lease, Logan County, Colorado

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FIGURE

4

TABLE

TABLE 1
MONITORING WELL AND PIEZOMETER MEASUREMENTS
CM Production, LLC
Rice Lease/Cliff Unit
Site Specific Subsurface Investigation

Station ID	Date	DTP (ft)	DTW (ft)	TD (ft)	Comments
MW-1	01/02/15	ND	ND	43.40	Confirmed well was dry using a disposable bailer – false positive of 40.26 with an oil/water interface probe was due to mud in the bottom of the well.
MW-2	01/02/15	ND	ND	41.39	Well was dry – interface probe did not detect water & probe was dry
MW-3	01/02/15	ND	ND	43.20	Well was dry – interface probe did not detect water & probe was dry
PZ-1	01/02/15	ND	ND	10.01	Piezometer was dry – interface probe did not detect water & probe was dry.
PZ-1	12/15/14	ND	ND	10.00	Piezometer was dry – interface probe did not detect water & probe was dry.
PZ-1	07/23/14	ND	ND	10.00	Piezometer was dry – interface probe did not detect water & probe was dry. Confirmed with a bailer.

DTP – Depth to Product

DTW – Depth to Water

TD – Total Depth

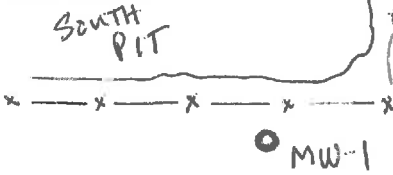
All measurements are in feet below surface grade (bsg)

ND – Not Detected

APPENDIX A

SOIL LITHOLOGIC LOGS

LOCATION MAP



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TEST HOLE/ WELL LOG

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Test/Well Number: MW-1 Project: Rice Lease / CM Prod.
Date: 12/15/14 Project Number: 514-0704
Logged By: JWH Drilled By: Site Services Jason
Drilling Method: Geoprobe A Sampling Method: Flyslave

Elevation: Detector: mini Ray Grout: Quikrete Geotech
Gravel Pack: 10-20 Silica Sand Hole Dia.: 2" F. L. Meter: 0/0 Probe
Casing Type: Schedule 40 PVC Diameter: 2" Length: 28 ft DTP: ND DTW: ND
Screen Type: Sch 40 Slot: 0.010" Diameter: 2" Length: 15 ft Well Depth: 40.95 Total Depth: 43.5

Soil/Rock Type	Color	Moisture Content	% Fines	Structure	Vapor	Staining	Sample #	Depth	Sample Recovery	Penetration Resistance	LITHOLOGY/REMARKS	WELL COMPLETION
CL	DRY 5/4	SL MOIST	45% 51	MASS	NO	NO		0			0.0 to 5.0 Clay-silty clay (CL) Moderate reddish brown (10R5/4) Dry to slightly moist, massive. No staining, No odor Dusky, yellow brown to 5/4	
								1				
								2	50%			
								3				
								4				
								5			5.0 to 10.0 clay/silty mod. red brown, clay very moist wet @ 7 ft	
								6				
								7	70%			
								8				
								9				
								10			10.0 to 14.0 orange gray wet upper 1 ft (8/4)	
								11			pale orn. Dry/slightly moist Fining with black olive gray - dry	
								12	100			
								13				
								14			14.0 - 16.0 Silt-silty sand mod. yellow brown (10YR5/4) massive	
								15				
								16			16.0 to 18.0 poorly sorted sand & fine gravel	
								17	80%			
								18				
								19				
								20				

LOCATION MAP

See
1st. Page
 4690 Table Mountain Drive #200
 Golden, CO 80403
 T. 303.237.2072 F. 303.237.2659

TEST HOLE/ WELL LOG

Page of

Test/Well Number: MW-1

Project: CM Production Rice

Date: 12/15/14

Project Number: 014-0704

Logged By: JWH

Drilled By: Site Services Jason

Drilling Method: Geoprobe 7730VT

Sampling Method: Fly sleeve

Elevation:

Detector: MiniRae

Seal: Bentonite Chips/Crumbles

Grout: Quikrete

Geotech.

