**Appendix F**

Pump Test # 8 Report

AQUI-VER, INC.

Cameco

# Marsland Hydrologic Testing Report - Test # 8

## Marsland Expansion Area, Dawes County, NE

## FINAL REPORT

July 8, 2011

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# 1. EXECUTIVE SUMMARY

As part of Cameco Resources U.S. Nuclear Regulatory Commission License Amendment Application to conduct In-Situ Recovery operations in the Marsland Expansion Area, a regional groundwater pumping test was completed to:

1. Demonstrate hydraulic communication between the production zone pumping well and the surrounding production zone observation wells;
2. Assess the hydrologic characteristics of the production zone aquifer within the test area;
3. Evaluate the presence or absence of hydrologic boundaries in the production zone; and
4. Demonstrate sufficient confinement between the production zone and the overlying aquifer for the purpose of ISR mining.

The pumping test at the Marsland Expansion Area utilized one pumping well (CPW-1A) and nine observation wells (CPW-1 and Monitor-2 through Monitor-8) completed in the Basal Chadron Sandstone, as well as three overlying observations wells (BOW-1 through BOW-3) completed in the Brule Formation. The total length of the test was 4.29 days. The average discharge rate was 27.08 gallons per minute (gpm).

During the test, drawdown of greater than 0.8 feet was observed in all Basal Chadron Sandstone observation wells included in the formal observation well network. Based on the drawdown response observed at the most distant observation well locations (Monitor-2 and Monitor-8), the radius of influence of the test is slightly more than 8,800 feet. The drawdown response measured in all Basal Chadron Sandstone observation wells demonstrates hydraulic communication between the production zone pumping well and the surrounding observation wells across the entire test area.

No drawdown was observed in overlying Brule Formation observation wells during the test period. This observation supports the conclusion that adequate confinement exists between the overlying Brule Formation and the Basal Chadron production zone.

Drawdown and recovery data collected from the monitor wells were graphically analyzed to determine the aquifer properties including transmissivity and storativity. The methods of analysis included the Theis (1935) drawdown and recovery methods, and the Jacob Straight-Line Distance-Drawdown method (Cooper and Jacob, 1946).

Transmissivities for the Basal Chadron Sandstone calculated from the drawdown and recovery data ranged from 230 $ft^2$/day to 2,469 $ft^2$/day, respectively. A value of 1,012 $ft^2$/day is believed representative of the average transmissivity over the radius of influence. Based on an average net sand thickness of 40 feet, the average hydraulic conductivity of the Basal Chadron Sandstone is 25 ft/day. Hydraulic conductivities of the aquifer materials in the vicinity of the pumped well (including wells CPW-1A, CPW-1, and Monitor-3) were approximately 3 to 9 times less than those calculated for other wells in the pumping test area based on both the drawdown and recovery analyses, as indicated by an apparent higher conductivity boundary condition effect (flattening of drawdown and recovery curves) in these wells. The storativity calculated from the drawdown data ranged from 1.7E-03 to 8.32E-05, with an average value of 2.56E-04 for the entire test area.

The transmissivity of the Basal Chadron Sandstone within the Marsland Expansion Area investigated herein is higher on average than the existing Class III Permit Area and the Three Crow and North Trend Expansion Areas.

## 2. INTRODUCTION

Cameco Resources intends to submit an U.S. Nuclear Regulatory Commission (NRC) License Amendment Application to conduct in-situ recovery (ISR) operations in the Marsland Expansion Area, which is located approximately seven miles southeast of the current Class III Underground Injection Control (UIC) permit area and about four miles northeast of Marsland, Nebraska (**Figure 1**). As part of the amendment application, and in accordance with Nebraska Department of Environmental Quality (NDEQ) regulations, a regional groundwater pumping test was completed in the Marsland Expansion Area as described herein.

### 2.1 Purpose and Objectives

As part of the NRC License Amendment Application to conduct ISR operations in the Marsland Expansion Area, a regional groundwater pumping test was completed to:

1. Demonstrate hydraulic communication between the production zone pumping well and the surrounding production zone observation wells;
2. Assess the hydrologic characteristics of the production zone aquifer within the test area;
3. Evaluate the presence or absence of hydrologic boundaries in the production zone; and
4. Demonstrate sufficient confinement between the production zone and the overlying aquifer for the purpose of ISR mining.

