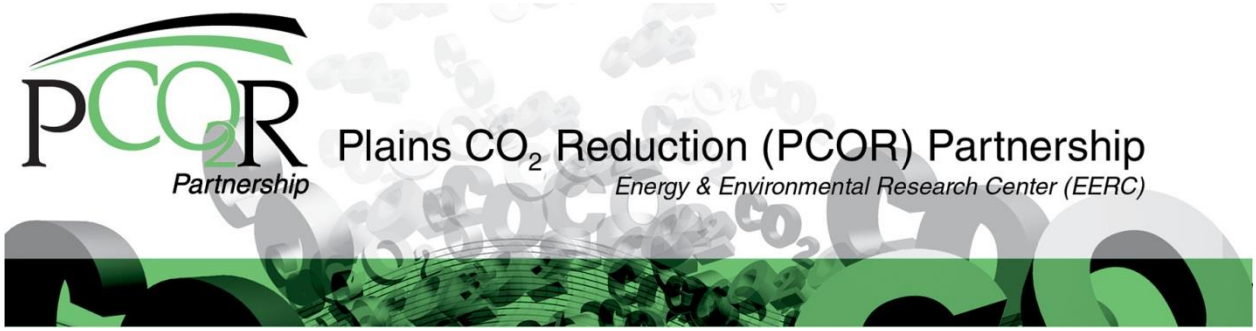

BELL CREEK TEST SITE – DRILLING AND COMPLETION ACTIVITIES REPORT

Plains CO_2 Reduction (PCOR) Partnership Phase III
Task 5 – Deliverable D44

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EXECUTIVE SUMMARY

The Plains CO_2 Reduction (PCOR) Partnership, led by the Energy & Environmental Research Center (EERC), is working with Denbury Onshore LLC (Denbury) to study carbon dioxide (CO_2) storage associated with a commercial enhanced oil recovery (EOR) project. The Denbury-operated Bell Creek oil field is located in southeastern Montana and has been on production since its discovery in the late 1960s. As of May 2013, CO_2 is being injected into the first of nine planned development phases (Phase 1) into the Lower Cretaceous Muddy (Newcastle) Formation. The reservoir is located at an average depth of 4500 ft (1372 meters) and target injection rates of 50 MMscf/day are being achieved as part of Denbury's commercial EOR project. Six new wells were successfully drilled between December 2011 and April 2013 as part of the PCOR Partnership's study to demonstrate CO_2 storage potential in clastic formations in association with CO_2 EOR. The name-intended purpose of each well is as follows: 05-06 OW and 04-03 OW, monitoring; 56-14R and 33-14R, characterization; and MW0504 (Fox Hills) and MW3312 (Fox Hills), shallow groundwater monitoring.

The wells were successfully drilled and completed using proven techniques and materials common to the oil and gas industry. Each newly drilled well has provided key characterization and operational monitoring data as part of the PCOR Partnership Bell Creek study. Advanced wireline log suites acquired during the drilling of the wells have aided in the creation of geologic models to be used in the dynamic simulation of the reservoir. Simulations will ultimately serve as a key tool for fine-tuning injection and reservoir performance, correlating with monitoring data, and estimating CO_2 storage associated with commercial EOR activities. Core samples have been analyzed from the 05-06 OW well, and at the time of this report, analyses are ongoing for the 33-14R and 56-14R wells. Results of analysis from the 05-06 OW core have provided additional porosity, permeability, and mineralogy (including advanced clay typing) data, as well as confirmation of lithofacies within the reservoir. Continuously collected pressure and temperature data have been retrieved from the site and are proving to be a valuable means of monitoring CO_2 injection and confirming its containment within the reservoir. Seismic data have been collected from the 04-03 OW and are in the process of being analyzed and incorporated into geomodeling efforts. Finally, the groundwater-monitoring wells have been samples on multiple occasions and are providing a physical, time-sensitive confirmation that CO_2 is not migrating into the source of drinking water.

The wells have provided an opportunity to conduct operational monitoring activities to 1) demonstrate that associated CO_2 storage can be safely and permanently achieved on a commercial scale in conjunction with an EOR operation, 2) demonstrate that oil-bearing

sandstone formations are viable CO_2 sinks, 3) develop and demonstrate monitoring, verification, and accounting (MVA) methods that can be used to effectively monitor commercial-scale CO_2 injection projects and provide a technical framework for the accounting of injected CO_2, and 4) acquire data, information, and knowledge needed to inform commercial-scale CO_2 storage and EOR projects throughout the region.

BELL CREEK TEST SITE – DRILLING AND COMPLETION ACTIVITIES REPORT

INTRODUCTION

The Plains CO_2 Reduction (PCOR) Partnership, led by the Energy & Environmental Research Center (EERC), is working with Denbury Onshore, LLC (Denbury), to study carbon dioxide (CO_2) storage associated with a commercial-scale enhanced oil recovery (EOR) project injecting into a clastic reservoir. Field-based activities are taking place in the Bell Creek oil field, located in southeastern Montana (Figure 1). The field is currently operated by Denbury, which is carrying out all of the day-to-day operations, including drilling, completion, field maintenance, CO_2 injection, and oil production activities as part of a commercial EOR project. The PCOR Partnership is conducting a variety of field, laboratory, and geologic modeling and simulation studies to demonstrate safe, effective, commercial-scale CO_2 storage associated with EOR and to both evaluate and demonstrate commercially viable monitoring strategies for similar commercial-scale CO_2 storage projects throughout the region.

Significant hydrocarbon accumulations were discovered in the northeastern corner of the Powder River Basin through exploration activities conducted in the late 1960s. During this time, the Bell Creek oil field was discovered. With development of the field, it was determined that the hydrocarbon accumulation resided within the constraints of a Cretaceous age barrier island complex known as the Muddy Formation. Many geologists have likened the structure to the modern day Galveston Island off the coast of Texas. The Muddy Formation is the only oil-producing formation within the vicinity of the Bell Creek oil field. A large majority of wells within the Bell Creek oil field are completed in the Muddy Formation, which is approximately 4500 ft (1372 meters) in depth. Other wells within the field boundaries are either completed as residential or agricultural wells into the shallow groundwater aquifer system or as water supply wells completed in the deeper Madison Formation for waterflood activities.

To accomplish specific monitoring and characterization goals of the PCOR Partnership's Bell Creek study, it was necessary to drill and complete devoted wells for the purpose of characterization and subsurface monitoring. The drilling and completion activities occurred between December 2011 and April 2013. Included were two wells for characterization and deep subsurface monitoring, two wells drilled for oilfield activities that were used to collect key characterization data, and two groundwater-monitoring and characterization wells. Figure 2 shows the location of each well drilled and a brief explanation of its intended purpose. During the drilling process, core was obtained, logs were run, and instrumentation was installed to support the Bell Creek study's objectives. This report provides a brief summary of the project

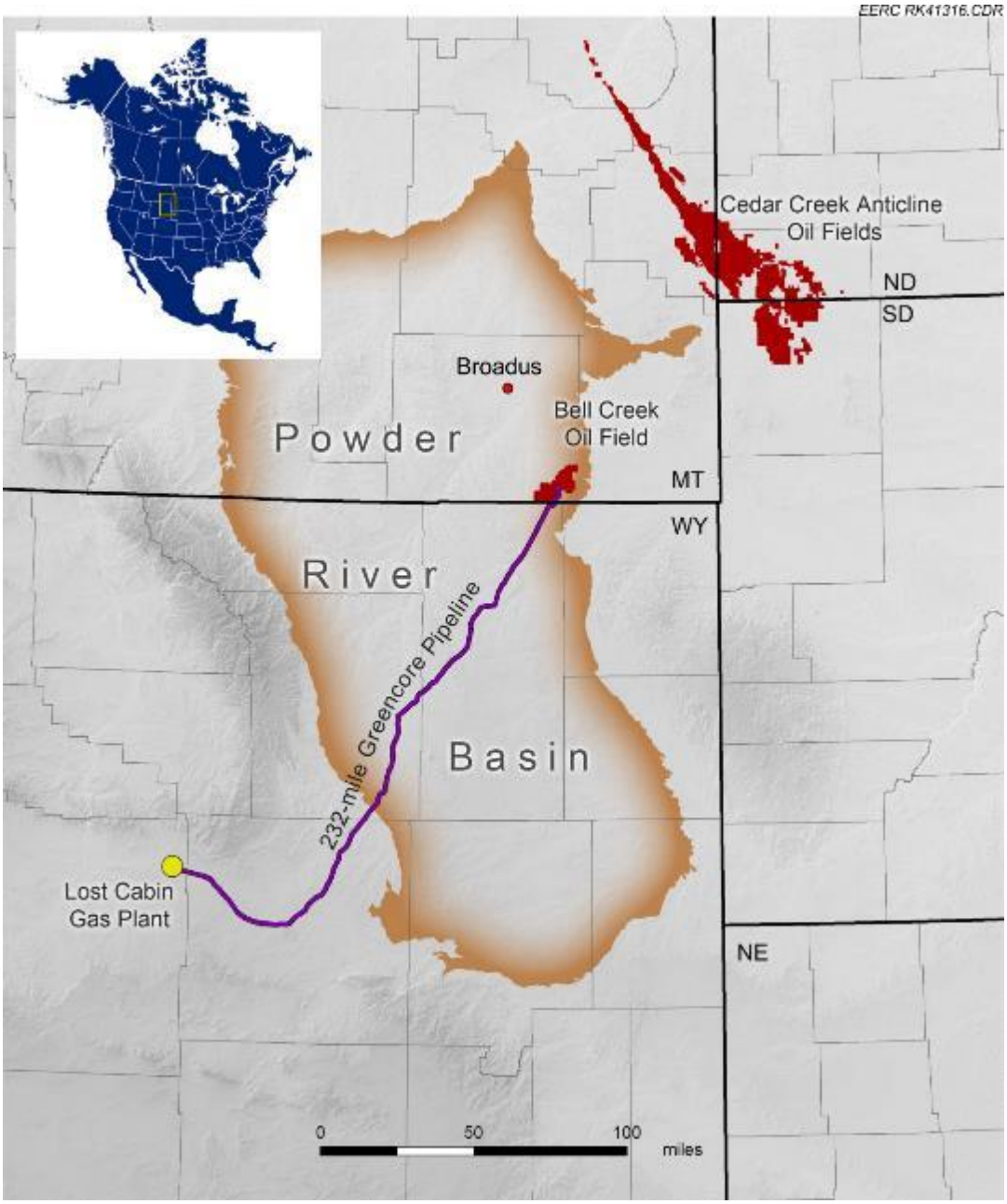

Figure 1. The Bell Creek project is located in the southwest corner of Montana on the northeastern portion of the Powder River Basin.

goals and objectives and describes the drilling and completion activities related to these six new wells. The results of the site characterization; modeling and simulation; risk assessment; and monitoring, verification, and accounting (MVA) activities will be published through separate reports.

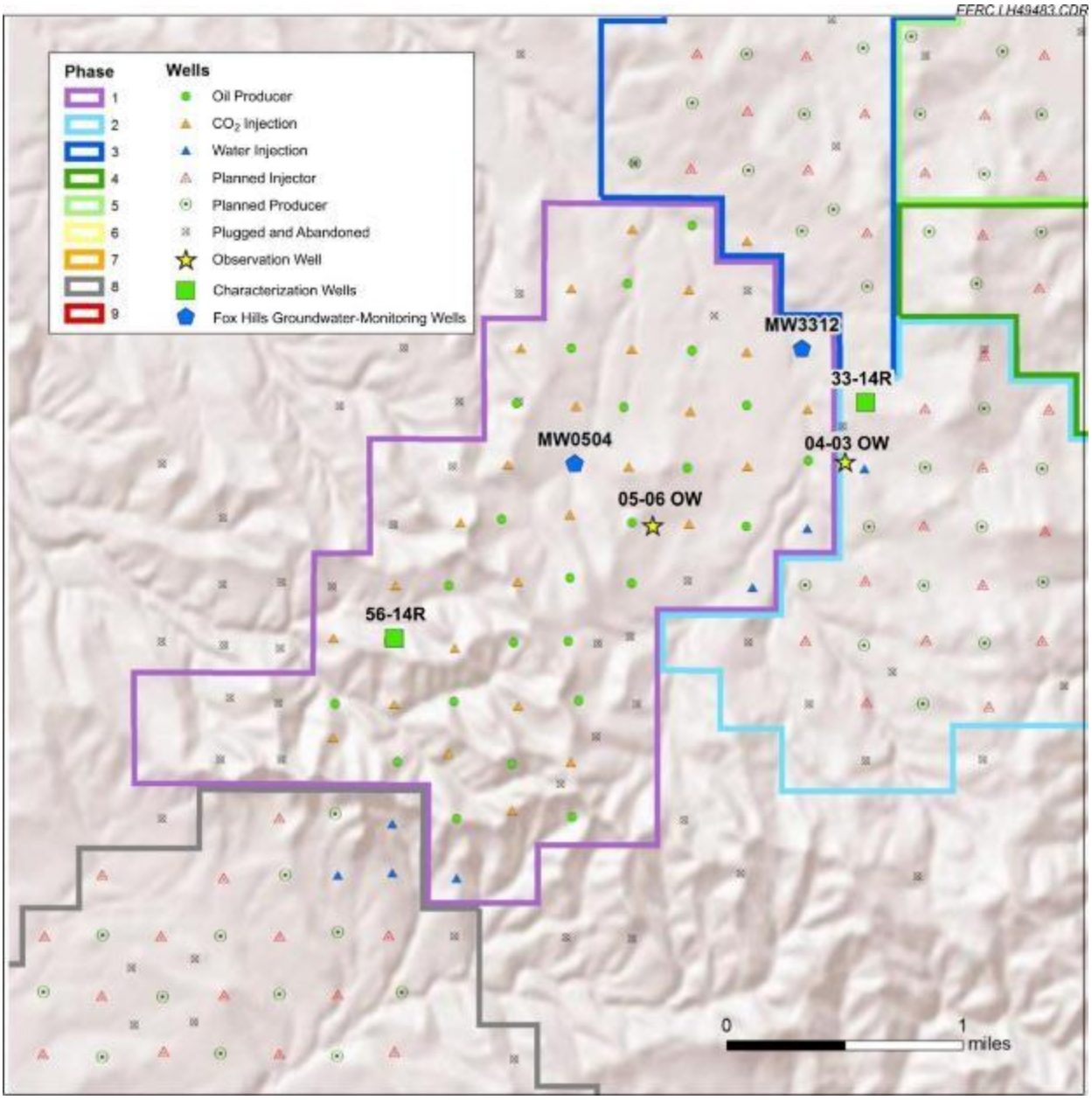

Figure 2. Location of wells drilled within the Bell Creek Field in support of the PCOR Partnership effort.

Geology and Stratigraphy of the Bell Creek Area

Within the Bell Creek oil field, the Muddy Formation is the targeted CO_2 injection zone and is dominated by high-porosity (15%–35%), high-permeability (150–1175-mD) sandstones deposited in a near-shore marine environment. Regionally, the Muddy Formation features an updip facies change from sand to shale that serves as a trap. The barrier bar sand bodies of the Muddy Formation strike southwest to northeast and are overlain by a deltaic siltstone that strikes

perpendicularly to the Muddy Formation and is partially dissected, and somewhat compartmentalized, by intersecting shale-filled incisive erosional channels.