Gravel Pack: 10-20 Silica Sand

Hole Dia.: 3"

F. L. Meter: W Probe

Casing Type: Schedule 40 PVC

Diameter: 2"

Length: 28.5'

DTP: ND

DTW: ND

Screen Type: Sch 40 PVC Slot: 0.010-36"

Diameter: 2"

Length: 15

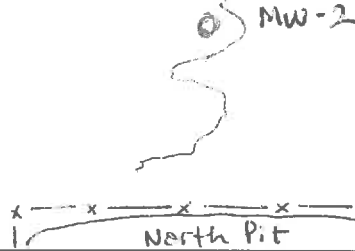
Well Depth: 43.4

Total Depth: 43.5

Soil/Rock Type	Color	Moisture Content	% Fines	Structure	Vapor	Staining	Sample #	Depth	Sample Recovery	Penetration Resistance	LITHOLOGY/REMARKS	WELL COMPLETION
							21				Soil Boring auger drilled using 3" diameter Solid Stem auger	
							22					
							23					
							24				No Samples Collected	
							25				Silty Clay / Sand	
							26				v. fine-grained sand	
							27				Approximately 16 feet of water in soil boring on 12/15/14	
							28					
							29					
							30					
							31					
							32					
							33					
							34					
							35					
							36					
							37					
							38					
							39					
							40					
							41					

TD = 43.4'

LOCATION MAP


MOLSSON
ASSOCIATES

 4690 Table Mountain Drive #200
Golden, CO 80403
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TEST HOLE/ WELL LOG

Page 1 of 2

Test/Well Number: MW-2

Project: CM Production-Rice Lease

Date: 12/16/2014

Project Number: 014-0704

Logged By: James Hix

Drilled By: Site Services Jackson

Drilling Method: Geoprobe 7730

Sampling Method: Poly Sleeve/MC

Elevation:

Detector: Mini Rae

Seal: Bentonite 12 ft

Grout: Quikrete

Gravel Pack: 10-20 silica sand

Top @ 28 ft

Hole Dia.: 3"

F. L. Meter Profile

Casing Type: Schedule 40 PVC

Diameter: 2"

Length: 30 ±

DTP: N/A

DTW: ND

Screen Type: Sch 40 PVC Slot: 0.010

Diameter: 2"

Length: 10 ft

Well Depth: 37

Total Depth: 40

Soil/Rock Type	Color	Moisture Content	% Fines	Structure	Vapor	Staining	Sample #	Depth	Sample Recovery	Penetration Resistance	LITHOLOGY/REMARKS	WELL COMPLETION
CL	10YR 7/4	Moist	50%	MASS		NO		0			0.0 Claystone subcrop	
ML	10YR 7/4	DRY	45%	MASS		NO		1	100%	1 ft	0.0 to 3.0 ft silty clay/silt - Hyperaccumulated in sleeve	
	10YR 5/4	DRY	40%	MASS		NO		2	100%	1 ft	Grayish orange → mod. yellow (10YR 7/4) Dry/sil. moist (10YR 5/4)	
	10YR 5/4	DRY	40%	MASS		NO		3	100%	1 ft	Hard - refusal @ 3 ft	
	10YR 5/4	DRY	40%	MASS		NO		4	100%	1 ft	Subangular blocky pebbles at base	
	10YR 5/4	DRY	40%	MASS		NO		5	100%	1 ft	2 ft clayey silt - weathered	
	10YR 5/4	DRY	40%	MASS		NO		6	100%	1 ft	Silt stone, PID 0.0 ppm	
	10YR 5/4	DRY	40%	MASS		NO		7	100%	1 ft	- Augered down to 8 ft 3" diameter solid stem, PID = 0.0 ppm	
CL	10YR 5/4	DRY	40%	MASS		NO		8	100%	1 ft	8.0 to 10.0 clay/clayey silt	
	10YR 5/4	DRY	40%	MASS		NO		9	100%	1 ft	Moderate yellow (10YR 5/4), massive	
	10YR 5/4	DRY	40%	MASS		NO		10	100%	1 ft	Slightly moist PID 0.0 ppm	
SC	10YR 5/4	WET	40%	MASS		NO		11	100%	1 ft	10.0 to 12.0 clay, silty clay	
	10YR 5/4	WET	40%	MASS		NO		12	100%	1 ft	Sand lens at 11.0 ft ~ 6" thick	
	10YR 5/4	WET	40%	MASS		NO		13	100%	1 ft	clayey sand, mod. yellow (10YR 5/4)	
	10YR 5/4	WET	40%	MASS		NO		14	100%	1 ft	PID 0.0 ppm @ 12 ft	
	10YR 5/4	WET	40%	MASS		NO		15	100%	1 ft	Solid stem - Refusal	
	10YR 5/4	WET	40%	MASS		NO		16	100%	1 ft	Auger drill down to total depth of 40 ft	
	10YR 5/4	WET	40%	MASS		NO		17	100%	1 ft	Cuttings	
	10YR 5/4	WET	40%	MASS		NO		18	100%	1 ft	Silty clay	
	10YR 5/4	WET	40%	MASS		NO		19	100%	1 ft		
	10YR 5/4	WET	40%	MASS		NO		20	100%	1 ft		