The pumping test described herein was performed in accordance with the NDEQ approved Regional Pumping Test Plan dated September 27, 2010 and subsequent approved changes to the Regional Pumping Test Plan dated March 16, 2011. In accordance with state regulations and Cameco Resources existing Class III UIC permit, the following information is included as part of the Hydrologic Test Report requirements:

- A description and maps of the proposed permit area;
- Construction details for pumping and observation wells;
- Description of site stratigraphy and hydrogeology;
- Geologic cross-sections;
- Description of pumping test configuration and equipment;
- Discussion of pumping test performance and methods used for data analysis;
- Presentation of the results of the pumping test, including best estimates of transmissivity, hydraulic conductivity, and storativity for all observation wells and the pumped well;
- Type-curve match for each monitoring well used to develop best estimates of aquifer parameters;
- Assessment demonstrating confinement of the ore-bearing aquifer;
- Contour map showing drawdown observed at the end of the pumping period;
- Calculation of radius of influence; and

- Compilation of water level (drawdown) and barometric pressure data for all wells, including pre-test, pumping test, and recovery data

Upon approval of the Hydrologic Test Report and other related permit documentation, NDEQ will provide Cameco Resources the authority to commence mining operations within the radius of influence (ROI) defined by the results of this hydrologic test report. Additional pumping tests will be necessary if ISR occurs outside of the demonstrated ROI. Additional approval must be granted from the NRC. This report addresses only the hydrologic testing activities and results. Baseline water quality data and subsequent discussion will be submitted under a separate cover.

## 2.2 Report Organization

This report includes nine sections. Subsurface geology and site stratigraphy are discussed in **Section 3**. **Section 4** presents historical pumping test results. Information related to the monitor well locations and completions is included in **Section 5.** Data Collection and Field Procedures are presented in **Section 6**. Test results and analytical procedures are presented in **Section 7**. Conclusions and references are included in **Sections 8 and 9**, respectively.

## 3. GENERAL SITE STRATIGRAPHY

The subsurface stratigraphy of the Marsland Expansion Area is based on preliminary test hole drilling conducted at the Marsland property and correlation of regional geologic formations observed at the current Class III permit area and proposed expansion areas. A generalized stratigraphic section and well completion intervals for the Marsland Expansion Area is provided in **Table 1**. A cross-section location map is provided in **Figure 2**. Geologic cross-sections are included in **Figures 3** through **8**. Structure contour maps of the top of the Basal Chadron Sandstone and underlying Pierre Shale are included in **Figures 9** and **10**, respectively. Isopach maps depicting the thickness of the Basal Chadron Sandstone and overlying Upper/Middle Chadron confining unit are included in **Figures 11** and **12**, respectively.

Ore-grade uranium deposits underlying the Marsland Expansion Area are located in the Basal Chadron Sandstone, which averages 50 feet in thickness (typically 40 feet net sand) and occurs at depths ranging from 900 to more than 1,100 feet below ground surface. Ore-grade deposits are generally located along a northwest-southeast trend in the Basal Chadron Sandstone. The width of the mineralized zone is generally less than 1,500 feet along this trend. Ore-grade deposits are located primarily in the lower portion of the Sandstone, although ore-grade deposits may occur locally throughout the section. Based on drilling to date, the highest concentration of mineralization is located in the north, northcentral, and southern portion of the expansion area.

The Basal Chadron Sandstone does not contain distinct clay layers that can be correlated over significant distances, and therefore represents a single sand "package" with some interbedded clay lenses. The Upper/Middle Chadron Formation (confining unit), consisting primarily of clay, claystone and siltstone, and separates the Basal Chadron Sandstone from the overlying Brule Formation. The Upper/Middle Chadron confining unit is approximately 700 feet thick in the Marsland Expansion Area. The overlying Brule Formation consists primarily of interbedded siltstone and clayey sandstone and is approximately 150 feet thick in the Marsland Expansion Area. The Brule Formation is overlain locally by the Arikaree Formation, a calcareous sandstone with interbedded siltstone and claystone generally less than 150 feet thick in the Marsland Expansion Area.