Overlying the Muddy Formation are the shales of the Lower Cretaceous Mowry Formation, which will act as the primary seal, preventing fluid migration to overlying aquifers and to the surface. On top of the Mowry Formation are several thousand feet of low-permeability shale formations, including the Belle Fourche, Greenhorn, Niobrara, and Pierre shales, which will provide redundant layers of protection in the unlikely event that the primary seal fails to prevent upward fluid migrations (Hamling and others, 2013). The Bell Creek chronostratigraphic column is portrayed in Figure 3 indicating the seals and sinks.

Exploration and production activities for mineral and energy resources in the area over the last 55 years have yielded significant amounts of legacy data about the subsurface geology of the area. However, these existing data had a given amount of uncertainty in the geologic reservoir and sealant properties. In addition, these legacy data are often limited in terms of data resolution, accuracy, extent, and diversity when compared to the modern state-of-the-art technologies available today. Furthermore, the legacy data available for the Bell Creek oil field, while significant in quantity, are limited in vertical extent, limited in spatial coverage, lack the diversity required for modern advanced interpretation and modeling techniques, and carry an unquantifiable uncertainty, as analysis and interpretation practices have evolved over the last 50 years. Additionally, the PCOR Partnership study of CO_2 storage associated with commercial EOR activities requires data sets not commonly acquired for primary oil-and-gas operations. This is especially true for overlying and underlying geologic structures which comprise primary and secondary seals as well as potential monitoring zones where very little legacy data exist. In support of the PCOR Partnership study and commercial EOR project, additional wells were drilled to provide critical characterization and monitoring data.

It was necessary to drill and complete multiple characterization and monitoring wells in proximity to the Phase 1 development area in order to acquire data and deploy monitoring technologies to 1) provide key characterization information for overlying and underlying seals, 2) provide key characterization information for overlying monitoring zones to aid in developing the Bell Creek monitoring program, 3) provide modern high-resolution data sets to correlate legacy data sets in order to enhance modeling and simulation workflows, 4) acquire key characterization data to better quantify the heterogeneous nature of the geology, 5) provide a correlation point for modern seismic data sets, and 6) acquire key monitoring data to demonstrate the commercial viability of monitoring techniques and to deploy a site-specific monitoring strategy to evaluate the efficiency and effectiveness of CO_2 storage associated with EOR.

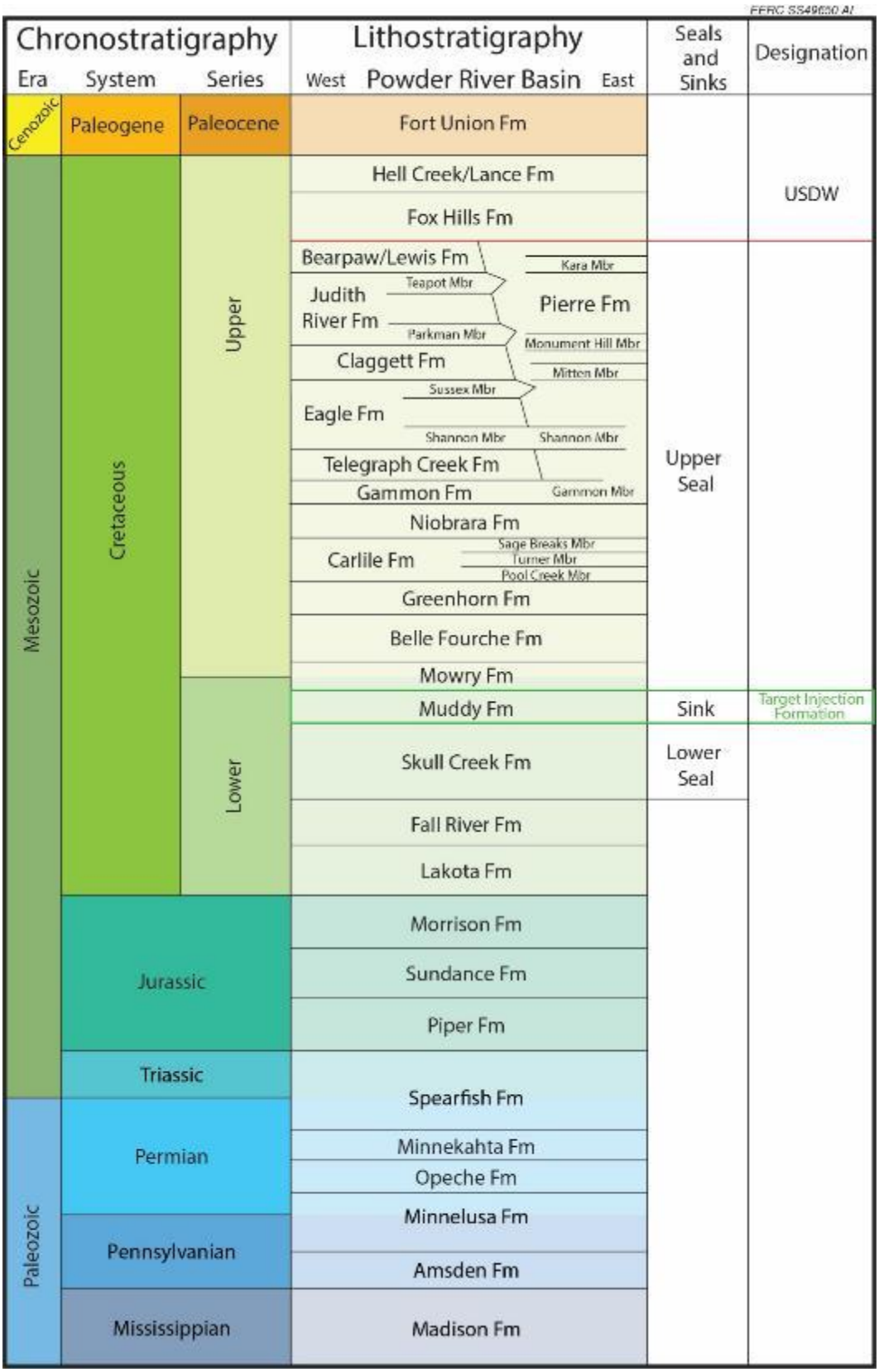

Figure 3. Bell Creek chronostratigraphic column.

DRILLING AND COMPLETION ACTIVITIES

Six wells were drilled and completed, each with well-defined and practical objectives designed to enhance various components of the PCOR Partnership's study. To accomplish programmatic elements such as site-characterization, modeling and simulation, risk assessment, and MVA activities, wells were drilled in new locations or very near existing wells (as redrilled wells). When possible and where there was a need, core was obtained, logs were acquired, and instrumentation was installed for characterization and MVA purposes. A summary of the intended purpose and location of each well was shown in Figure 2 and is summarized in Table 1.

Table 1. Wells and Purpose

Well	Purpose
05-06 OW	Deep subsurface monitoring and characterization
04-03 OW	Installation of geophone array/monitoring
56-14R	Characterization
33-14R	Characterization
MW0504 (Fox Hills)	Characterization and groundwater monitoring in Fox Hills Formation
MW3312 (Fox Hills)	Characterization and groundwater monitoring in Fox Hills Formation

Regulations

The EERC and Denbury were required to adhere to relevant local, state, and federal regulations pertaining to the drilling and completion of the new wells. A permitting action plan was compiled prior to the drilling of the new wells related to PCOR Partnership activities (Botnen and others, 2011). The permitting action plan served as a road map to ensure the appropriate regulatory agencies were informed of activities, and received the appropriate detail required. As required by the U.S. Department of Energy, the EERC completed an Environmental Questionnaire prior to initiating any field work at the Bell Creek Field Demonstration Test. The EERC's activities for this field evaluation were granted a categorical exclusion from preparation of any formal National Environmental Policy Act environmental analysis with respect to activities that are either separately or cumulatively known to have no or only minor environmental effects. For the two groundwater-monitoring wells, a Montana Well Log Report containing well construction and test data was completed and submitted to the Montana Bureau of Mines & Geology in accordance with state requirements.

Other regulations pertained to Denbury as the operator of the wells. The Montana Board of Oil and Gas Conservation (MBOGC) was given primacy by the U.S. Environmental Protection Agency under the Safe Water Drinking Act Underground Injection Control Program to regulate Class II and III injection wells. The general rules and regulations of MBOGC are contained in the Administration Rules of Montana, Title 36 – Department of Natural Resources and Conservation, Chapter 22 – Oil and Gas Conservation (Department of Natural Resources and Conservation Montana Board of Oil and Gas, 2013). The following items were required as part of the drilling process:

- As the field operator, Denbury applied for and was granted an area injection permit that encompasses the entire Bell Creek Field.

- An application to drill was filed with the MBOGC for each new well.

- An MBOGC Environmental Assessment was completed prior to a well permit approval.

- Any additional work or changes to the drilling permit required the filing of a Sundry Notice (Form 2).

- The project must abide by Montana Rule 36.22.1001, which is set up to protect groundwater.

Dedicated Monitoring Wells 05-06 OW and 04-03 OW

Two dedicated monitoring wells were drilled in/near the Phase 1 development area of the Bell Creek Field. Wells 05-06 OW and 04-03 OW were completed in January 2012 and April 2013, respectively. The 05-06 OW well is near the center of the Phase 1 area, and the 04-03 OW well is on the Phase 2 side of the eastern boundary of Phase 1 and is able to monitor portions of both development Phases 1 and 2 (Figure 4). The positioning of the wells allows for the collection of a modern, robust data set to enhance ongoing geologic characterization activities and provides access for a downhole monitoring program that will not interfere with oilfield operations. The 05-06 OW was drilled for the dual purposes of serving as 1) a dedicated deep subsurface monitoring well which was conducive to acquiring monitoring data sets such as real-time in-situ pressure and temperature data during the preinjection and operational monitoring periods, 3-D vertical seismic profiles (VSPs), and pulsed-neutron log (PNL) surveys and 2) a characterization well to obtain key geologic characterization data. The 04-03 OW was drilled for the purpose of seismic characterization and monitoring; however, limited characterization data in the form of basic well logs were acquired to aid in seismic processing and in accordance with state requirements. Baseline 3-D VSPs were collected in both wells (retrievable in 05-06 OW and permanent in 04-03 OW) to aid in the long-term monitoring of CO_2 in the inter-wellbore environment. A brief discussion of activities for these wells follows with a complete summary of drilling and completion activities provided in Appendix A.

05-06 OW Dedicated Monitoring and Characterization Well

Prior to drilling operations of the 05-06 OW monitoring well, legacy data were examined, including offset well logs and core in order to design the coring program. Particularly, geologic core was used to identify and target a 150-ft interval utilizing five 30-ft core barrels. The target zone included the reservoir (Muddy Formation and Rozet), the transition zone between the reservoir and overlying seal (Coastal Plains), and key areas of both the upper and lower seals (Mowry and Skull Creek shale, respectively). Each section of the target interval was ranked based on importance, and contingency plans were developed in the event challenges were encountered during the coring process to allow field personnel the ability to prioritize each interval. Offset well logs were utilized to generate cross sections of formation tops and target

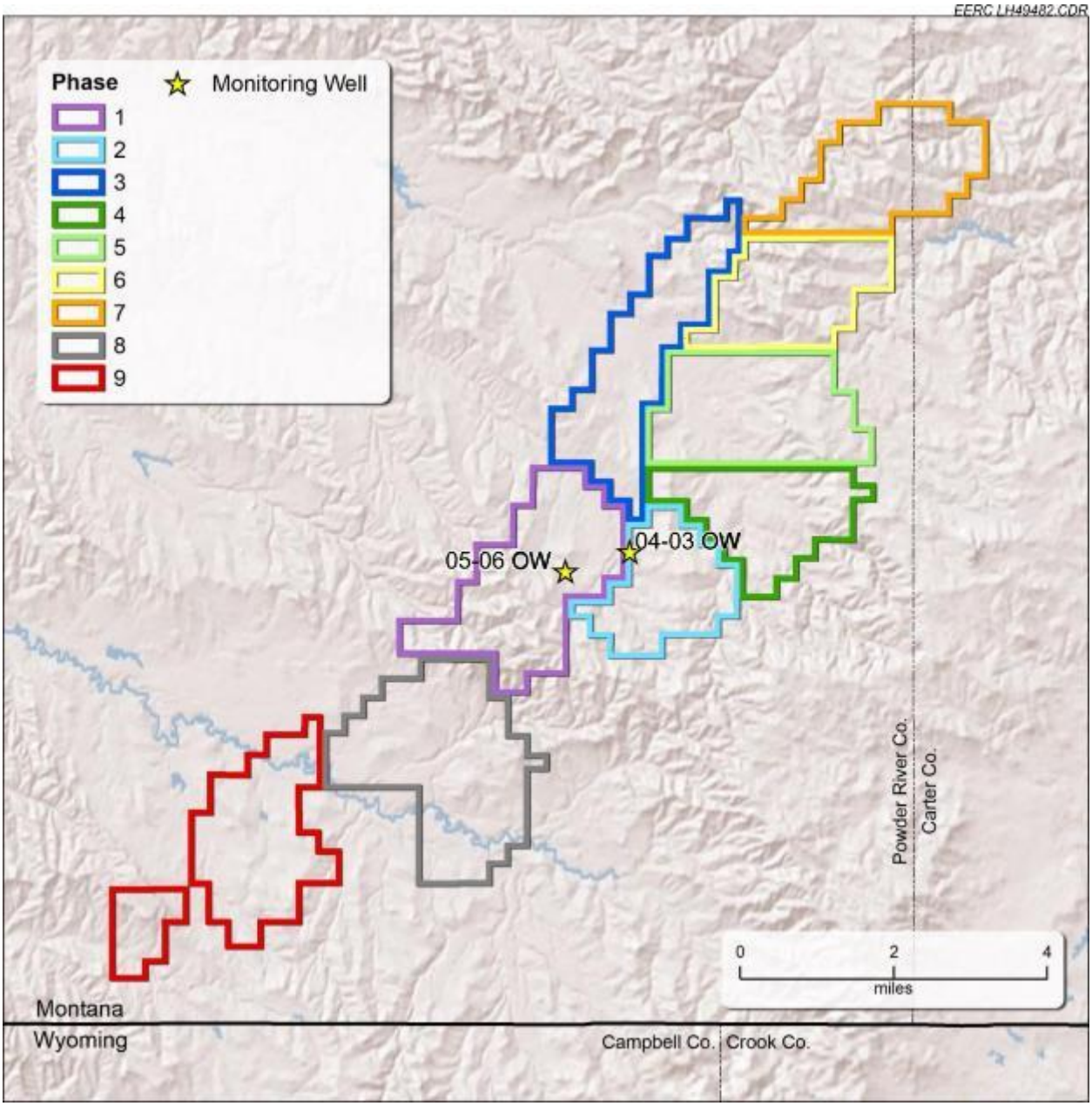

Figure 4. The locations of the 05-06 OW and 04-03 OW monitoring wells within the Bell Creek oil field.

intervals in order to predict the anticipated depth of the core point. The following discussion provides a summary of the 05-06 OW coring process.