 3" DIA
BORING

LOCATION MAP

See Page 1



4690 Table Mountain Drive #200
Golden, CO 80403
T. 303.237.2072 F. 303.237.2659

TEST HOLE/ WELL LOG

Page 2 of 2

Test/Well Number: MW-2

Project: CM Production/Rice Lease

Date: 12/16/14

Project Number: 014-0704

Logged By: James Hix

Drilled By: Site Services

Drilling Method: Geoprobe 1730D

Sampling Method: Polysew/ML

Elevation:

Detector: MiniPac

Seal: Bentonite

Grout: Quikrete

Gravel Pack: 10-20 Silica Sand

Top @ 28 ft

Hole Dia: 3" B"

F. L. Meter 0/w probe

Casing Type: Schedule 40 PVC

Diameter: 2"

Length: 30 ft

DTP: ND

DTW: ND

Screen Type: Schedule 40 Slot: 0.010 slot

Diameter: 2"

Length: 10 ft

Well Depth: 37.3

Total Depth: 43

Soil/Rock Type	Color	Moisture Content	% Fines	Structure	Vapor	Staining	Sample #	Depth	Sample Recovery	Penetration Resistance	LITHOLOGY/REMARKS	WELL COMPLETION
							21				Three-inch diameter augers - cutting 2. Silty clay mod yel brn - gray brown - No Samples Collected	37
							22					
							23					
							24					
							25					
							26					
							27					
							28					
							29					
							30					
							31				Bentonite chips Bentonite Grumblers SEAL TOP 28' 10-20 Silica Sand	34 DIA BORING
							32					
							33					
							34					
							35					
							36					
							37					
							38					
							39					
							40					
							41				BOTTOM 40ft	

LOCATION MAP		MOLSSON ASSOCIATES		4690 Table Mountain Drive #200 Golden, CO 80403 T. 303.237.2072 F. 303.237.2659								
TEST HOLE/ WELL LOG				Page 1 of 1								
Test/Well Number: MW-3		Project: CM Production/Rice Lease										
Date: 12/16/14		Project Number: 014-0704										
Logged By: James Hix		Drilled By: Site Services										
Drilling Method: Geoprobe TT30D		Sampling Method: MC/Poly Sleeve										
Seal: Bentonite Grumbles/Chips		Grout: Quikrete		Geotech								
Elevation:		Detector: MiniRac		Hole Dia.: 3"								
Gravel Pack: 10-20 Silica Sand		Diameter: 2"		Length: 33ft								
Casing Type: Schedule 40 PVC		DTP: ND		DTW: ND								
Screen Type: Schedule 40 Slot: 0.010		Diameter: 2"		Length: 10ft								
		Well Depth: 40ft		Total Depth: 43ft								
Soil/Rock Type	Color	Moisture Content	% Fines	Structure	Vapor	Staining	Sample #	Depth	Sample Recovery	Penetration Resistance	LITHOLOGY/REMARKS	WELL COMPLETION
								0			0.0 to 5.0	
								1			compacted interval down to 21 ft. kept going to 10	
						NO		2	100%	N/A		
								3				
								4				
ML	10YR 7/4	Dry	60% 35CI 5S	MSS	0.0	NO		5			0.0 to 10.0 ft clayey silt/silt	
								6			Pale grayish orange to grayish orange (10YR 7/4 - 10YR 8/6) v.f. dry, 60% silt - 35% clay, 5% sand	
								7	65%		massive, no straining	
								8	stain	N/A	PID 0.0 ppm	
								9				
								10			10.0 to 15.0 ft clayey silt (ML)	
								11			compacted very pale orange (10YR 8/2) to grayish orange (10YR 7/4)	
ML	10YR 8/2	Dry	60% 35CI 5S	MSS	0.0	NO		12	65%		dry, massive, 60% silt, 35% clay	
								13	full	N/A	weak platy parting. no odor. No staining	
								14			PID = 0.0 ppm	
								15			15.0 to 20.0 ft clayey silt	
								16			compacted, very pale orange (ML) to grayish brown (10YR 8/2 - 7/4)	
ML	10YR 8/2	Dry		WK PTH	0.0	NO		17	55%	N/A	dry, weak platy parting - platy shale fragments	
								18	stain		No odor. No staining	
								19			fragile	
								20			PID 0.0 ppm	
								21			20.0 to 25.0 fissile clayey silty	
								22			shale fragments/shale	