No significant sands have been identified within the Upper/Middle Chadron Formation that can be over any significant distance. Hence, wells installed in the overlying Brule Formation were monit overlying aquifers during the pumping test.

Text updated to 350-550 feet thick U/M Chadron confinement

## 4. SUMMARY OF HISTORICAL TESTING RESULTS

During the initial permitting and development of the Crow Butte mine, four pumping tests (referred to as Tests #1 though #4) were performed in the current UIC Permit (NE0122611) area. The tests were performed to: 1) confirm confinement of the ore-bearing aquifer, and 2) assess the hydraulic characteristics of the Basal Chadron Sandstone. Three additional pumping tests (#5 though #7) were performed to characterize the Basal Chadron Sandstone in the North Trend and Three Crow expansion areas. **Table 2** summarizes historical testing results.

Results of previous testing indicate the Basal Chadron Sandstone is relatively homogeneous and isotropic within the current Class III UIC permit area (e.g. the hydraulic conductivity is reasonably uniform with respect to location and direction), although higher values of hydraulic conductivity (permeability) are observed in the southern portion of the Class III UIC permit area (Test #4).

In the Three Crow area, values of hydraulic conductivity, transmissivity, and storage are similar to the permitted Class III UIC area, although the Basal Chadron Sandstone at Three Crow is divided locally into Upper and Lower Basal Sand units. The stratigraphy of the Basal Chadron Sandstone in the North Trend area is more complex and anisotropic than observed at other test locations.

In addition to the aforementioned historical pumping tests, a failed pumping test was undertaken in the Marsland Expansion Area on November 18, 2010. The pumping test was terminated after only 19 hours of operation due to pump failure. Although data collected as part of the failed pumping test was not formally analyzed, information gained from the failed test was used to modify the Pumping Test Plan for the subsequent successful test described herein.

## 5. MONITORING WELL LOCATIONS, INSTALLATION AND COMPLETION

As part of the Marsland Pumping Test #8, Cameco Resources installed seven new wells in the Basal Chadron Sandstone (CPW-1, CPW-1A, Monitor-4A, Monitor-5 through Monitor-8) and redeveloped two existing wells (Monitor-2 and Monitor-3). Of these wells, only the pumped well (CPW-1A) and Monitor-3 through Monitor-7 were included in the formal Basal Chadron Sandstone observation well network. Cameco also installed three new wells in the overlying Brule Formation (BOW-1 through BOW-3). The pumping and observation wells are located in Sections 1, 2, and 12 of Township 29 North, Range 51 West, and Section 18 of Township 29 North, Range 50 West (**Figure 1**).

Because the underlying Pierre Shale is over 1,500 feet thick, no underlying monitoring wells were warranted. The depth to water in the Basal Chadron Sandstone is approximately 450 feet bgs.

**Table 3** summarizes well construction details for all test wells and **Figure 13** illustrates the locations of these wells. **Appendix A** includes the NDEQ well completion reports. The nature and thickness of the subsurface formations encountered during the installation of monitoring wells is representative of the stratigraphic section presented in **Table 1**. Monitoring wells were located at various distances and directions from the pumping well (CPW-1A) such that sufficient drawdown would be observed to allow hydraulic properties of the Basal Chadron Sandstone to be determined over the entire test area.

# 6. FIELD PROCEDURES AND DATA COLLECTION

The following tasks were accomplished as part of the pumping test field data collection program:

- Installation of In-Situ brand Level TROLL® data loggers (vented) into the observation wells and pumping well to record changes in water levels during the test;
- Measurement of baseline (pre-test) water levels and barometric pressure for a period of at least one week prior to the test;
- Periodic measurement of the pumping rate from the pumping well, and
- Collection of water level and barometric pressure data throughout the background, pumping, and recovery periods.

## 6.1 Pumping Test Equipment

Marsland Pumping Test #8 was performed using a 4-inch diameter 10 horsepower electrical submersible pump powered by a portable generator. The pump was set in well CPW-1A at an approximate depth of 600 feet, or 150 feet below the static water level. Flow from the pump was controlled with a manual valve and surface flow measured with two flow/totalizer meters. Per NDEQ direction, discharge water was collected in FRAC tanks and trucked to the Crow Butte facility for disposal.