After surface casing was set, the borehole was drilled to a depth of 4400 feet on December 21, 2011. An intermediate logging run consisting of resistivity, gamma ray, and spontaneous potential, was conducted to determine the anticipated measured depth of the core point. By correlating the log to cross sections from the offset well logs, a core point of 4446 ft, 60

ft above the anticipated top of the Muddy Formation, was selected. The core point depth was selected to acquire sufficient core within the upper seal (previously not well characterized), and to allow for the transition between the Coastal Plains and the top of the Muddy Formation to occur near the top section of the third core barrel so that the entire Muddy interval would likely be collected within a single core barrel. The selected core point was within 4 ft of the predicted core point based on offset well log correlations. Baker Hughes acquired the 4-inch-diameter drill stem core utilizing an 8¾-inch perforation depth control bit and a full-closure aluminum catcher system to minimize the likelihood of losing unconsolidated sections of core within the Muddy Formation. Core Laboratories was contracted to handle the core as it was brought to the surface. Figure 5 shows the core bit as it was installed in the drilling assembly, and Figure 6 shows the core samples being extracted from the aluminum tubing. Coring started in the Mowry Formation at 4446 ft on December 21, 2011. Gamma ray spectra were collected on the core after it was brought to the surface to estimate recovery and to better correlate the recovered core with well logs.

In total, 110 ft out of 150 ft of core was recovered utilizing a total of seven core barrels. Multiple issues, including slow penetration rates caused by jamming of the core barrel, plugging of the bit caused by shale buildup, and a premature engagement of the catcher system, caused early termination of coring for all but two coring attempts. The early termination of these attempts precluded recovery of full 30-ft sections, which increased the anticipated coring time for this well.

A 100% recovery was realized on five out of seven attempts. Core Barrel No. 4 experienced a failure in the clamshell catcher system of the coring tool during retrieval leading to a 0% recovery of the 30-ft section comprising the majority of the Muddy interval. A fishing attempt utilizing a backup core barrel was made to retrieve the missing core. The attempt was partially successful, recovering 9½ ft out of 30 ft of lost core (~30% recovery). It is believed that loosely consolidated sand comprising the bottom of the cored interval collapsed under the weight of the drill pipe and filled the bottom of the hole. Coring attempts on separate wells encountered a similar issue regarding successful core recovery for the Muddy interval. It is now believed that unconsolidated sand in a portion of the Muddy Formation precludes successful coring in at least a portion of the field. The coring intervals and recovery are noted in Table 2. Following coring, the hole was drilled to the total depth of 4855 ft.

A comprehensive well-logging, mud-logging, and in situ pressure-testing program was conducted in order to 1) provide key characterization data for the Muddy Formation, overlying and underlying seals, and potential overlying monitoring zones; 2) provide a correlation log for legacy data and a tie-in for seismic interpretations; 3) assess wellbore integrity including casing–cement–formation bond, cement integrity, and casing integrity; and 4) provide a baseline point of comparison for operational monitoring logs. A summary of openhole and cased-hole logs obtained and pressure-testing points are provided in Table 3. Mud samples were collected for water saturation determination at 5-ft intervals over the cored section of 4446–4577 ft. Well 05-06 OW was included in a suite of wells for the collection of PNLs, which provide a quantitative assessment of water, oil, and CO_2 saturations in the near-wellbore environment.

Figure 5. Core bit installed in the drill string assembly.

Figure 6. Example of core sample being extracted from the aluminum tubing used during the coring process.

Table 2. Core Recovery from 05-06 OW

	Interval, ft		Recovery	
Core	From	To	ft	%
1	4446	4450.7	4.7	100
2	4450.7	4480.7	30.0	100
3	4480.7	4496.6	15.9	100
4	4496.6	4527.8	Empty	0
4 (fishing)	4499	4508.4	9.4	30
5	4529	4546.7	17.7	96
6	4546.7	4577.8	31.8	102

Table 3. Logs for Well 05-06 OW

Log Type	Range, ft
Openhole Logs	
Resistivity	1009–4850
Gamma Ray	42–4788
Neutron Porosity	1010–4832
Bulk Density	1010–4840
Spectral Gamma Ray	1000–4792
Capture Spectroscopy	3790–4792
Spontaneous Potential	1000–4850
Dipole Sonic	
– Anisotropy	1535–4805
– Semblance	830–4805
– P & S* Wave	
– Mechanical Rock Properties	1086–4805
Resistivity Microimage (fracture analysis, dip, …)	3751–4750
Pressure Testing	4535, 4531, 4525, 4519, 4514, 4400, 4380, 4121, 4115, 4027, 3657, 3463, 3462, 2963, 2937, 1967, and 1963
Borehole Volume	1000–4840
Multiarm Caliper	1000–4830
Magnetic Resonance	4376–4692
Dielectric Log	1369–4712
Cased-Hole Logs	
Cement Isolation Scanner	101–4728
Cement Bond Log	212–4728
Corrosion Log	101–4728
Casing Collar Locator	104–4728

* Primary and secondary.

Collection of 30 sidewall cores was originally planned to provide a quick turnaround of key analyses to aid in time-sensitive characterization efforts. However, because of the lost full-diameter core over a key section of the Muddy Formation interval, a contingency plan was enacted to acquire sidewall core through the missing zone in ½-foot intervals (4538.5 to 4496 ft). In total, 90 core points were selected to efficiently fill three 30-plug core sidewall core barrels. Because of slow coring, repeated tool failures, and smaller than expected core retrieval, the EERC suspended sidewall-coring operations on January 1, 2012, after the successful recovery of 47 sidewall-cores through key intervals. Figure 7 shows the sidewall core bit used in the coring process. A detailed list of the sidewall cores recovered is provided in Appendix A.

Following the sidewall-coring and well-logging program, 5¾-inch, 15.5-lb, long-thread casing was outfitted to deploy a permanent downhole monitoring (PDM) system. The system consists of three permanent downhole pressure and temperature gauges and a distributed fiber optic measurement system. The casing was run to a total depth of 4846 ft, approximately 300 ft below the injection target. This additional depth allows for adequate space for logging tools and monitoring of the formations below the injection target. A gamma/casing collar locator log was run to set the downhole-monitoring stations to depth. The pressure and temperature-monitoring sensors were set at 4535 ft in the BC30 (Bell Creek) interval and 4515 ft in the BC10 interval of the Muddy Formation reservoir and at 4110 ft in a shallow overlying Niobrara porosity/permeability zone (Kalenze and others, 2013).

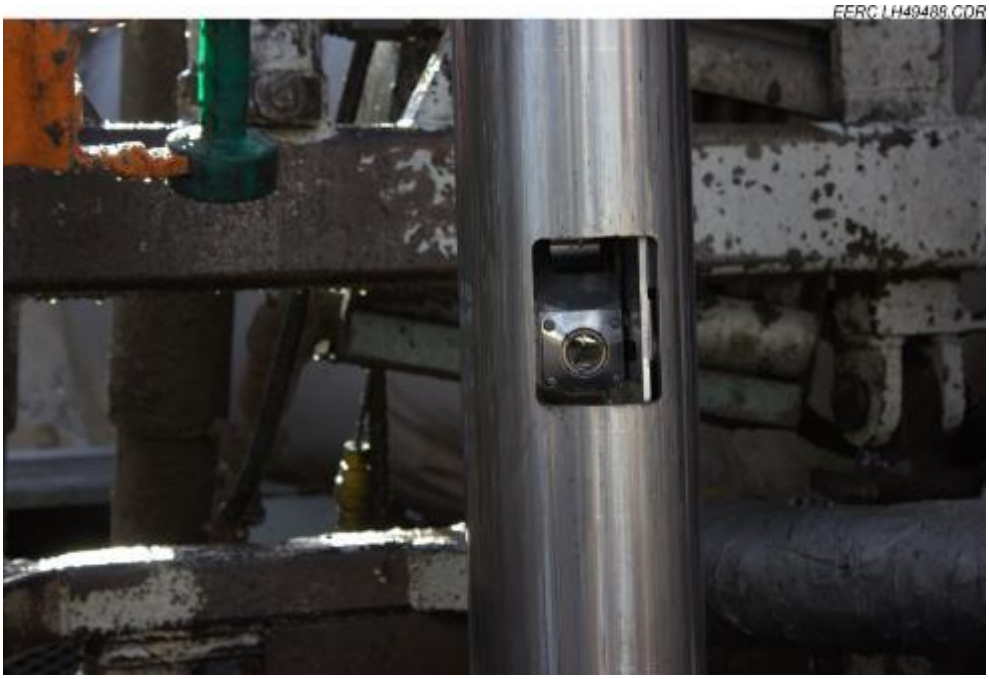

Figure 7. Sidewall core bit used in the collection of 47 sidewall cores from the 05-06 OW monitoring well.

The purpose of these sensors is to monitor changes in reservoir pressure and temperature to be used as early indicators of leakage outside of the reservoir and to provide continuous in situ data of reservoir conditions during the CO_2 flood. The downhole pressure and temperature gauges provide real-time pressure and temperature data at a 5-minute frequency. The distributed-temperature fiber optic measurement system provides a temperature profile along the wellbore. Currently, the system is acquiring measurements at a 1-meter resolution from a depth of 4750 ft to the surface at a frequency of every 4 hours (Kalenze and others, 2013). A 20-minute videographic best practices manual has been produced with the intention of acquainting a technical audience with the basics of casing-conveyed permanent downhole monitoring (PDM) systems, as well as the unique field installation practices that these systems require, using this well as an example (Prairie Public Broadcasting and University of North Dakota Energy & Environmental Research Center, 2013).

The PDM system surface installation was completed in April 2012. The system is fully operational and acquiring data (Figure 8). The 05-06 OW well was completed but not perforated in to order to provide a highly accessible wellbore for operational monitoring technologies such as time-lapse VSPs and pulsed-neutron well logs throughout the operational monitoring portion of the study.

Figure 8. Qorex staff checking the functionality of the fiber optic distributed pressure/temperature data logger (left-most open panel).

Permanent Seismic Monitoring Installation in the 04-03 OW Monitoring Well

Initially, the 08-12A well, which Denbury had completed as a plugged and abandoned well, was targeted for repurposing for the permanent installation of a 50-level three-component geophone array. The well was perforated at approximately 2500 ft in an unsuccessful attempt to establish circulation within the casing annulus. A cement bond log and a temperature log were run, which indicated blockage in the casing annulus, most probably due to a swelling shale formation. A chemical cutter was run to separate casing at approximately 2500 ft, casing stretch was pulled, and a free-point indicator log was run, which determined the casing was stuck at 1500 feet. After multiple attempts to free the casing, it was determined that the casing could not be freed without risking severe damage to the well and/or formation and the decision was made to replug and abandon the well. After an analysis of available locations, the 04-03 OW well location was chosen based on site access and geographic location on the updip side of the Phase 1 area providing a key location for monitoring portions of both development Phases 1 and 2 as well as an area which is believed to represent a lateral flow boundary within the field.

The 04-03 OW was drilled to install a permanent 50-level three-component geophone array to allow for time-lapse VSP acquisitions (Figure 9) and to provide continuous passive seismic monitoring of the injection target and adjacent formations (Figure 10). The basic logs acquired are listed in Table 4. Installation was completed by drilling a 2575-ft hole and installing the

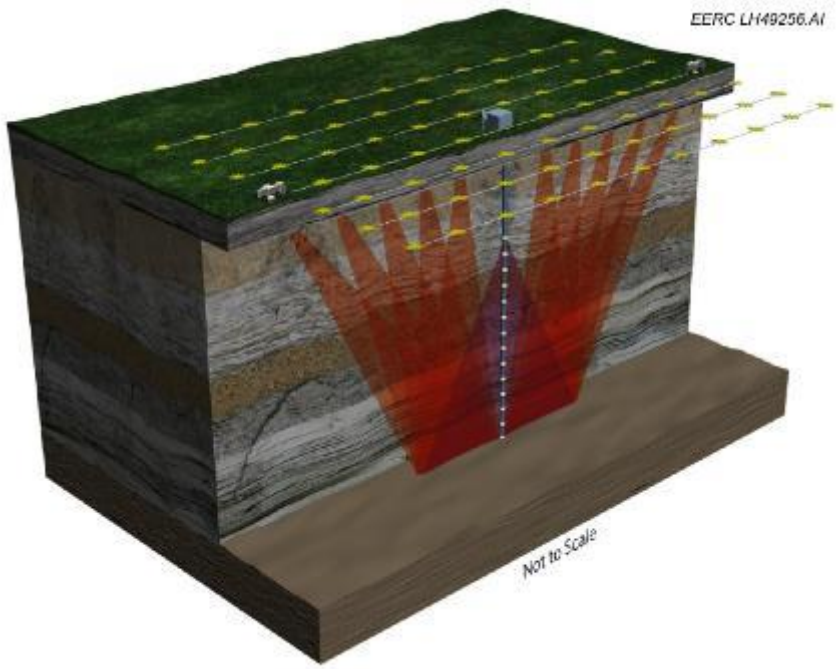

Figure 9. The 04-03 OW well has been used to acquire a baseline 3-D-VSP and repeat 3-D-VSPs. As shown, a series of source points are shot on the surface, which are recorded underground by the permanently installed geophones.

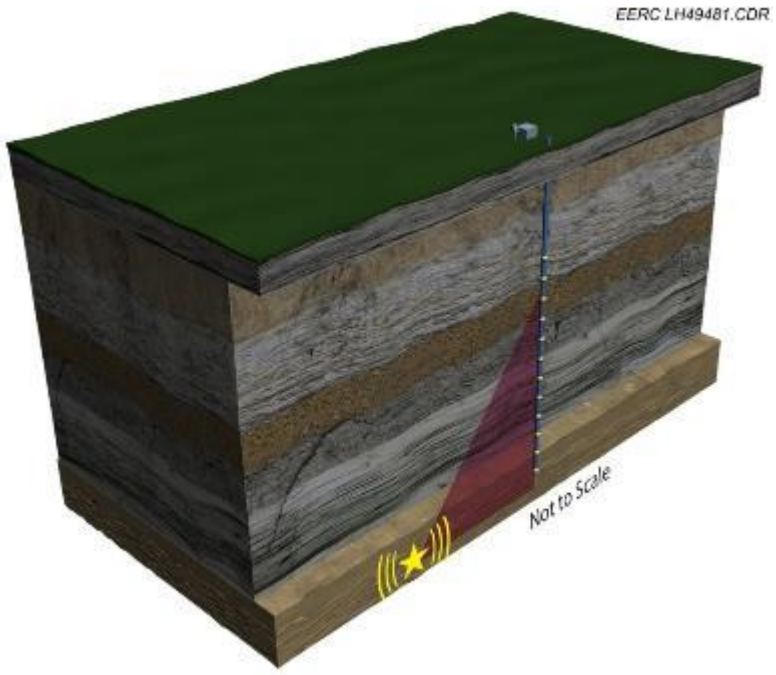

Figure 10. The 04-03 OW well is continuously recording and monitoring for microseismic events in the subsurface. Depending on the magnitude and location of the event, the geophones in 04-03 OW will record and locate these events in space and time and the magnitude of the event.