LOCATION MAP



4690 Table Mountain Drive #200
Golden, CO 80403
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See Page 1

TEST HOLE/ WELL LOG

Page 2 of 2

Test/Well Number: MW-3

Project: CM Production/Rice Lse

Date: 12/16/14

Project Number: 014-0704

Logged By: James Hix

Drilled By: Site Services

Drilling Method: 600 PSI TBODI

Sampling Method: MC Poly sleeve

Elevation:

Detector: Mnifae

Seal: Bentonite Crumbles 2'/chips

Grout: Sakrete

Gravel Pack: 10-20 Silica Sand

Hole Dia.: 3"

F. L. Meter: w/Probe

Casing Type: Schedule 40 PVC

Diameter: 2"

Length: 33 ft

DTP: ND

DTW: ND

Screen Type: Schedule 40 Slot: 0.010" slot

Diameter: 2"

Length: 10 ft

Well Depth: 40 ft

Total Depth: 43 ft

Soil/Rock Type	Color	Moisture Content	% Fines	Structure	Vapor	Staining	Sample #	Depth	Sample Recovery	Penetration Resistance	LITHOLOGY/REMARKS	WELL COMPLETION
AL TX	10YR 8/2	DRY	60% 35%	Wk Platy	0.0	NO	81				20.0 to 25.0 Clayey Silty Shale Siltstone, very pale orange (10YR 8/2) Dry, 60% silt, 35% clay weak platy parting, NO staining friable PID 0.0 ppm	
							82		65% N/A			
							23		70% Full			
							24					
SM RX	10YR 7/4	DRY	70% 30%	MASS	0.0	NO	25				25.0 to 30.0 ft clayey silt v. fine sand, grayish brown (10YR 7/4) Dry, 70% sand 30% silt No staining or odor friable - sand, silty sand Dry PID 0.0 ppm	
							26					
							27					
							28		70% N/A			
							29		Full			
							30					
SM	5YR 4/4 10YR 7/4	DRY	70% 30%	MASS	0.0	NO	31				30.0 to 33.0 sand - coarse grained, dry, 70% sand 30% silt massive, NO staining PID 0.0 ppm Refusal @ 33 ft	
							32		100% %			
							33				Auger - Solid Stem 3" dia. drill down to 43 ft Sand/clay sand cuttings Collapsed back to 40 ft	
							34					
							35					
							36					
							37					
							38					
							39					
							40				TD = 40.0 ft	
							41				BOB = 43.0 ft / collapsed	

LOCATION MAP

NORTH LATERAL
DRAINAGESB-1
0

LATERAL DRAINAGE

NORTH PIT

MOLSSON
ASSOCIATES4690 Table Mountain Drive #200
Golden, CO 80403
T. 303.237.2072 F. 303.237.2659

TEST HOLE/ WELL LOG

Page 1 of 1

Test/Well Number: SB-1

Project: CM - Rice Lease

Date: 12/16/14

Project Number: 014-0704

Logged By: James Hix

Drilled By: Site Services Jason

Drilling Method: Circ Drill 7730

Sampling Method: Polyacetates below

Elevation:

Detector:

Seal: Bentonite/Cuttings

Grout: N/A

Gravel Pack: N/A

Hole Dia.: 2"

F. L. Meter:

Casing Type: N/A

Diameter:

Length:

DTP:

DTW:

Screen Type: N/A

Slot:

Diameter:

Length:

Well Depth:

Total Depth: 9 ft

Soil/Rock Type	Color	Moisture Content	% Fines	Structure	Vapor	Staining	Sample #	Depth	Sample Recovery	Penetration Resistance	LITHOLOGY/REMARKS	WELL COMPLETION
CL	5YR 4/4	Slight Moist						0			0.0 to 6.0	NO WELL SET TEST HOLE
								1			Clay / Clayey silt	
								2			Moderate brown (5YR 4/4)	
								3	100%		Slightly moist	
								4			Mod. yellowish brown (10YR 5/4)	
								5			Massive clayey silt	
								6			Shale / rock fragments, very pale orange (10YR 8/2)	
								7			Grayish orange to medium (5YR 9/4)	
								8			Pink	
								9			6.0 to 9.0 Mod. yel brn (10YR 5/4)	
								10			Bottom 3"	
								11			Mod. yellowish brown (10YR 5/4)	
								12			hard, dry, Massive	
								13			Silty clay to bottom,	
								14			Refusal @ 9 ft	
								15				
								16				
								17				
								18				
								20				
								21				