Water levels in the observation wells and the pumping well were measured and recorded with dedicated In-Situ brand Level TROLL® 500 and Level Troll® 700-series pressure transducers/data loggers equipped with vented cables (for barometric pressure compensation). The data loggers were programmed to automatically calibrate prior to the test, record an initial reference water level elevation (head), and measure and record water levels according to programmed linear time schedules. The pressure rating for the transducers ranged from 30 pounds per square inch (PSI) in the observation wells to 100 pounds PSI in the pumping well. A separate barometric pressure transducer/data logger was deployed near the pumping well in the center of the test area. **Table 4** summarizes the PSI range and model for each transducer deployed at the Site.

## 6.2 Data Collection

To assess pre-test baseline water level fluctuations, water level data and barometric pressure data were recorded prior to the pumping period (pre-test period). Pre-test baseline monitoring was initiated on May 6, 2011 and ran for a period of 7 days before initiating the pumping test.

All pressure transducers were programmed to record water levels every 4 minutes during the pre-test, pumping, and recovery periods with the exception of observation well CPW-1 and pumping well CPW-1A. These wells were programmed using an event schedule. The transducers checked the water level in these wells every 30 seconds and if the water level in CPW-1 changed by 0.1 feet a reading was recorded and if the water level in CPW-1A changed by 0.5 feet a reading was recorded otherwise readings were recorded every 4 minutes. **Table 4** summarizes the logging interval for each transducer deployed at the Site.

The pumping test was started at 05:00 hours on May 16, 2011 and was terminated at 12:00 hours on May 20, 2011. The total length of the test was 4.29 days. As shown in **Table 5** the average discharge rate was 27.08 gallons per minute (gpm).

## 6.3 Water Management

Pumped water was collected in on-site FRAC tanks and transported to the Crow Butte facility evaporation ponds for disposal. Approximately 167,300 gallons of groundwater was collected and disposed over the 4.29 day pumping period.

# 7. TEST RESULTS

## 7.1 Potentiometric Surface

**Figure 14** presents the potentiometric surface for the Basal Chadron Sandstone aquifer based on the monitoring wells installed within the Marsland Expansion Area. Water levels were measured and recorded on November 12, 2010 and are summarized in **Table 6**. The pumping well for the test (CPW-1A) was installed after these measurements were recorded and is therefore not included in the data set presented in **Figure 14** and **Table 6**. The data are considered representative of static conditions within this aquifer. Based on these data, groundwater in the Basal Chadron Sandstone flows predominantly to the northwest toward the White River drainage at a lateral hydraulic gradient of 0.0004 ft/ft (slope of the potentiometric surface).

**Figure 15** presents the potentiometric surface for the overlying Brule Formation aquifer based on monitoring wells installed within the Marsland Expansion Area. Water levels were measured and recorded on November 12, 2010 and are summarized in **Table 6**. All wells measured were utilized as observation wells during the test. The data are considered representative of static conditions within this aquifer. Based on these data, groundwater in this aquifer flows predominantly to the southeast toward the Niobrara River drainage at a lateral hydraulic gradient of 0.011 ft/ft.

## 7.2 Pre-Test Baseline Trends

As discussed in **Section 6.2**, water level data were collected for a period of approximately 7 days prior to the start of the pumping test. Graphs of the pre-test, pumping and recovery water level data and barometric pressure data vs. time are included in **Appendix B (Graphs B1** through **B12)**. Water levels were variable and did respond slightly to barometric fluctuations but were generally stable (+/- 0.9 feet) prior to the test in both the Basal Chadron Sandstone and Brule Formation aquifers.

## 7.3 Brule Formation Response (Overlying Unit)

During the test (pumping and recovery periods), no discernable drawdown or recovery response was observed in Brule observation wells. Observation wells BOW-1, BOW-2, and BOW-3 did exhibit small fluctuations in water levels during the test period; however, these fluctuations are directly related to atmospheric pressure variations and not due to drawdown from pumping, as illustrated by **Graphs B1** through **B3** in **Appendix B**.