Table 4. Logs for Well 04-03 OW

Log	Range, ft
Resistivity	90–2562
Gamma Ray	0–2592
Spontaneous Potential	16–2563
Multiarm Caliper	0–2540

geophones spaced 49.2 ft (15 m) apart. This string of geophones was attached to 2⅞-inch tubing (Figure 11) and deployed so that the bottom geophone was at about 2550 ft in depth and the shallowest geophone was within 50 ft of the surface. Cement was then circulated through the tubing and up the annulus to surface encasing the geophones and effectively permanently plugging the wellbore (Figure 12). This well was then connected to a recording unit (Figure 13) for continuous passive monitoring and to acquire periodic 3-D VSP surveys.

The geophone array installed in the 04-03 OW well is being used to passively and continuously monitor for and locate background seismic and microseismic events in the vicinity of the Bell Creek oil field since mid-May 2013. The geophone array will detect the source and amplitude of both seismic and microseismic events. The resolution can accurately locate the events both laterally and vertically to determine the source location and whether the events originated either within or external to the reservoir underlying the field.

Figure 11. Each of the 50 three-component geophones was clamped to 2⅞-inch tubing for installation.

Figure 12. The 50 three-component geophones were cemented in place, effectively and permanently plugging the 04-03 OW well. The wellhead is shown here with the geophone cable coming out of the plugged well.

Figure 13. A small recording unit was placed on the surface at the 04-03 OW wellhead to continuously record passive seismic events and for use in the acquisition of 3-D VSPs.

Characterization Wells 56-14R and 33-14R

Four wells were drilled by Denbury as part of infill drilling activities, including water/CO_2 injection and oil production. Two of the redrill wells provided the PCOR Partnership additional opportunities to acquire key subsurface data to be used for advanced geological characterization. Well 56-14R is located in the Phase 1 area, 33-14R is located just over the eastern border of Phase 1 in the Phase 2 area, and both are considered unique. The 56-14R well was drilled in an area where the geology was believed to have very similar lithologic and petrophysical characteristics to Monitoring Well 05-06 OW. The 33-14R well was drilled into an area between phases where the top of the geologic structure (Barrier Island) was incised by an ancient stream. This resulted in the deposition of shales which are believed to provide lateral flow barriers within the field and form the basis for subdividing the operational phases. Both wells were drilled using traditional material choices for mud systems, surface and intermediate casing, and production casing.

The addition of Wells 56-14R and 33-14R to the program was a unique opportunity to collect and analyze rock that filled in data gaps for 1) rock from the upper sand interval of the reservoir and contact between the reservoir and the cap rock (56-14R), which was unable to be collected in Well 05-06 OW, and 2) the potential in Well 33-14R to collect some of the incised valley fill shale that divides several of the phases, including Phase 1 from Phase 2. Dipole sonic logs were collected to improve the ability to analyze and tie in the seismic data to give the team a better understanding of the reservoir and overlying formation's geomechanical and structural properties. This additional data collection and analysis helps to promote a better understanding of how CO_2 moves in the reservoir, how well the lateral seals will prevent updip CO_2 migration, and how the reservoir and overlying formations will respond geomechanically to injection and production operations. A summary of the drilling and completion activities for Wells 56-14R and 33-14R is provided in Appendix A.

56-14R

In February 2013, Denbury began the drilling of the 56-14R well. The well was permitted as, and is intended to be used as, an oil production well and was drilled to a total depth of 4850 ft. As the well was drilled, the EERC, through the PCOR Partnership, collected additional full-diameter and sidewall cores and ran advanced logs to provide additional subsurface characterization data, especially the bottom portion of the cap rock through the top portion of the Muddy Formation reservoir. Drill stem (or full-diameter) core was obtained March 5–7, 2013, by Baker Hughes using 30-ft barrels with an aluminum liner and a 4-inch core diameter. The first core was attempted at the 4606–4611-ft interval in the Muddy Formation sandstone with core recovered from 4608 to 4611 ft, a recovery of 3.0 ft or 60%. This first core was pulled after only a few feet because the penetration rate was slow, which, upon viewing, appeared to be caused by the core bit plugging. The second core was attempted at the 4612–4658-ft interval in the Muddy Formation sandstone with core recovered from 4612 to 4644.8 ft, a recovery of 32.8 ft or 71.3%. The core intervals and recovery are noted in Table 5.

Table 5. Full-Diameter Core Recovery from 56-14R

	Interval, ft		Recovery	
Core	From	To	ft	%
1	4608	4611	3.0	60
2	4612	4658	32.8	71.3

To provide additional material for laboratory analysis, sidewall cores were obtained from a depth of 2146 ft through 4640 ft. This activity took place over 2 days March 9–10, 2013. Thirty sidewall cores were planned, 31 were attempted, and 22 were recovered. A detailed list of the intervals recovered is provided in Appendix A. A summary of the well log suite acquired is listed in Table 6.

Table 6. Logs for Well 56-14R

Log	Range, ft
Resistivity	1055–4848
Gamma Ray	0–4813
Neutron Porosity	855–4760
Bulk Density	1060–4760
Spectral Gamma Ray	1025–4751
Spontaneous Potential	930–4848
– P & S* Wave	1060–4800
– Mechanical Rock Properties	1060–4800
Borehole Volume	930–4835
Multiarm Caliper	930–4848
Magnetic Resonance	2120–2230, 2960–3090, 4470–4847

* Primary and secondary.

33-14R

Prior to the drilling of Well 33-14R, limited information was available regarding the valley infill shale barriers evident throughout the field, which evidence suggested were behaving as, at least partially, effective lateral flow barriers within the field. Well 33-14R, on the border of Phases 1 and 2, had a high probability of intercepting this valley infill shale, allowing the opportunity to collect full-diameter core from this unique and very important area in the reservoir. Full-diameter core and additional well logs in this well were collected to better understand the overall depositional environment of the Bell Creek Field and the potential lateral sealing capacity of the valley infill shales to better guide and inform monitoring strategies, predictive simulation activities, and storage efficiency/capacity estimates.

Core was obtained by Baker Hughes in two runs: March 17–19, 2013, using 30-ft barrels with an aluminum liner. The first run was from 4413 to 4444 ft, the upper portion of the Muddy Formation, with a recovery of 28.35 ft (91%) to 4441.35 ft. The second run, which included the Muddy sandstone, was expected to be from 4444 to 4476 ft but showed a recovery of 32.75 ft

(102%). There appeared to be a void in the aluminum core holder at 4461 ft. The recovery of the second core was correlated to a depth of 4441.35 to 4473.35 ft. These core intervals are listed in Table 7. The logs obtained are listed in Table 8.

Production casing was set and cemented on March 23, 2013. The production casing was perforated from 4445 to 4451 ft with four holes per foot on April 17, 2013. Tubing was strung to 4406 ft with a 5½-inch permanent packer at 4390 ft. The 33-14R well was completed/shut-in in the Muddy Formation awaiting activation as an injection well, which was permitted December 3, 2013.

Table 7. Core Intervals from 33-14R

	Attempted Interval, ft		Actual Interval, ft	
Core	From	To	From	To
1	4413	4444	4413	4441.35
2	4444	4476	4441.35	4473.35

Table 8. Logs for Well 33-14R

Log	Range, ft
Resistivity	850–4747
Gamma Ray	0–4732
Neutron Porosity	756–4660
Bulk Density	756–4660
Spontaneous Potential	830–4740
– Anisotropy	4200–4700
– P & S* Wave	840–4730
– Mechanical Rock Properties	4200–4700
Borehole Volume	108–4675
Magnetic Resonance	1947–4756

* Primary and secondary.

Groundwater-Monitoring Wells

Two new groundwater-monitoring wells in the Phase 1 injection area were installed to further enhance near-surface monitoring capabilities. These groundwater wells were completed in the Fox Hills Formation, the deepest underground source of drinking water (USDW). The Fox Hills Formation and the overlying Hell Creek Formation (Figure 3) are part of the Upper Cretaceous aquifer systems and represent the lowermost USDWs in the vicinity of the Bell Creek oil field. The primary goal of the Fox Hills groundwater-monitoring effort is to provide a means to identify and characterize baseline water chemistry in the lowermost USDW as well as identify water chemistry anomalies (should they occur) associated with or in proximity to the CO_2 injection area. The baseline groundwater chemistry and periodic monitoring during the injection period could thus be utilized, in conjunction with the greater monitoring program, to identify an anomaly,

determine the source of the anomaly, and confirm or contest the impact of an anomaly to local groundwater aquifers (should an impact be observed) (Stepan and others, 2014).

The groundwater-monitoring wells are collocated on pads associated with Oil-Producing Wells 05-04 and 33-12. These pads are sited close to ravines that will allow for surface discharge of casing purge volumes and potential low flows of groundwater that would be required for potential continuous monitoring throughout the CO_2 injection period. The wells were fitted with electric submersible pumps and will be sampled monthly for field analyses and at least annually for laboratory analyses. Groundwater data in the Phase 1 development area and data for deep sources of drinking water are underrepresented within the groundwater-monitoring program because of limited well availability. Information gathered from these wells will be used to provide baseline characteristics for deep sources of drinking water in the area and will further strengthen the groundwater-sampling program. Baseline and operational water chemistry analysis (both field and laboratory) will provide key data for monitoring for a potential vertical CO_2 migration event.

MW0504 (Fox Hills) Groundwater-Monitoring Well

A groundwater-monitoring well was drilled on the same pad as the 05-04 production well. A simple well completion diagram for the groundwater-monitoring well is provided in Appendix A. It was drilled to a total depth of 820 ft below ground surface into the Pierre Shale just below the Fox Hills Formation. The well was screened over an 80-ft interval from 677 to 757 ft, which corresponds to the middle of the Fox Hills aquifer. The well was installed in January 2013, and a larger pump was installed in March 2013. The groundwater-monitoring well was completed on April 1, 2013.

MW3312 (Fox Hills) Groundwater-Monitoring Well

The MW3312 (Fox Hills) groundwater-monitoring well was drilled and collocated on the same pad as the 33-12 production well. A summary of the drilling activities for MW3312 (Fox Hills) is provided in Appendix A. Installation of the well was first attempted in February 2013; however, it had to be plugged and abandoned because of a screen collapse during casing installation. The well was successfully redrilled to a total depth of 605 ft in March 2013. The top of the Fox Hills is 480 ft below ground surface, and the well was screened with PVC (polyvinyl chloride) over a 60-ft interval, from 545 to 605 ft. A complete diagram of the well is provided in Appendix A. The groundwater-monitoring well was completed on April 1, 2013.

SUMMARY

In December 2011, the 05-06 OW monitoring and characterization well was drilled to a depth of 4856 ft between a producer/injector well pair. A robust, modern, high-resolution data set was collected to characterize the reservoir as well as both underlying and overlying geology. Characterization activities included acquisition of a comprehensive logging suite, 110 ft of 4-inch-diameter core, 47 sidewall cores, drill cuttings, formation pressure tests, and a baseline 3-D VSP survey. These data sets were collected to refine existing geologic properties, understanding of the subsurface structure, and to correlate newly generated data with historic data

to improve the overall understanding of the study area. Three in situ casing-conveyed downhole pressure/temperature gauges and a distributed fiber optic temperature system were installed to aid in both reservoir and above-zone-monitoring activities. The 05-06 OW well was completed but not perforated to order to provide a highly accessible wellbore suitable for operational monitoring technologies such as time-lapse VSPs and pulsed-neutron well logs throughout the operational monitoring portion of the study.

In April 2013, the 04-03 OW monitoring well was drilled to a depth of 2604 ft adjacent to the eastern updip edge of the Phase I development area. This well was purpose-drilled to install a permanent 50-level geophone array. The geophone array spans a 2500-ft interval (from 50 ft MD [measured depth] to 2550 ft MD) and employs 49.2 ft (15-m) spacing between the geophones. The geophone array was installed to provide continuous passive seismic monitoring and as a receiver array for periodic time-lapse 3-D VSP acquisitions. After successful geophone installation, the hole was filled with cement to effectively plug and abandon the hole; however, the geophones remain active for continued use with the Bell Creek monitoring program.

In February 2013, the 56-14R well was drilled near the western edge of the Phase I development area by Denbury as part of the commercial EOR project's infill drilling program. The 56-14R well is located approximately 1.2 miles southwest from the 05-06 OW well and possesses similar geologic characteristics within the reservoir interval, making it an ideal candidate to characterize heterogeneity within the Muddy Formation. The PCOR Partnership partnered with Denbury to collect 32.8 ft of 4-inch-diameter drill stem core and 22 1-inch-diameter sidewall cores to assess geologic variability within the Muddy Formation. An advanced logging suite, including magnetic resonance and dipole sonic logs, was also acquired to further enhance characterization of the reservoir. The logs were also used to assist with time-depth seismic correlations and to enhance characterization of overlying strata including potential above-zone-monitoring intervals.

In March 2013, the 33-14R well was drilled adjacent to the eastern boundary of the Phase I development area by Denbury as part of the commercial EOR project's infill drilling program. The 33-14R well is located approximately 1 mile east of the 05-06 OW well in an area anticipated to intersect erosional valley infill shale, which is believed to be representative of the prominent lateral flow boundaries present throughout the Bell Creek oil field and, hence, provided a unique and ideal location for characterizing the lateral sealing capacity of these boundaries. The PCOR Partnership partnered with Denbury to collect 61.1 ft of 4-inch-diameter drill stem core and an advanced logging suite, including magnetic resonance and dipole sonic logs, to perform a detailed characterization of these lateral flow boundaries as well as to enhance characterization of overlying strata and potential above+zone monitoring intervals.

In January and February 2013, the MW0504 (Fox Hills) and the MW3312 (Fox Hills) were drilled to characterize the lowermost USDW underlying the Bell Creek oil field and to expand shallow groundwater-monitoring spatial resolution within the Phase I development area. MW0504 (Fox Hills) was drilled to a depth of 820 ft below ground level into the Pierre shale and screened from 677–757 ft, an interval corresponding to the middle of the Fox Hills Formation. MW3312 (Fox Hills) was drilled to a depth of 605 ft into the Pierre shale and screened from 545–605 ft, an interval corresponding to the middle of the Fox Hills Formation. The Fox Hills Formation is the deepest USDW zone in the region. The groundwater-monitoring wells are collocated on the well

pads of active oil-producing wells 05-04 and 33-12. The locations were selected based on spatial monitoring coverage of the Phase 1 development area and site access and proximity to surface drainage features (ravines) to allow for surface discharge of casing purge volumes and potential low flows of groundwater that would be required if continuous monitoring were employed. The wells were fitted with electric submersible pumps and are sampled monthly for field analytes and at least annually for detailed laboratory chemical and isotopic analysis as part of an ongoing monitoring effort designed to demonstrate security of the reservoir/storage complex.