APPENDIX B

WELL COMPLETION LOGS

MONITORING WELL COMPLETION DIAGRAM

Project: CM Production, LLC – Rice Lease Sensitive Area Subsurface Investigation

Monitoring Well No. MW-1

Location: MW-1 – Southeast of the south produced water pit

Borehole No. _____

Contractor: N/A

Date: 12/15/2014

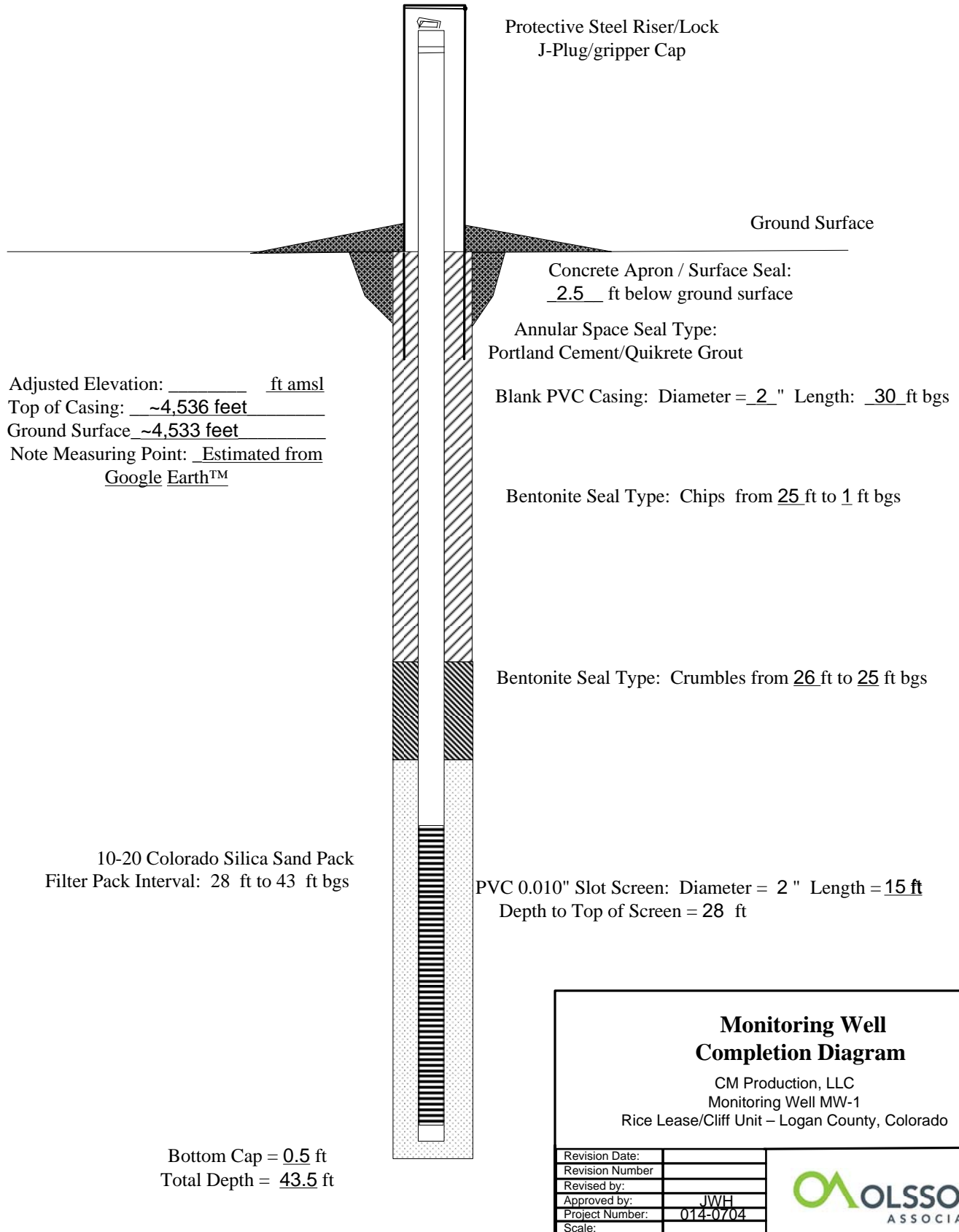
Driller: Site Services – Golden, Colorado

Observed By: James W. Hix

Method: Geoprobe 7730 DT – Geoprobe/3-inch diameter solid stem augers

Checked By: _____

Sheet 1 of 1



MONITORING WELL COMPLETION DIAGRAM

Project: CM Production, LLC – Rice Lease Sensitive Area Subsurface Investigation

Monitoring Well No. MW-2

Location: MW-2 – North of the north produced water pit (upgradient)