## 7.4 Basal Chadron Sandstone Response (Production Zone)

**Table 7** summarizes the corrected and uncorrected observed drawdown in the Basal Chadron Sandstone immediately prior to shutting off the pump. During the pumping portion of the test there was a low pressure event (cold front) that caused the observed drawdown to fluctuate by approximately 0.1 foot. **Figure 16** illustrates the drawdown immediately prior to shutting off the pump using the corrected drawdown values. With the exception of distal wells Monitor-2 and Monitor-8 (which are not part of the formal observation well network) drawdown of greater than 0.8 feet was observed in all of the observation wells, with a maximum drawdown of 23.40 feet observed in CPW-1A (pumping well).

## 7.5 Data Analysis

### 7.5.1 Analytical Methods

Drawdown data vs. time were plotted for each observation well, and based on the character of the curves it was determined that confined aquifer analytical methods were appropriate for the analysis of water level data. These methods are consistent with that proposed in the Pumping Test Workplan.

Drawdown and recovery data collected from the observation wells were graphically analyzed to determine aquifer properties including transmissivity and storativity. The methods of analysis included Theis drawdown and recovery methods (1935), and the Cooper-Jacob Distance-Drawdown method (Cooper and Jacob, 1946). The software used to graphically analyze the data was Aquifer$^{Win32}$ version 3 developed by Environmental Simulations, Inc.

The major assumptions inherent in the application of these analytical methods include:

- The aquifer is confined and has apparent infinite extent;
- The aquifer is homogeneous and isotropic, and of uniform effective thickness over the area influenced by pumping;
- The piezometric surface is horizontal prior to pumping;
- The well is pumped at a constant rate;
- Water removed from storage is discharged instantaneously with a decline in head;
- The pumping well is fully penetrating; and
- Well diameter is small, so well storage is negligible.

These assumptions are reasonably satisfied over the test area. Locally, the Basal Chadron Sandstone is not homogenous and isotropic; however, over the scale of the pumping test, it can be treated as such for analytical purposes.

As discussed previously, no background trend corrections were warranted; however, all of the water levels measured in the observation wells, with the exception of CPW-1 and CPW-1A, were corrected for atmospheric pressure fluctuations.

### 7.5.2 Barometric Pressure Correlations and Corrections

As discussed previously, all of the Level TROLL® data loggers used in the test were vented (gauged). The vent eliminates the impact of barometric pressure on the sensor; however, a change in water levels due to barometric changes will occur whether a vented sensor is used or not. Hence, use of vented equipment eliminates the barometric impact on the sensor, but does not correct the water level measurements for barometric effects on the aquifer. As such, the vented data loggers are barometrically compensated, but not corrected.

#### 7.5.2.1. Barometric Corrections

To evaluate if corrections due to barometric fluctuations were necessary, graphs of barometric pressure and groundwater levels vs. time were prepared for all of the wells monitored during the test. These graphs include data from the pre-test, drawdown, and recovery periods and are presented in **Appendix B (Graphs B1** through **B12)**. In addition the barometric efficiency of the Basal Chadron Sandstone aquifer was estimated to better understand the relationship between a change in barometric pressure and a measurable change in groundwater levels.

The barometric efficiency is the water level change caused by a barometric pressure change divided by that barometric pressure change (Clark, 1967). In a confined aquifer like the Basal Chadron Sandstone, an increase in barometric pressure usually will cause a decrease in water level in an open well by an amount governed by the barometric efficiency (Todd, 1959; Ferris and others, 1962; Freeze and Cherry, 1979; Kruseman and de Ridder, 1991; Landmeyer, 1996; Rasmussen and Crawford, 1997; and Batu, 1998). There are several methods to estimate the barometric efficiency. For this analysis the slope method on water level and barometric pressure change was used (Ferris and others, 1962). Measurements of change in water level are plotted on the y-axis and measurements of change in barometric pressure are plotted on the x-axis. A line is fitted to the plotted points and the slope of the line is the estimate of barometric efficiency.

The barometric efficiency of the aquifer was estimated using the pre-test water level data from Monitor-3 and the Baro TROLL® as the barometric sensor was located near the Basal Chadron Sandstone observation well Monitor-3. **Figure 17** illustrates the change in barometric pressure vs. change in water level for the pre-test period. Based on the slope of the data a barometric efficiency of 0.33 or 33 percent was estimated.