The drilling and completion activities conducted by the PCOR Partnership in conjunction with the Bell Creek associated CO_2 storage study have provided key data sets integral to the characterization, modeling and simulation, monitoring, and risk assessments activities. Additionally the 05-06 OW, 04-03 OW, MW0504 (Fox Hills), and MW3312 (Fox Hills) wells have provided crucial access to conduct operational monitoring activities to 1) demonstrate that associated CO_2 storage can be safely and permanently achieved and monitored on a commercial scale in conjunction with an EOR operation; 2) demonstrate that oil-bearing sandstone formations are viable CO_2 sinks; 3) develop and demonstrate MVA methods that can be used to effectively monitor commercial-scale CO_2 injection projects and provide a technical framework for the accounting of injected CO_2; and 4) acquire data, information, and knowledge needed to inform commercial-scale CO_2 storage and EOR projects throughout the region.

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APPENDIX A

DRILLING AND COMPLETION DETAILS

DRILLING AND COMPLETION DETAILS

DRILLING AND COMPLETION BASICS

An oil or gas well is drilled and completed with an integrated set of components designed to isolate the formations penetrated from the produced or injected reservoir fluids. Although the wells in this project are meant for monitoring purposes instead of production, the same steps are followed. Brief explanations of the steps involved in drilling and completion activities are as follows:

Drilling

- The first hole to be drilled is often the conductor hole, usually drilled prior to the arrival of the drilling rig. It is the largest-diameter drill of the well and is cemented into place before drilling begins. Conductor casing is installed and cemented to prevent surface erosion, which can cause a cave-in, and to help in the process of circulating drilling fluids up from the bottom of the well.

- A surface hole is drilled generally deep enough to protect any freshwater aquifers. Following drilling of the hole, surface casing is set and cemented, typically the full length of the casing. The surface casing provides blowout protection, support for the weight of subsequent production casing string(s), and ensures the well will not close in upon itself. Cement slurry is pumped in to displace drilling fluids still in the well. It flows to the bottom of the wellbore through the casing, fills in the space between the casing and the wellbore, and hardens. Cement provides a hydraulic seal between the casing and the hole that was drilled, which prevents outside materials from entering the well flow and hydrocarbons from encroaching into freshwater zones. Cementing the casing permanently positions the casing in place.

- A blowout preventer is installed to protect against any inflow of pressure as the well is deepened.

- A smaller-diameter hole is drilled through the surface casing to the next desired depth. Coring takes place if it is part of the project. If the well is to be drilled deeper, intermediate casing is set and cemented, and drilling with a smaller-diameter drill continues. Production casing is set and cemented when the total depth is reached with the drilling. The production casing string must isolate all permeable intervals from each other and be able to safely contain the well fluid pressures.

- Geophysical tools can be run in conjunction with the drilling string and/or on a separate wireline logging unit. The information obtained helps analyze the formations penetrated for reservoir and other geophysical properties.

- The pipe used to drill the well is removed, a wellhead is put in place, and the drilling rig is moved off location. A wellhead consists of components mounted at the surface of the wellbore to manage the extraction of hydrocarbons and prevents leaking of oil or natural gas out of the well and blowouts caused by high pressure. The casing head provides a seal between the casing

and the surface and serves as a support for the entire length of casing. The tubing head serves the same purpose for the tubing. A production or Christmas tree fits on top of the casing and tubing heads and allows for surface monitoring and regulation of the production of hydrocarbons from a producing well.

Completion

- The production casing is perforated with high-explosive shape charges in the production zone. If the well were to be used for production of oil or gas, a smaller-diameter pipe (tubing) would be run inside the casing after the well was cleaned out.

Plug and Abandon

- The type of well and its original construction dictate the plugging method. Typically, cement is pumped into the perforations, and a series of cement plugs are placed throughout the wellbore to ensure surface formations are protected from the production zones. The production tubing, any related downhole equipment, and any remaining surface equipment are all removed. The wellhead is cut off and released with a marker cemented on top of the old wellbore.

PERMANENT MONITORING WELL 05-06 OW

Well

Operator: Denbury Onshore, LLC/Energy & Environmental Research Center
Permit Type: Monitor
PCOR Partnership Purpose: Deep subsurface monitoring & characterization
Well: 05-06 OW
API Number: 25-075-22431-0000
Field: Bell Creek
County: Powder River
State: Montana
Location: Section 5, Township 9 South, Range 54 East, SENW 1980' FNL & 2609' FWL
Ground Level (GL): 3792 ft
Kelly bushing: 3803 ft (11 ft)
Latitude: 45.08588 N
Longitude: −105.13037 W
Spud Date: 15-December-11
Contractor: Capstar 314
Drilling Fluid Type: Water-based mud

Completions

Bit Size for Conductor Casing: 20 inches
Conductor Casing: 16-inch 84 lb J-55
Conductor Casing Shoe: 80 ft
Bit Size for Surface Casing: 13.5 (13½) inch
Surface Casing: 9.625 (9⅝)-inch 36 lb J-55 LTC
Surface Casing Shoe: 1009 ft
Surface Casing Cement:

Lead Cement: Rockies LT
0.2% Veraset (thixotropic additive)
0.2% D-AIR 3000 (defoamer)
0.125 lbm/sk Poly-E-Flake (lost circulation additive)
0.25 lbm/sk Kwik Seal (lost circulation additive)

Tail Cement: Rockies LT
0.2% Veraset (thixotropic additive)
0.2% D-AIR 3000 (defoamer)
0.125 lbm/sk Poly-E-Flake (lost circulation additive)
0.25 lbm/sk Kwik Seal (lost circulation additive)

Bit Size for Production Casing: 8.75 (8¾) inch
Total Depth (TD): 4855 ft
Production Casing: 5.5 (5½) inch 15.5 lb J-55 LTC, 4.950-inch ID, 4.825-inch drift diameter
Bottom of Production Casing Float Shoe: 4846.0 ft
Top of Float Collar: 4756.5 ft
Production Casing Cement: CORROSACEM™ SYSTEM
Top of Cement: 1800 ft
TD Cased Hole: TD not tagged during logging, calculated at 4756 ft
Tubing (kill string): 2.875 (2⅞)-inch 6.5 lb J-55
Tubing Depth: 1245 ft

Equipment

Distributed Temperature Sensor Anchor: 4750 ft
Pressure Temperature Gauge (PTG) 1: 4535.5 ft (pressure pad located at 4539 ft)
Note: There was not a strong positive indication that the casing-conveyed perforating charge on PTG1 fired. If the charge did not fire, pressure reading will be at pad depth.
PTG2: 4515.5 ft
PTG3: 4110 ft
Gamma Ray Radiation Pip Tag: 4058 ft

EERC JH43397.CDR

Denbury

Casing, Liner and Cement report

Bell Creek Unit #D 05-06 OW CO2

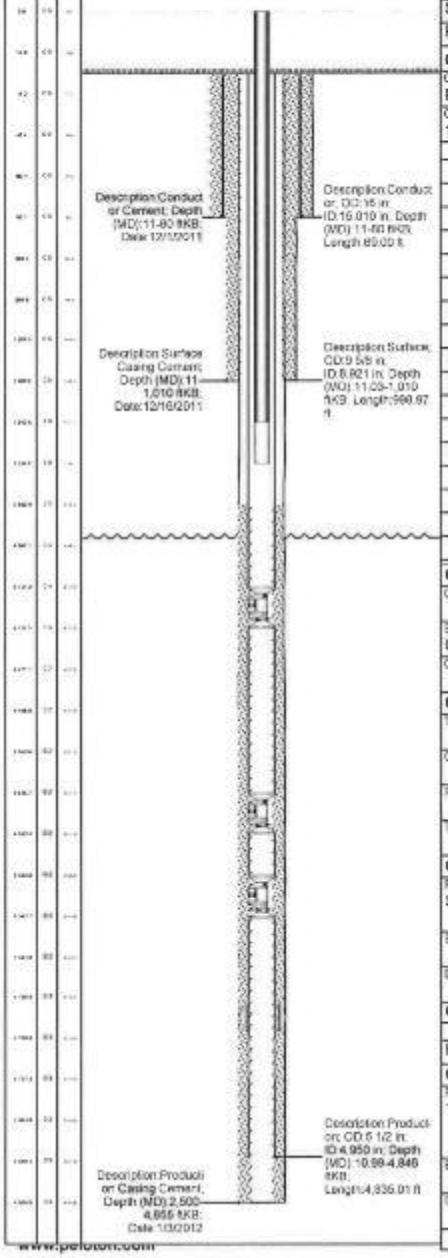
Production

API/UWI	Surface Legal Location	Field Name	License #	State/Prov	Well Config
2507522431		Bell Creek CO2		MT	

Gr Elev (ft)	CF Elev (ft)	KB-Grd (ft)	KB-CF (ft)	Total Depth (All) (ftKB)	PBTD (All) (ftKB)	Spud Date	Rig Release Date
3,792.00		11.00		Original Hole - 4,855.0		12/15/2011	1/3/2012

Original Hole, 1/19/2012 8:28:16 AM

Vertical schematic (actual)



Wellbore

Wellbore Name	Profile Type	Kick Off Depth (ftKB)	Vertical Section Direction (°)
Original Hole	Vertical		

Section Des	Hole Size (in)	Act Top (ftKB)	Act Btm (ftKB)
Conductor	20	11.0	80.0
Surface	13 1/2	80.0	1,010.0
Production	8 3/4	1,010.0	4,855.0

Casing

Casing Description	Run Date	Set Depth (ftKB)	Wellbore
Production	1/3/2012 05:00	4,846	Original Hole

Centralizers	Scratchers	Centralizer/Scratcher Info
114	0	One every joint to surface

Jts	Item Des	OD (in)	ID (in)	Wt (lb/ft)	Grade	Len (ft)	Top (ftKB)	Btm (ftKB)
0	Casing Joints	5 1/2	4.950	15.50	J-55	0.00	11.0	11.0
0	Cut Off	5 1/2	4.950	15.50	J-55	0.00	11.0	11.0
1	Casing Joints	5 1/2	4.950	15.50	J-55	29.23	11.0	40.2
2	Pup Joint	5 1/2	4.950	15.50	J-55	20.29	40.2	60.5
94	Casing Joints	5 1/2	4.950	15.50	J-55	4,036.73	60.5	4,097.2
1	Upper PTG 04	5 1/2	4.950	15.50	J-55	13.90	4,097.2	4,111.1
1	Lower PTG 04	5 1/2	4.950	15.50	J-55	6.23	4,111.1	4,117.4
9	Casing Joints	5 1/2	4.950	15.50	J-55	385.36	4,117.4	4,502.7
1	Upper PTG 03	5 1/2	4.950	15.50	J-55	13.10	4,502.7	4,515.8
1	Lower PTG 03	5 1/2	4.950	15.50	J-55	6.90	4,515.8	4,522.7
1	Upper PTG 02	5 1/2	4.950	15.50	J-55	13.10	4,522.7	4,535.8
1	Lower PTG 02	5 1/2	4.950	15.50	J-55	6.98	4,535.8	4,542.8
5	Casing Joints	5 1/2	4.950	15.50	J-55	193.60	4,542.8	4,736.4
1	DTS Anchor 01	5 1/2	4.950	15.50	J-55	20.04	4,736.4	4,756.5
1	Float Collar	5 1/2	4.950	15.50	J-55	0.90	4,756.5	4,757.4
2	Casing Joints	5 1/2	4.950	15.50	J-55	87.37	4,757.4	4,844.7
1	Float Shoe	5 1/2	4.950	15.50	J-55	1.28	4,844.7	4,846.0

Cement: Production Casing Cement

Cementing Start Date	Cementing End Date	Wellbore
1/3/2012	1/3/2012	Original Hole

Evaluation Method	Cement Evaluation Results
Calculated	

Comment

Cement Stage: Production Casing Cement

Top Depth (ftKB)	Bottom Depth (ftKB)	Full Return?	Vol Comm...	Top Plug?	Bottom Plug?
2,500	4,855	Yes		Yes	Yes

Q Pump Init (bbl/min)	Final Pump Rate (bbl/min)	Avg Pump Rate (bbl/min)	Final Pump Pressure (psi)	Plug Bump Pressure (psi)
5	2	4	1,170.0	1,800.0

Pipe Reciprocated?	Stroke (ft)	Reciprocation Rate (spm)	Pipe Rotated?	Pipe RPM (rpm)
No			No	

Tagged Depth (ftKB)	Tag Method	Depth Plug Drilled Out T...	Drill Out Diameter (in)	Drill Out Date

Cement Fluid: Spacer

Fluid Type	Fluid Description	Amount (s...	Class	Volume Pumped (bbl)
Spacer	Tuned Spacer 111		Spacer III	40.0

Estimated Top (ftKB)	Est Btm (ftKB)	Yield (ft³/sack)	Mix H2O Ratio (gal/sack)	Free Water (%)

Density (lb/gal)	Plastic Viscosity (cp)	Thickening Time (hr)	1st Compressive Strength (psi)
12.50			

Cement Fluid Additives

Add	Type	Conc
Barite		

Cement Fluid: Tail

Fluid Type	Fluid Description	Amount (s...	Class	Volume Pumped (bbl)
Tail	Latex Cement System	685	Corrosacem+Latex Sys	146.0

Estimated Top (ftKB)	Est Btm (ftKB)	Yield (ft³/sack)	Mix H2O Ratio (gal/sack)	Free Water (%)
2,500	4,855	1.19	5.10	

Density (lb/gal)	Plastic Viscosity (cp)	Thickening Time (hr)	1st Compressive Strength (psi)
14.50			

Figure A-1. Well completions "Casing, Liner, and Cement report," page 1 of 2.