Borehole No. _____

Contractor: N/A

Date: 12/16/2014

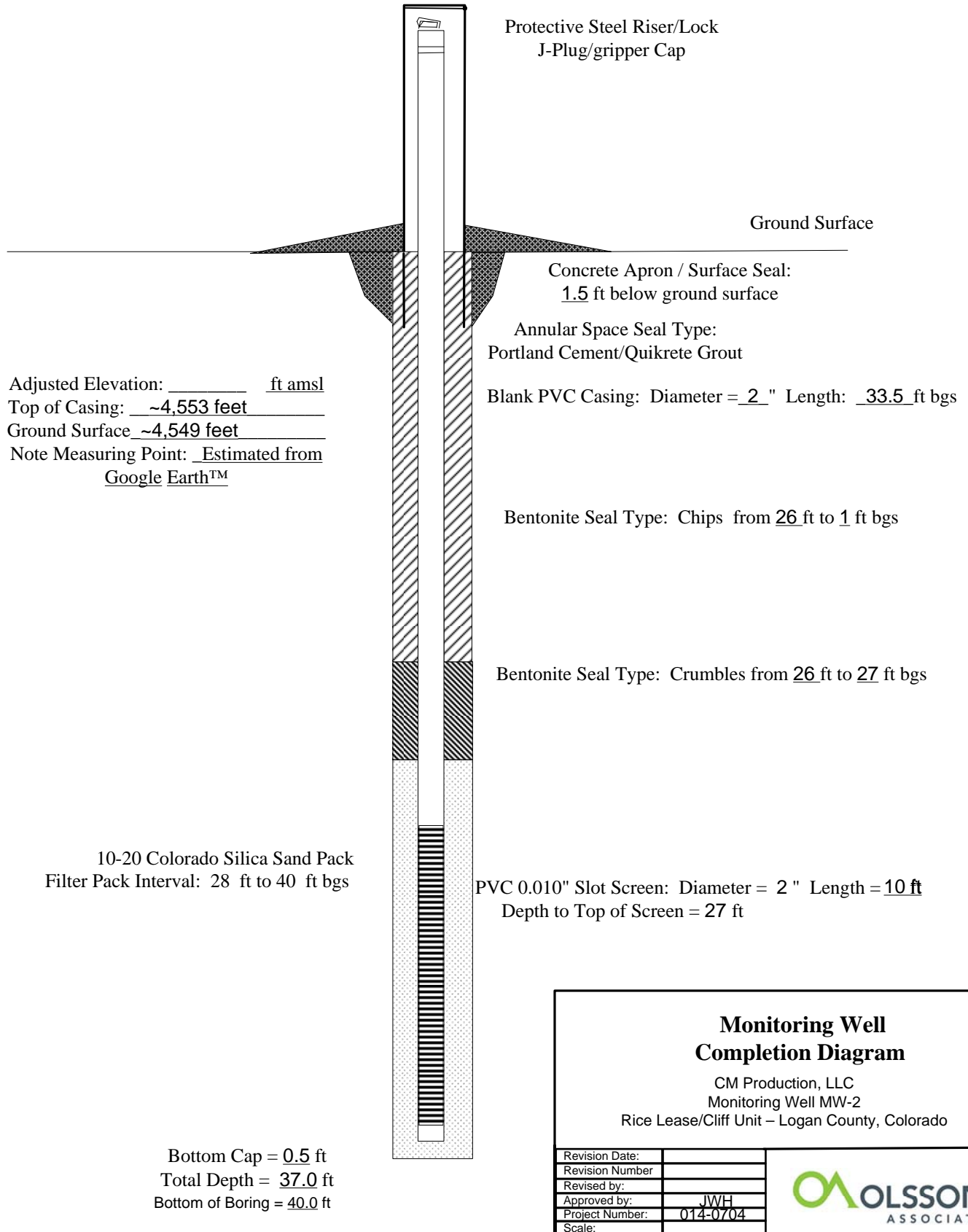
Driller: Site Services – Golden, Colorado

Observed By: James W. Hix

Method: Geoprobe 7730 DT – Geoprobe/3-inch diameter solid stem augers

Checked By: _____

Sheet 1 of 1



MONITORING WELL COMPLETION DIAGRAM

Project: CM Production, LLC – Rice Lease Sensitive Area Subsurface Investigation

Monitoring Well No. MW-3

Location: MW-3 – South of southeast produced water pit (downgradient)