During the drawdown and recovery phases of the test the atmospheric pressures were variable with both increasing and decreasing pressure events as shown by the graphs in **Appendix B**. All of the Basal Chadron Sandstone observation wells appear to demonstrate a small but discernable barometric water level response during the test (up to 0.3 feet of barometric water level variation over the entire test period). As a conservative measure, barometric water level corrections were made for all Basal Chadron Sandstone wells except the pumped well (CPW-1A) and the closest observation well (CPW-1), which experienced large drawdowns (greater than 6 feet) relative to much smaller barometric fluctuations (making corrections unnecessary in these wells). As shown in the graphs in **Appendix B**, barometric corrections did not significantly affect the data but did smooth water level trends during low and high pressure events. These transducers were set to log based on an event schedule as discussed in **Section 6.2**.

## 7.6 Analytical Test Results

**Appendix C** includes the type curve matches for the drawdown and recovery data. Water level data for all wells monitored, including the pre-test, pumping, and recovery phases of the test, are included in **Appendix D** on a CD ROM.

### 7.6.1 Distance Drawdown Analysis

A distance drawdown graph of the data was prepared as a preliminary estimate of transmissivity and storativity and is shown on **Figure 18**. Based on this simple analysis the average transmissivity over the area of influence is approximately 737 square feet per day ($ft^2$/day) and the storativity is approximately 4.9E-

05. Based on an average net sand thickness of 40 feet, the average hydraulic conductivity over the area of influence is approximately 18.4 feet per day (ft/day)

### 7.6.2 Theis Drawdown Analysis

Transmissivity was calculated for all wells except for the pumping well using the Theis (1935) method for drawdown analysis in a confined aquifer. Type curve matches for the drawdown data are included in **Appendix C**, **Graphs C-1** through **C-8**. Type curve matching generally focused on late-time drawdown data since this data normally considered the most reliable indicator of overall aquifer response. Type curve matching for wells CPW-1A, CPW-1, and Monitor-3 focused on middle-time data for the drawdown phase of test due to the presence of a higher permeability boundary condition apparent in the late-time data for these wells. Log-log plots of drawdown data for wells CPW-1A, CPW-1, Monitor-3, and Monitor 5 are shown in **Figure 19**. The drawdown data for wells CPW-1A, CPW-1, and Monitor-3 show a late-time flattening of the curve (indicative of higher permeability boundary condition), whereas the drawdown data for Monitor-5 (and all other distant observation wells) exhibited a more typical confined aquifer drawdown response. Aquifer storativity ranged from 1.7E-03 to 8.32E-05, with an average value of 2.56E-04 for the entire test area (geometric mean of all values).

The flattening of the drawdown curve in wells located in the immediate vicinity of the pumping well (including wells CPW-1A, CPW-1, and Monitor-3) is believed to be related to a transmissivity contrast between lower permeability aquifer materials near the pumped well location, and higher permeability aquifer materials elsewhere within the radius of influence of the test. As illustrated by the structure contour and isopach maps of the Basal Chadron Sandstone (**Figures 10 and 11**), the pumping test area is located within a northwest trending ancient river channel system (paleochannel) incised into the underlying Pierre Shale. Coarse-grained sands and some gravel are present in drill cuttings and core in exploration boreholes installed west of the test area, as well as more localized areas north and south of the pumped well location (e.g. area between Monitor-2 and Monitor-6) (Mike Brost, Cameco Geologist, personal communication). This permeability contrast is believed to be responsible for the majority of the observed higher transmissivity boundary condition. In addition to the observed permeability contrast, the thickness of the Basal Chadron Sandstone increases to the west of the pumped well location (**Figure 11**), likely resulting in an incremental increase in transmissivity. As shown in **Table 8,** these observations are supported by higher transmissivity and hydraulic conductivity in more distant observation well locations.

Transmissivities calculated from the drawdown data ranged from 230 $ft^2$/day at Monitor-3 to 1780 $ft^2$/day in Monitor-2, with an average transmissivity of 892 $ft^2$/day for the entire test area. Based on an average net sand thickness of 40 feet throughout the pumping test area, hydraulic conductivities ranged from 6 to 45 ft/day, with an average hydraulic conductivity of 22 ft/day for the entire test area. Transmissivity and hydraulic conductivity in the vicinity of the pumped well (including wells CPW-1A, CPW-1, and Monitor 3) were approximately 3 to 8 times lower than transmissivity measured elsewhere within the test area.