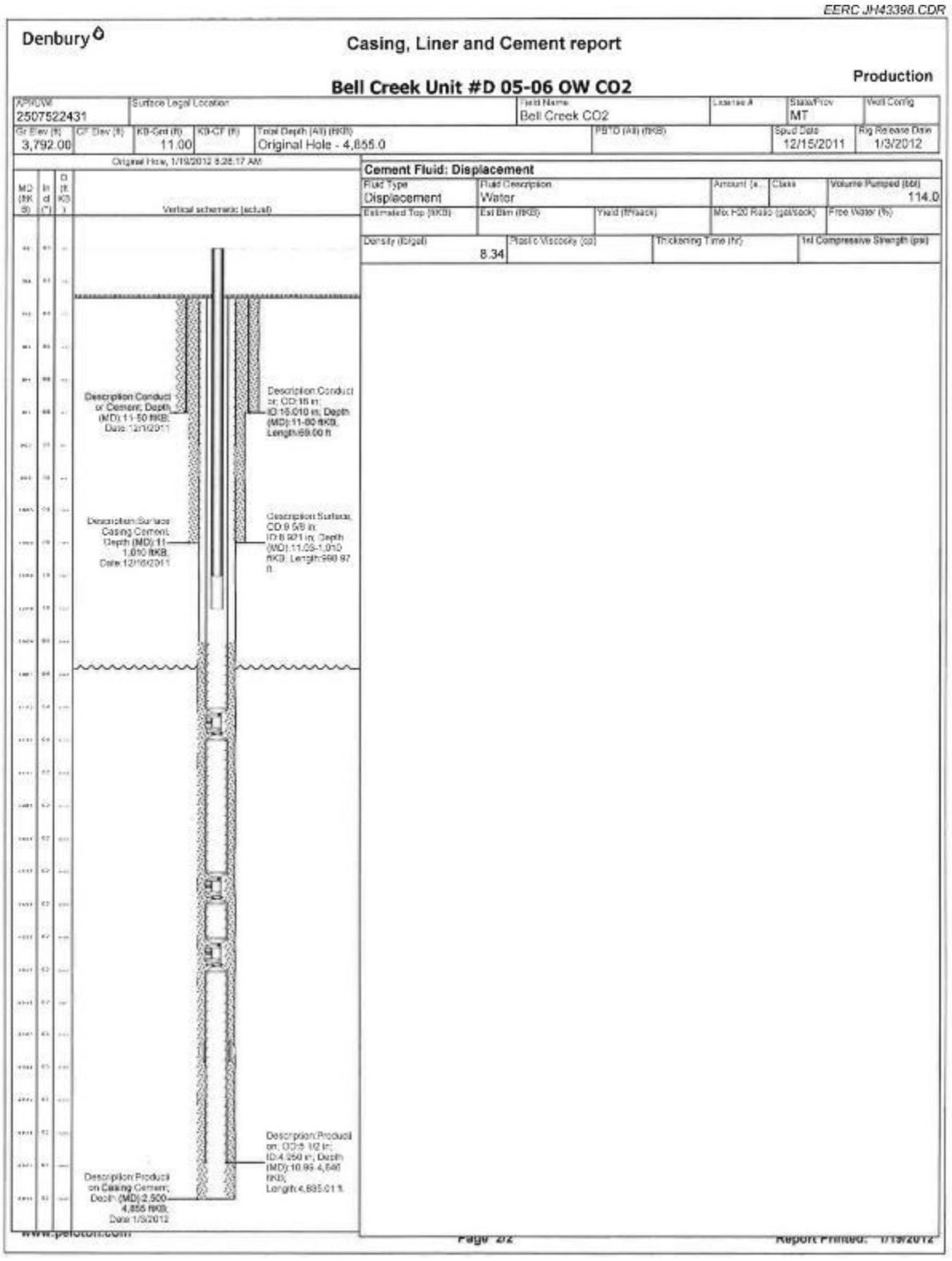


Figure A-2. Well completions "Casing, Liner, and Cement report," page 2 of 2.

Table A-1. 05-06 OW Regulation-Related Drilling and Completion Summary

Date	Action
September 30, 2011	MBOGC[1] environmental assessment signed.
October 6, 2011	Application for a permit to drill approved.
November 29, 2011	Initial spud date, with the set of a 16-inch conductor pipe.
December 2, 2011	Sundry Notice was approved, included changes to the plans for TD,[2] surface hole and casing specifics, production hole and casing specifics, and coring program.
January 10, 2012	Completion date.

[1] Montana Board of Oil and Gas Conservation.
[2] Total depth.

Table A-2. 05-06 OW Full-Diameter Core Recovery

	Interval, ft		Recovery	
Core	From	To	ft	%
1	4446	4450.7	4.7	100
2	4450.7	4480.7	30.0	100
3	4480.7	4496.6	15.9	100
4	4496.6	4527.8	Empty	0
4 (fishing)	4499	4508.4	9.4	30
5	4529	4546.7	17.7	96
6	4546.7	4577.8	31.8	102

Table A-3. 05-06 OW Sidewall Cores

Depth, ft	Formation	Total Length, in.	Usable Length, in.
2937.00	Niobrara	1.57	1.35
2943.00	Niobrara	1.58	1.30
4111.00	Niobrara	1.57	0.82
4113.00	Niobrara	1.27	0.25
4400.00	Mowry	1.70	N/A*
4508.75	Muddy	2.18	1.90
4511.50	Muddy	1.64	1.02
4512.00	Muddy	1.00	N/A
4514.00	Muddy	0.91	0.72
4514.50	Muddy	1.57	1.09
4515.00	Muddy	1.49	1.16
4515.50	Muddy	1.60	N/A
4516.00	Muddy	1.52	N/A
4516.50	Muddy	1.35	0.56
4517.00	Muddy	1.42	1.24
4517.50	Muddy	1.25	N/A
4518.00	Muddy	2.13	1.53
4518.50	Muddy	1.81	1.55
4519.00	Muddy	1.67	1.43
4519.25	Muddy	1.38	0.79
4519.50	Muddy	2.03	1.60
4520.00	Muddy	1.55	1.10
4520.50	Muddy	1.48	1.09
4521.00	Muddy	1.12	0.80
4522.00	Muddy	1.72	1.39
4522.50	Muddy	1.44	0.58
4523.00	Muddy	1.44	1.21
4523.25	Muddy	1.59	1.29
4523.50	Muddy	1.45	1.17
4524.00	Muddy	1.18	0.89
4524.50	Muddy	1.85	1.63
4525.00	Muddy	1.86	1.68
4525.25	Muddy	1.88	1.59
4525.50	Muddy	1.91	1.58
4526.00	Muddy	1.78	1.49
4526.50	Muddy	1.91	1.62
4527.00	Muddy	1.84	N/A
4527.50	Muddy	1.77	1.02
4528.00	Muddy	2.09	1.65
4528.50	Muddy	1.85	N/A
4529.50	Muddy	1.99	1.68
4530.00	Muddy	1.98	1.70
4536.50	Muddy	2.08	N/A
4537.00	Muddy	1.50	0.79
4537.50	Muddy	1.83	1.50
4538.00	Muddy	1.95	1.58
4538.50	Muddy	2.01	N/A

* Not applicable.

Table A-4. Logs for Well 05-06 OW

Log Type	Range, ft
Openhole Logs	
Resistivity	1009–4850
Gamma Ray	42–4788
Neutron Porosity	1010–4832
Bulk Density	1010–4840
Spectral Gamma Ray	1000–4792
Capture Spectroscopy	3790–4792
Spontaneous Potential	1000–4850
Dipole Sonic	
– Anisotropy	1535–4805
– Semblance	830–4805
– P & S* Wave	
– Mechanical Rock Properties	1086–4805
Resistivity Microimage (fracture analysis, dip, …)	3751–4750
Pressure Testing	4535, 4531, 4525, 4519, 4514, 4400, 4380, 4121, 4115, 4027, 3657, 3463, 3462, 2963, 2937, 1967, and 1963
Borehole Volume	1000–4840
Multiarm Caliper	1000–4830
Magnetic Resonance	4376–4692
Dielectric Log	1369–4712
Cased-Hole Logs	
Cement Isolation Scanner	101–4728
Cement Bond Log	212–4728
Corrosion Log	101–4728
Casing Collar Locator	104–4728
Gauge Depth Correlation	100–4728

* Primary and secondary.

Table A-5. Picked Formation Tops Based on Wireline Logs for Well 05-06 OW, ft

Formation	Prognosis		Geological Report Log Depth		EERC[1] Wireline Logs	MBOGC[2] Well Information
	MD[3]	S.S.[4]	MD	S.S.	MD	MD
Fox Hills	667	3144	670	3133	660	660
Pierre Shale	804	3007	846	2957	846	846
Eagle	–	–	1838	1965	–	1837
Shannon	No pick	No pick	2046	1757	2044	2045
Niobrara	2898	913	2894	909	2892	2893
Carlile	3011	800	No pick	No pick	–	–
Mowry	4299	−488	4298	−498	4296	4298
Shell Creek	4471	−660	No pick	No pick	4457	–
Springen Ranch	4496	−685	No pick	No pick	4470	–
Coastal Plain					4496	
Muddy (BC10)[5]	4507	−696	4508	−695	4507	4508
BC20					4518	
BC30					4530	
Rozet	4545	−734	4543	−740	4538	–
Skull Creek	4555	−939	4562	−795	4549	4549
Total Depth	**4750**	**−947**	**4855**	**−1052**	**4856**	**4855**

[1] Energy & Environmental Research Center.
[2] Montana Board of Oil and Gas Conservation.
[3] Measured depth.
[4] Subsea elevation.
[5] BC is Bell Creek.

PERMANENT MONITORING WELL 04-03 OW

Well

Operator: Denbury Onshore, LLC
Permit Type: Monitor/observation
PCOR Partnership Purpose: Installation of geophone array/monitoring well
Well: 04-03 OW
API Number: 25-075-22441-0000
Field: Bell Creek
County: Powder River
State: Montana
Location: Section 4, Township 9 S, Range 54 East, NENW 552' FNL & 1494' FWL
Ground Level: 3730 ft
Kelly Bushing (KB): 3740 ft (10 ft)
Latitude: 45.089815 N
Longitude: −105.113694 W
Spud Date: 5-April-13
Contractor: Capstar 311
Drilling Fluid Type: Water-based mud and calcium/PHPA (partially hydrolyzed polyacrylamide)

Completions

Bit Size for Conductor Casing: 20 inches
Conductor Casing: 16-inch 32.3 lb H-40
Conductor Casing Shoe: 120 ft (KB)
Bit Size for Surface Casing: 9.875 (9⅞)-inch [8.5-inch bicenter bit] followed by 8.75 (8¾)-inch
Surface Casing: 2.875 (2⅞)-inch 6.5 lb J-55
Surface Casing Shoe: 2604 ft
Surface Casing Cement: Cement plug
Lead Cement: VariCem™ 985 sk
0.05% FE200 (retarder)
0.125 gal us/12.0 gal Poly-E-Flake (lost circulation additive)
Tail Cement: Not applicable
Bit Size for Production Casing: Not applicable
Total Depth (TD): 2604 ft (KB)
Production Casing: Not applicable
Bottom of Production Casing Float Shoe: Not applicable
Top of Float Collar: Not applicable
Production Casing Cement: Not applicable
Top of Cement: 10 ft (KB) (surface, 3730 ft)
TD Cased Hole: TD not tagged
Tubing (kill string): Not applicable
Tubing Depth: 2596 ft (KB)

Equipment

50-level GeoRes Wellbore Sensor Array: Every 49.2 ft (15 m) from ~50 to ~2550 ft

EERC LH49520.CDR

Denbury

Casing Summary Schematic

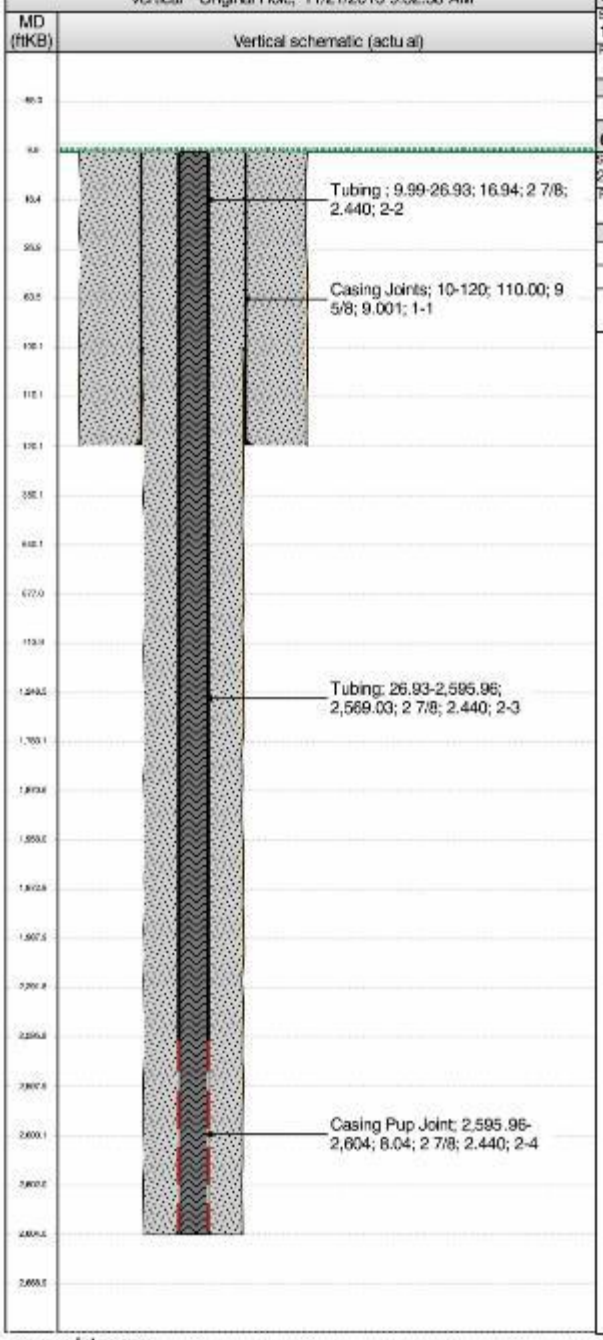
Bell Creek Unit #C 04-03 OW CO2

1/2013

API/UWI	Serial Number	Surface Legal Location	Field Name	License #	State/Province	Well Config
2507522441		Section 4 - T9S - R54E	Bell Creek CO2	30656 (MBOGC)	MT	Vertical

Gr Elev (ft)	Kb-Grd (ft)	Of Elev (ft)	Spud Date	Rig Release Date
3,730.00			4/5/2013	4/12/2013

Vertical - Original Hole, 11/21/2013 9:32:38 AM



Casing String: Conductor, 120ftKB

Set Depth (ft)	Run Date	Tension (kips)	OD (in)
120	4/1/2013		9 5/8

Prop Run? No

Centralizer/Scratcher In To

Jts	Item Des	OD (in)	ID (in)	Wt (lb/ft)	Grade	Top (ftKB)	Btm (ftKB)
3	Casing Joints	9 5/8	9.001	32.30	H-40	10.0	120.0

Casing String: Geophone 'Tubing, 2,604ftKB

Set Depth (ft)	Run Date	Tension (kips)	OD (in)	Drift Min (in)	Centralizers	Scratchers
2,604	4/11/2013		2 7/8	2.340	50 Geophones	

Prop Run? No

Centralizer/Scratcher In To

Geophones (total 50) in

Jts	Item Des	OD (in)	ID (in)	Wt (lb/ft)	Grade	Top (ftKB)	Btm (ftKB)
1	Tubing	2 7/8	2.440	6.50	J-55	10.0	26.9
82	Tubing	2 7/8	2.440	6.50	J-55	26.9	2,596.0
2	Casing Pup Joint	2 7/8	2.440	6.50	J-55	2,596.0	2,604.0

Figure A-3. Well completions "Casing Summary Schematic."

Table A-6. 04-03 OW Regulation-Related Drilling and Completion Summary

Date	Action
March 28, 2013	MBOGC* environmental assessment signed.
March 29, 2013	Application for a permit to drill approved.
April 3, 2013	Spud date.
April 12, 2013	Completion date; plugged and abandoned.
April 30, 2013	Reserve pit reclaimed. The cuttings were solidified with and covered with native soil.
May 17, 2013	Sundry Notice for reserve pit approved.

* Montana Board of Oil and Gas Conservation.