Borehole No. _____

Contractor: N/A

Date: 12/16/2014

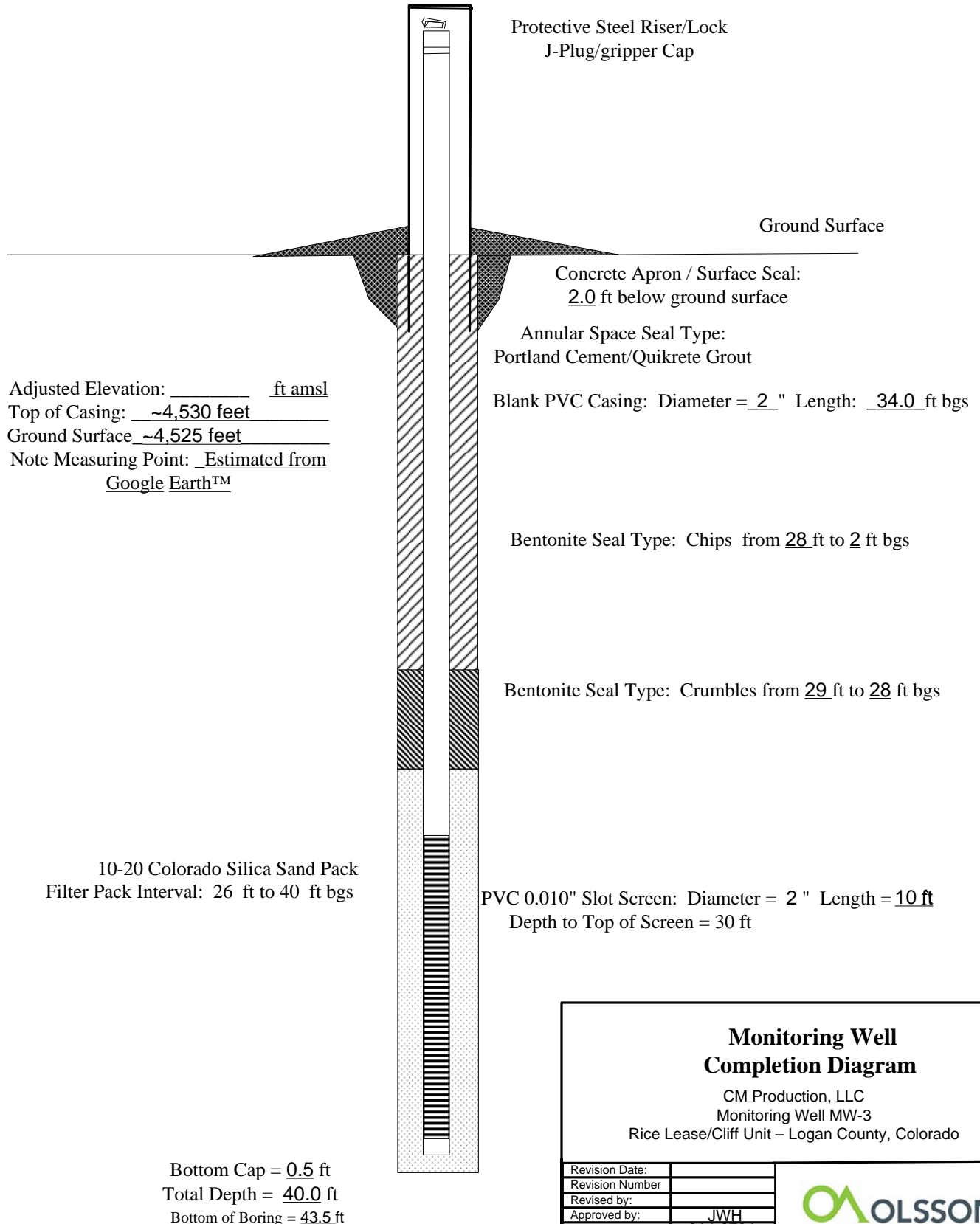
Driller: Site Services – Golden, Colorado

Observed By: James W. Hix

Method: Geoprobe 7730 DT – Geoprobe/3-inch diameter solid stem augers

Checked By: _____

Sheet 1 of 1



APPENDIX C

SITE PHOTOGRAPHS



Subject: Site Services setting up to begin drilling the MW-1 location on the southeast corner of the south pit.

Date: 12/15/2014

View: Northeast



Subject: Site Services used a 7730 DT track-mounted Geoprobe® to collect soil samples in Macro-core® barrels containing polyacetate soil sample sleeves.

Date: 12/15/2014

View: Northeast



Subject: Photograph shows the location of the test hole for monitoring well, MW-1, located on the southeast corner of the south produced water pit. The berm for the south pit is shown on the right.

Date: 12/15/2014

View: West



Subject: Site Services used 3-inch diameter solid stem augers to advance the test holes for the monitoring wells once probe refusal occurred. Photograph shows the test hole drilling for monitoring well MW-1 on the southeast side of the south produced water pit.

Date: 12/15/2014

View: East



Subject: Photograph shows the location of monitoring well MW-2 and the Chalk Bluffs of the Chimney Canyons.