Table A-7. Logs for Well 04-03 OW

Log	Range, ft
Resistivity	90–2562
Gamma Ray	0–2592
Spontaneous Potential	16–2563
Multiarm Caliper	0–2540

Table A-8. Formation Tops in 04-03 OW, ft

Formation	Prognosis	Formation Top
	MD[1]	MD
KB[2]	3742	3740
Fox Hills	640	646
Pierre Shale	741	740
Eagle	1783	1743
Shannon	1958	1944
Steele Shale	1988	
Niobrara		2795
Mowry Shale		4193
Shell Creek		4339
Muddy		4373
Springen Ranch		4394
Coastal Plain		4415
Rozet		4432
Skull Creek		4446
Total Depth	**2600**	**2604**

[1] Measured depth.
[2] Kelly bushing.

CHARACTERIZATION WELL 56-14R

Well

Operator: Denbury Onshore, LLC
Permit Type: Oil
PCOR Partnership Purpose: Characterization
Well: 56-14R
API Number: 25-075-22437-0000
Field: Bell Creek
County: Powder River
State: Montana
Location: Section 6, Township 9 S, Range 54 East, SESW 738' FSL & 1854' FWL
Ground Level: 3829.7 ft
Kelly Bushing: 3840.7 ft (10.7 ft)
Latitude: 45.07886 N
Longitude: −105.15338 W
Spud Date: 16-February-13
Contractor: Capstar 312 and Capstar 311
Drilling Fluid Type: Water-based mud

Completions

Bit Size for Conductor Casing:
Conductor Casing: 16 inch
Conductor Casing Shoe: 90 ft
Bit Size for Surface Casing: 13.5 (13½) inch
Surface Casing: 9.625 (9⅝)-inch 36 lb ST&C J-55
Surface Casing Shoe: 1057 ft
Surface Casing Cement
Lead Cement: VariCem™ 205 sk 11.5 ppg
0.125 lbm Poly-E-Flake (lost circulation additive)
Tail Cement: VariCem™ 265 sk 13 ppg
0.125 lbm Poly-E-Flake (lost circulation additive)
Bit Size for Production Casing: 8.75 (8¾) inch
Total Depth (TD): 4850 ft
Production Casing: 5.5 (5½) inch 15.5 lb K-55
Bottom of Production Casing Float Shoe: 4850 ft
Top of Float Collar: 4763.97 ft
Production Casing Cement: EconoCem™ 705 sk 12.7 ppg
0.125 lbm Poly-E-Flake (lost circulation additive)
0.3% HR®-5, 50 lb sk (cement retarder)
1 lbm PhenoSeal™ Medium, 40 lb bag (lost circulation additive)
Top of Cement: surface
TD Cased Hole:
Tubing (kill string): 2.375 (2⅜)-inch 4.7 lb J-55
Tubing Depth: 4576.7 ft

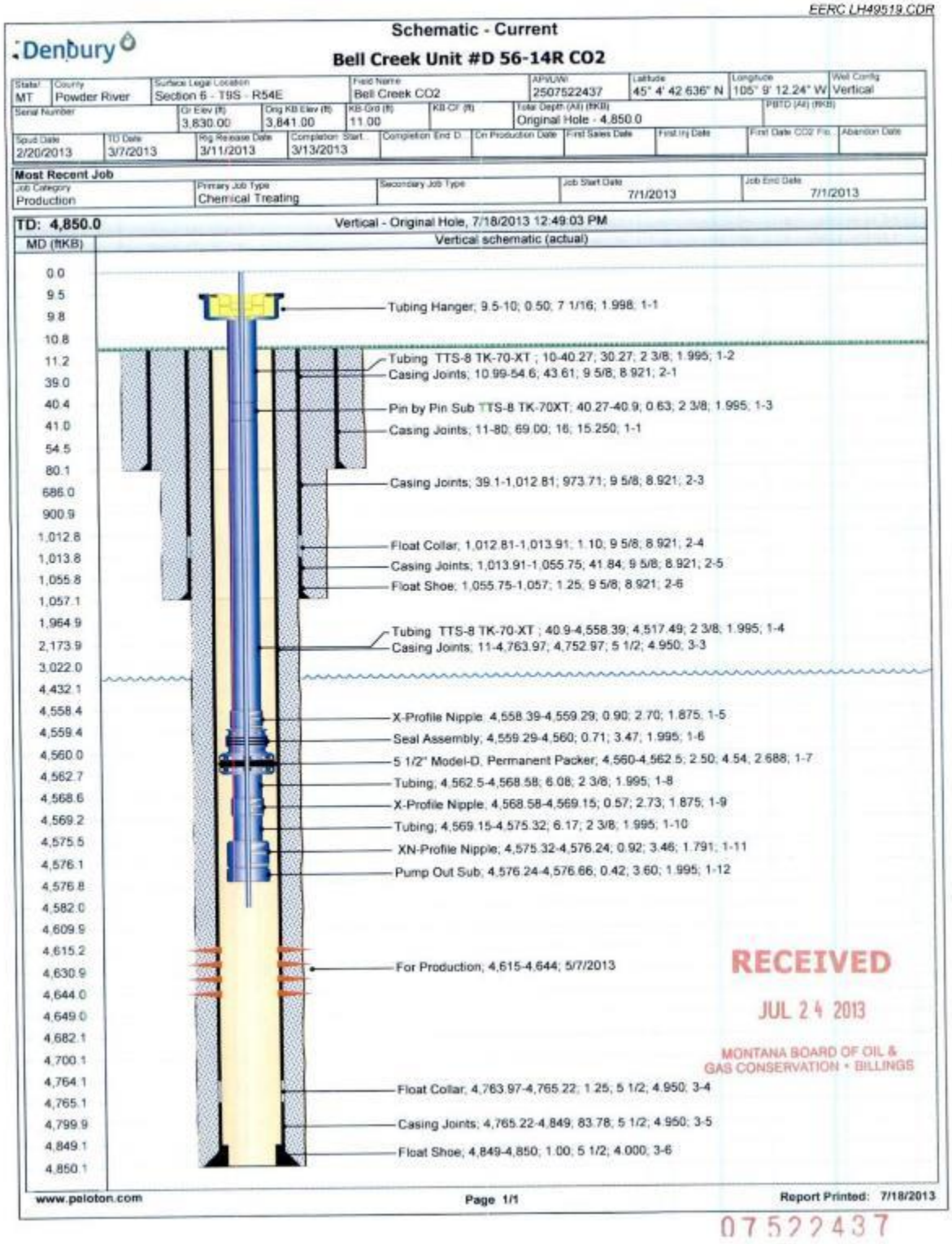


Figure A-4. Well completions “Schematic.”

Table A-9. 56-14R Regulation-Related Drilling and Completion Summary

Date	Action
January 27, 2012	Application for a permit to drill approved
July 26, 2012	Repermitted
December 19, 2012	Modification to permit, to move the location and enlarge the well pad
January 24, 2013	Repermitted
January 25, 2013	Modification to permit, to include a coring program
February 16, 2013	Spud date
March 26, 2013	Modification to permit, to haul excess drill cuttings to a remote storage pond
July 1, 2013	Completion date
October 16, 2013	Reserve pit reclaimed

Table A-10. Full Diameter Core Recovery from 56-14R

	Interval, ft		Recovery	
Core	From	To	ft	%
1	4608	4611	3.0	60
2	4612	4658	32.8	71.3

Table A-11. 56-14R OW Sidewall Cores

Depth, ft	Formation	Unit/Member/ Facies	Total Length, in.	Usable Length, in.	EERC[1] Sample Receipt Notes
3055	Niobrara		1.7375	1.334	
4203	Belle Fourche		1.586	1.142	
4571	Mowry		1.6215	0.977	
4592	Muddy		0.412	N/A[2]	The sample is only a chip.
4616	Muddy	Springen Ranch	1.564	1.38	
4619	Muddy	Springen Ranch	1.136	0.59	
4620	Muddy	Coastal Plain Sand	1.318	1.0405	
4621	Muddy	Coastal Plain Sand	1.425	0.65	Irregularly shaped diameter with channel/groove across plug.
4625	Muddy	Coastal Plain Sand	N/A	N/A	The sample is an awkward shape.
4626	Muddy	Coastal Plain Sand	1.5905	1.1695	
4627	Muddy	BC[3] Sand	0.8895	0.566	
4628	Muddy	BC Sand	1.4795	1.334	
4629	Muddy	BC Sand	1.038	1.0098	
4630	Muddy	BC Sand	N/A	N/A	The sample consisted of drilling mud and sand.
4632	Muddy	BC Sand	1.4265	1.038	
4633	Muddy	BC Sand	1.521	1.421	
4635	Muddy	BC Sand	1.2985	1.127	
4636	Muddy	BC Sand	1.364	N/A	Half plugs are held together with drilling mud.
4637	Muddy	BC Sand	1.327	1.2065	
4638		Rozet	1.088	N/A	The plug is split in the middle.
4639		Rozet	1.4395	0.768	
4640		Rozet	1.1145	0.89	

[1] Energy & Environmental Research Center.
[2] Not applicable.
[3] Bell Creek.

Table A-12. Logs for Well 56-14R

Log	Range, ft
Resistivity	1055–4848
Gamma Ray	0–4813
Neutron Porosity	855–4760
Bulk Density	1060–4760
Spectral Gamma Ray	1025–4751
Spontaneous Potential	930–4848
– P & S* Wave	1060–4800
– Mechanical Rock Properties	1060–4800
Borehole Volume	930–4835
Multiarm Caliper	930–4848
Magnetic Resonance	2120–2230, 2960–3090, 4470–4847

* Primary and secondary.

Table A-13. Picked Formation Tops Based on Wireline Logs for Well 56-14R, ft

Formation	Prognosis	Geological Report Log Depth			MBOGC[2] Well Information
	MD[3]	Sample	E-Log	Datum	MD
KB[4]	+3877	+3841			
Fox Hills	686	642	–	3199	
Pierre Shale	901	859	–	2982	
Eagle	1965	1930	1934	1907	1932
Shannon	2174	2132	2139	1707	2138
Niobrara	3022	2991	2991	850	2985
Mowry	4432	4398	4394	−553	4393
Shell Creek	4610		4583	−742	4400
Springen Ranch	4631		4594	−753	4595
Muddy	4649	4620	4614	−773	4611
					Coastal Plain 4612
Rozet	4682		4648	−804	4645
Skull Creek	4700	4655	4657	−816	4657
Dakota Silt		4810	4811	−970	
Dakota Sand		4825	4822	−981	
Total Depth	**4800**	**4850**	**4845**	**−1004**	**4850**

[1] Energy & Environmental Research Center.
[2] Montana Board of Oil and Gas Conservation.
[3] Measured depth.
[4] Kelly bushing.

CHARACTERIZATION WELL 33-14R

Well
Operator: Denbury Onshore, LLC
Permit Type: Oil, permitted injection well
PCOR Partnership Purpose: Characterization
Well: 33-14R
API Number: 25-075-22438-0000
Field: Bell Creek
County: Powder River
State: Montana
Location: Section 33, Township 8 S, Range 54 East, SESW 731' FSL & 1944' FWL
Ground Level: 3757.8 ft
Kelly Bushing: 3767.7 ft
Latitude: 45.09327 N
Longitude: −105.11256 W
Spud Date: 12-March-13
Contractor: Capstar 311
Drilling Fluid Type: Water-based mud

Completions
Bit Size for Conductor Casing:
Conductor Casing: 16-inch 65 lb H-40
Conductor Casing Shoe: 90 ft
Bit Size for Surface Casing: 13.5 (13½) inch
Surface Casing: 9.625 (9⅝)-inch 36 lb ST&C J-55
Surface Casing Shoe: 848 ft
Surface Casing Cement:
Lead Cement: VariCem™ 120 sk 11.5 ppg
0.125 lbm Poly-E-Flake (lost circulation additive)
Tail Cement: VariCem™ 255 sk 13 ppg
0.125 lbm Poly-E-Flake (lost circulation additive)
Bit Size for Production Casing: 8.75 (8¾) inch
Total Depth (TD): 4765 ft
Production Casing: 5.5 (5½) inch 15.5 lb J-55 LTC
Bottom of Production Casing Float Shoe: 4760 ft
Top of Float Collar: 4669.8 ft
Production Casing Cement:
Lead Cement: EconoCem™ 435 sk 11.8 ppg
0.125 lbm Poly-E-Flake (lost circulation additive)
0.05% FE-2 (iron-sequestering agent)
Tail Cement: EconoCem™ 275 sk 14.3 ppg
0.125 lbm Poly-E-Flake (lost circulation additive)
0.05% SA-1015™ (suspending agent)
Top of Cement: Surface
TD Cased Hole:
Tubing (kill string): 2.375 (2⅜)-inch 4.7 lb J-55
Tubing Depth: 4406 ft

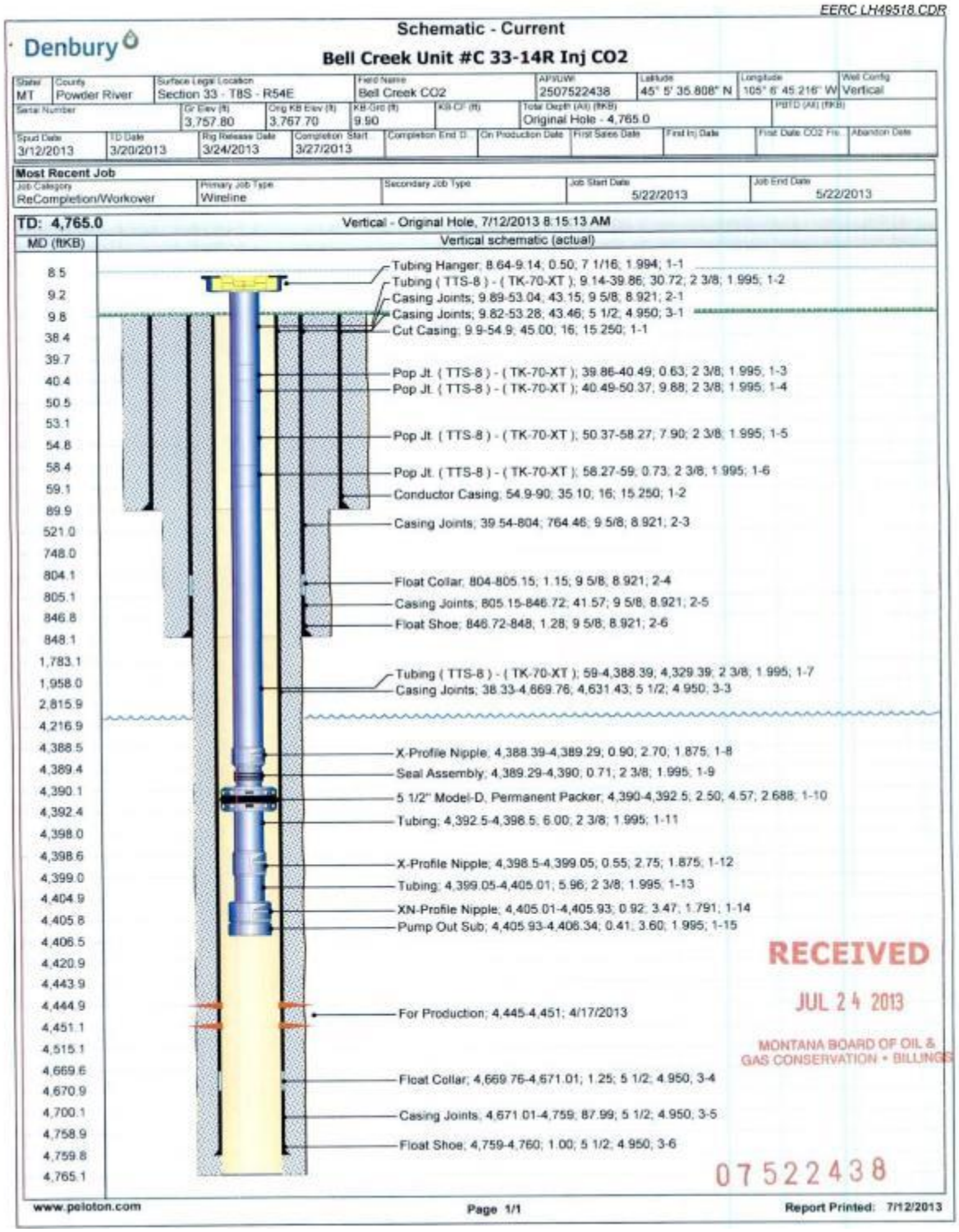


Figure A-5. Well completions “Schematic.”