Date: 12/16/2014

View: North



Subject: Site Services sets up to probe/drill the test hole for MW-2 using a rubber track mounted 7730 DT Geoprobe® rig.

Date: 12/16/2014

View: Northeast



Subject: Site Services direct-push boring for collection of soil samples at the MW-2 location (up gradient) of the site.

Date: 12/16/2014

View: Northwest



Subject: Photograph shows the silty clay lithologies encountered in the test hole that was completed as monitoring well, MW-2. Refusal was encountered at 3 feet bsg, and then again at 12 feet bsg, after augering down using the 3-inch diameter auger. Subcrop consisting of siltstone was observed at the surface.

Date: 12/16/2014

View: N/A



Subject: Site Services used 3-inch diameter augers to advance the test hole for MW-2 to 40 feet bsg.

Date: 12/16/2014

View: West



Subject: Site Services set up to advance the direct-push soil test hole for monitoring well, MW-3, on the north side of the Rice #2 well pad.

Date: 12/16/2014

View: Northwest



Subject: Photograph shows the location of the test hole for down gradient monitoring well, MW-3, on the north side of the Rice #2 well pad.

Date: 12/16/2014

View: East



Subject: Site Services setting monitoring well MW-3 after augering down to 43 feet. The test hole collapsed back to 40 feet, which was where the well was set. A sand pack of 10-20 silica sand was placed around the screened interval in the well.

Date: 12/16/2014

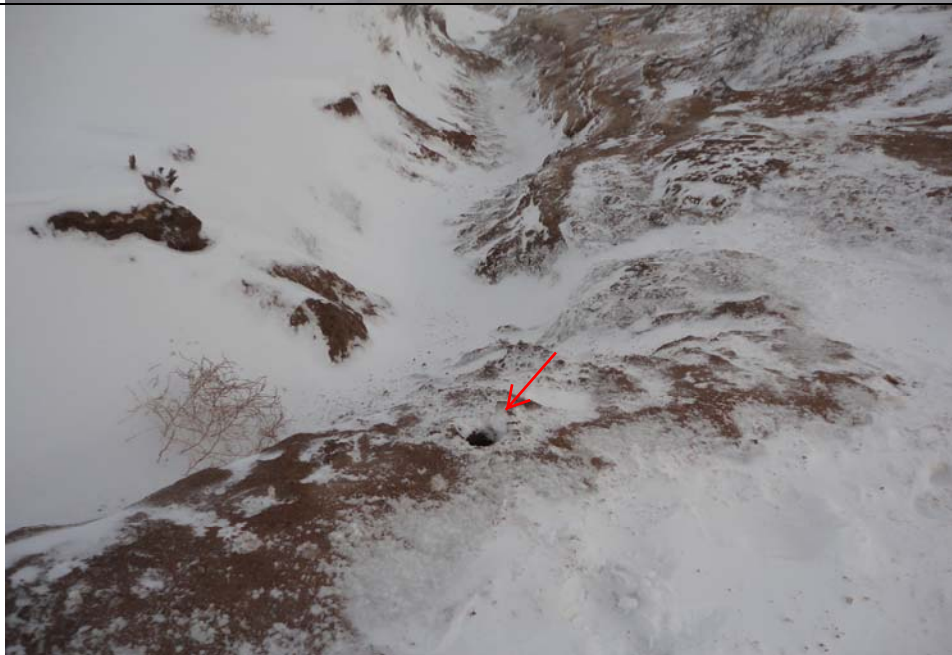
View: Northwest



Subject: Photograph shows the location of piezometer, PZ-1, and the main drainage down from the southeast pit.

Date: 12/15/2014

View: North



Subject: Photograph shows the location of hand auger boring, HA-2, (lower center) at the head of the east-west lateral drainage. Auger refusal was encountered at approximately 4.5 feet. The first hand auger boring, HA-1, was attempted on the lower bench near the center of the photograph, but encountered refusal at approximately 1 foot bsg.

Date: 12/15/2014

View: East



Subject: Photograph shows the location of the up gradient hand auger boring, HA-3, (bottom center) on the west side of the main channel north of the east-west lateral drainages and the north pit.

Date: 12/15/2014

View: South



Subject: Photograph shows the east-west lateral channel down from the northeast corner of the north pit. The location of the hand auger boring, HA-2, was located near the center of the photograph where the smaller drainages come together to form the channel for the lateral drainage.

Date: 12/16/2014

View: Southeast



Subject: Photograph shows the location of the Geoprobe® boring SB-1 to the north – northeast of the north pit.

Date: 12/16/2014

View: Northeast



Subject: Photograph shows the steel riser completion for monitoring well, MW-2.

Date: 12/16/2014

View: East