Table A-14. 33-14R Regulation-Related Drilling and Completion Summary

Date	Action
January 11, 2013	Application for a permit to drill was approved.
January 25, 2013	Modification to permit, to include a coring program.
March 12, 2013	Spud date.
March 26, 2013	Modification to permit, to haul excess drill cuttings to a remote storage pond.
March 28, 2013	Approval for the well to be completed as an injector in the Muddy Formation was granted.
April 4, 2013	The previously approved landowner agreement for the remote cuttings pit was approved.
April 19, 2013	Completion date.
April 15, 2013	Reserve pit reclaimed. The cuttings were solidified with and covered with native soil.
May 20, 2013	Sundry Notice for reserve pit was approved.
December 3, 2013	Well was permitted as an injection well.

Table A-15. Core Intervals from 33-14R

	Attempted Interval, ft		Actual Interval, ft	
Core	From	To	From	To
1	4413	4444	4413	4441.35
2	4444	4476	4441.35	4473.35

Table A-16. Logs for Well 33-14R

Log	Range, ft
Resistivity	850–4747
Gamma Ray	0–4732
Neutron Porosity	756–4660
Bulk Density	756–4660
Spontaneous Potential	830–4740
– Anisotropy	4200–4700
– P & S* Wave	840–4730
– Mechanical Rock Properties	4200–4700
Borehole Volume	108–4675
Magnetic Resonance	1947–4756

* Primary and secondary.

Table A-17. Picked Formation Tops Based on Wireline Logs for Well 33-14R, ft

Formation	Prognosis	Geological Report Log Depth			Completion Report
	MD[2]	Sample	E-Log	Datum	MD
KB[3]	+3817			+3767.7	
Fox Hills	521	558	–	3210	
Pierre Shale	748	759	–	3009	
Eagle	1783	1755	1750	2018	
Shannon	1958	1965	1957	1811	
Niobrara	2816	2823	2813	955	
Mowry	4217	4222	4216	−448	
Shell Creek	4398	4403	4399	−631	4401
Springen Ranch	4421	4427	4421	−652	4419
Muddy BC20[4]	4444	4451	4444	−676	4443
					4445
Rozet		4459	4451	−683	4454
Skull Creek	4515	4472	4471	−703	4464
Dakota Silt			4324	−856	
Upper Dakota Sand			4633	−865	
Lower Dakota Sand			4696	−928	
Total Depth	**4700**	**4765**	**4756**	**−988**	**4765**

[1] Energy & Environmental Research Center.
[2] Measured depth.
[3] Kelly bushing.
[4] Bell Creek.

GROUNDWATER-MONITORING WELL MW0504 (FOX HILLS)

Well
Operator: EERC
Permit Type: Not applicable
PCOR Partnership Purpose: Groundwater monitoring
Well: MW0504 (Fox Hills)
API Number: Not applicable
Field: Bell Creek
County: Powder River
State: Montana
Location: Section 5, Township 9 S, Range 54 East, NWNW
Ground Level:
Kelly Bushing:
Latitude: 45.08965 N
Longitude: −105.137683 W
Spud Date: Jan-13
Contractor:
Drilling Fluid Type: Water-based mud

Completions
Bit Size for Conductor Casing: 10.5 (10½) inch
Conductor Casing: 8 inch
Conductor Casing Shoe: 63 ft
Bit Size for Surface Casing: 5.875 (5⅞) inch
Surface Casing: 4-inch steel
Surface Casing Shoe:
Surface Casing Cement: Cement + bentonite
Bit Size for Production Casing: Not applicable
Total Depth (TD): 820 ft
Production Casing: Not applicable
Bottom of Production Casing Float Shoe: Not applicable
Top of Float Collar: Not applicable
Production Casing Cement: Not applicable
Top of Cement:
TD Cased Hole:
Tubing (kill string):
Tubing Depth:
Screen: 80-ft stainless steel from 677 to 757 ft

Equipment: Electric submersible pump

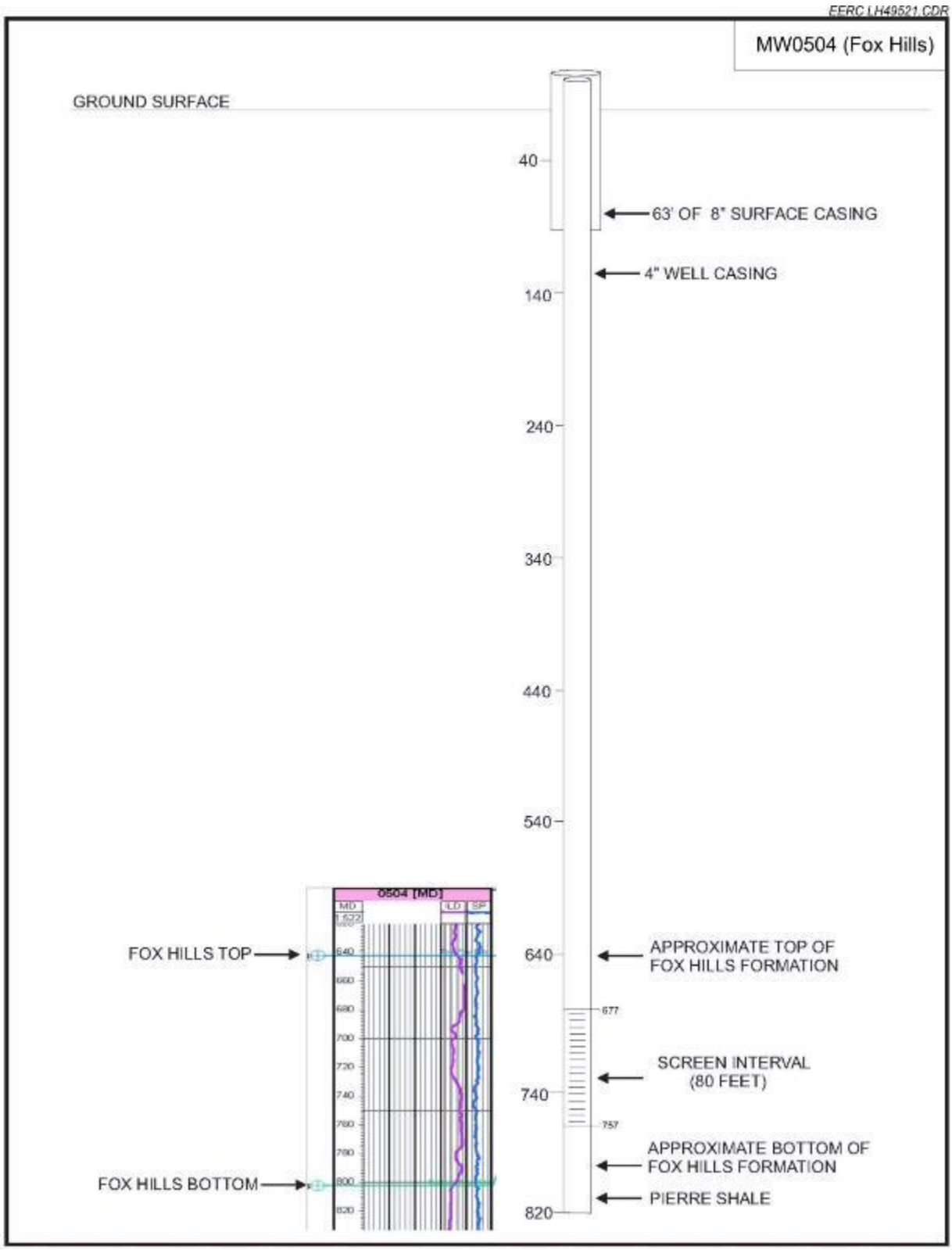


Figure A-6. Completion diagram for Groundwater-Monitoring Well MW0504 (Fox Hills).

Table A-18. Materials Encountered During Drilling of MW0504 (Fox Hills)

Depth, ft		
From	To	Material
0	18	Sandy brown clay
18	60	Sandy brown clay
60	61	Rock
61	79	Brown shale
79	300	Blue shale
300	313	Coal
313	345	Shale
345	361	Sandy shale
361	405	Sand
405	407	Rock
407	485	Shale
485	487	Coal
487	500	Blue shale
500	575	Sand
515	563	Shale
563	570	Coal
570	606	Brown shale
606	685	Blue shale
685	760	Sand
760	800	Shale

GROUNDWATER-MONITORING WELL MW3312 (FOX HILLS)

Well
Operator: Energy & Environmental Research Center
Permit Type: Not applicable
PCOR Partnership Purpose: Groundwater monitoring
Well: MW3312 (Fox Hills)
API Number: Not applicable
Field: Bell Creek
County: Powder River
State: Montana
Location: Section 33, Township 8 S, Range 54 East, NWSW
Ground Level:
Kelly Bushing:
Latitude: 45.096883 N
Longitude: −105.11785 W
Spud Date: Feb-13
Contractor:
Drilling Fluid Type: Water-based mud

Completions
Bit Size for Conductor Casing: 8.75 (8¾) inch
Conductor Casing: 6-inch plastic
Conductor Casing Shoe: 400 ft
Bit Size for Surface Casing: 5.875 (5⅞) inch
Surface Casing: 4-inch steel
Surface Casing Shoe:
Surface Casing Cement: cement + bentonite
Bit Size for Production Casing: Not applicable
Total Depth (TD): 605 ft
Production Casing: Not applicable
Bottom of Production Casing Float Shoe: Not applicable
Top of Float Collar: Not applicable
Production Casing Cement: Not applicable
Top of Cement:
TD Cased Hole:
Tubing (kill string):
Tubing Depth:
Screen: 60-ft PVC from 545 to 605 ft

Equipment: Electric submersible pump

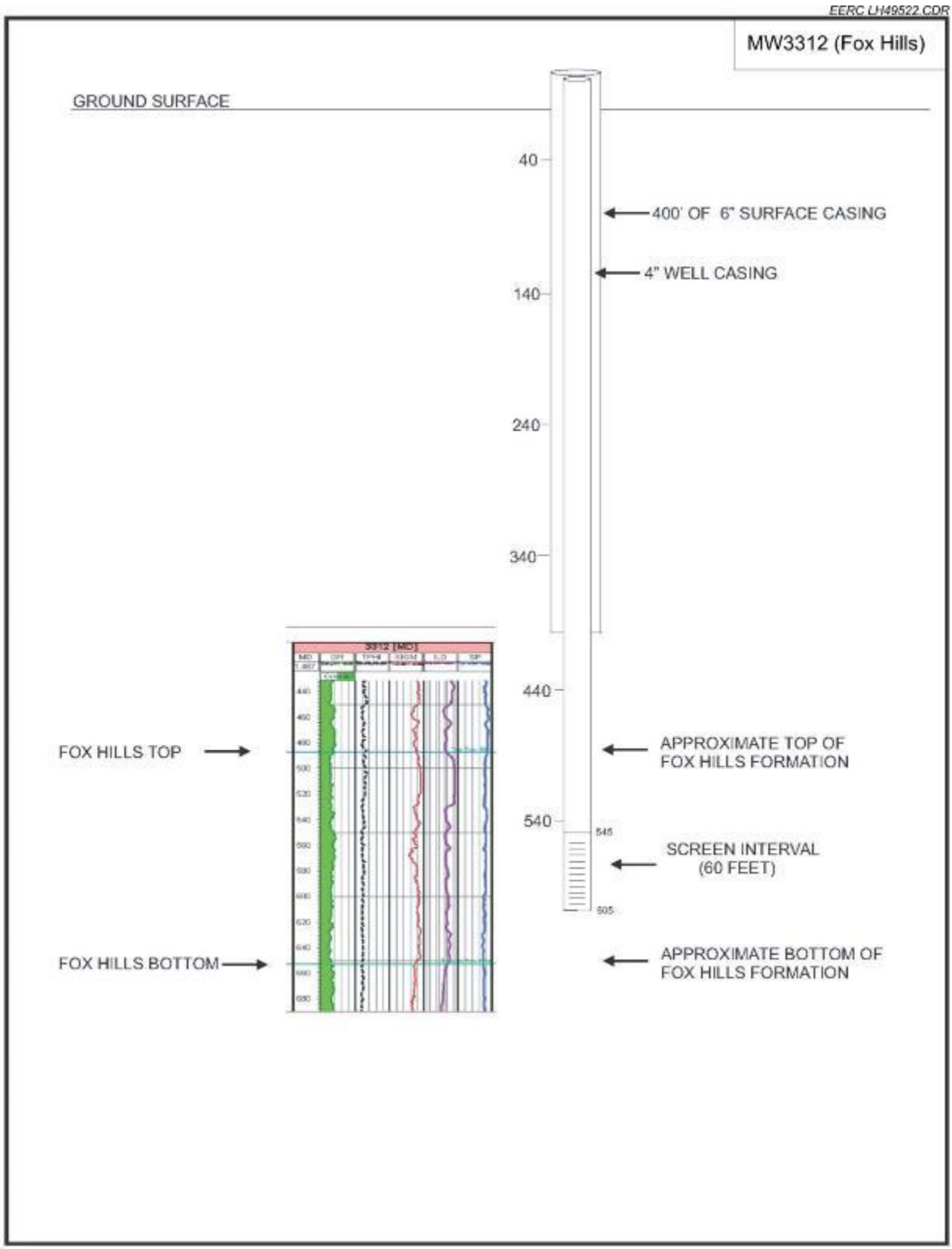


Figure A-7. Completion diagram for Groundwater-Monitoring Well MW3312 (Fox Hills).

Table A-19. Materials Encountered During Drilling of MW3312 (Fox Hills)

Depth, ft		
From	To	Material
0	80	Shale
80	81	Rock
81	86	Shale
86	100	Carbonate shale
100	135	Sandy shale
135	136	Rock
136	200	Shale
200	220	Sand
220	230	Shale
230	260	Sand
260	262	Rock
262	272	Sand
272	278	Coal
278	380	Shale
380	405	Sand
405	478	Shale
478	510	Sand
510	540	Shale
540	598	Sand
598	605	Shale