### 7.6.3 Theis Recovery Analysis

Transmissivity was calculated using the Theis (1935) Recovery method for all wells monitored during the test. Type curve matching of the recovery data generally focused on late-time data. However, type curve matching for wells CPW-1A, CPW-1, and Monitor-3 focused on middle-time data as a higher permeability

boundary condition was apparent in the late-time data. The flattening of the recovery curve was also observed in the drawdown data, as discussed in the preceding section (**Section 7.6.2**). Type curve matches for the recovery data are included in **Appendix C**, **Graphs C9** through **C17**.

Transmissivities calculated from the recovery data ranged from 299 $ft^2$/day at Monitor 3 to 2,470 $ft^2$/day in Monitor 2, with an average transmissivity of 1,132 $ft^2$/day for entire test area. Based on an average net sand thickness of 40 feet throughout the pumping test area, hydraulic conductivities ranged from 7 to 62 ft/day, with an average hydraulic conductivity of 28 ft/day for the entire test area. Transmissivity and hydraulic conductivity in the vicinity of the pumped well (including wells CPW-1A, CPW-1, and Monitor 3) were approximately 3 to 9 times lower than transmissivity measured elsewhere within the test area.

### 7.6.4 Summary of Analytical Results

Transmissivities calculated from the drawdown and recovery data using the Theis (1935) and Theis (1935) Recovery methods ranged from 230 $ft^2$/day to 2,469 $ft^2$/day with an representative average value of 1,012 $ft^2$/day over the test area. The transmissivities for the recovery data were slightly higher than the drawdown data and are considered more representative of the aquifer properties because of the slight variability in the discharge rate during drawdown phase of the test. Based on average net sand thickness of 40 feet, the representative average hydraulic conductivity of the Basal Chadron Sandstone is 25 ft/day. Hydraulic conductivities and transmissivity of the aquifer in the vicinity of wells CPW-1A, CPW-1, and Monitor-3 were approximately 3 to 9 times less than those calculated elsewhere in the test area. The storativity calculated from the drawdown data ranged from 1.7E-03 to 8.32E-05 with an average value of 2.56E-04 for the entire test area.

## 7.7 Transmissivity Distribution

An isopach of the Basal Chadron Sandstone thickness and spatial distribution of transmissivity is shown on **Figure 20**. Transmissivity values calculated from the recovery data were plotted on the map. In general, higher transmissivities are in areas of thicker sand. However, as discussed previously, lower transmissivities and corresponding lower hydraulic conductivities are present in the vicinity of the pumping well, CPW-1 and Monitor 3. The circular nature of the drawdown cone (**Figure 16**) suggests no significant anisotropic qualities (e.g. directional transmissivity) to the aquifer on a regional scale.

## 7.8 Radius of Influence (ROI)

Based on the drawdown response of 0.86 feet in distant observation well Monitor-7 (located approximately 6,200 feet south of the pumping well), the ROI of the test was in excess of 6,200 feet. Although not included in the formal test monitoring network, data collected from the most distant observation wells (Monitor-2 and Monitor 8) clearly identify drawdown in excess of 0.4 feet due to pumping, and these data are of sufficient quality to reliably determine aquifer parameters at these locations. Therefore, based on the data collected from Monitor-2 and Monitor-8, the ROI for the test is slightly greater than 8,800 feet.

## 8. SUMMARY AND CONCLUSIONS

The following are significant results and conclusions of this work:

- The pumping well and all Basal Chadron observation wells exhibited significant and predictable drawdown during the test, demonstrating that the production zone has hydraulic continuity throughout the test area.
- The average transmissivity of the Basal Chadron Sandstone within the Marsland Expansion Area investigated herein is significantly higher than the existing Class III UIC Permit Area and the Three Crow and North Trend Expansion Areas.
- A zone of lower permeability (although not abnormally low by regional standards) is apparent in the vicinity of the pumping well (CPW-1A) and observation wells CPW-1 and Monitor-3, with significantly higher transmissivity noted elsewhere within the radius of influence of the test.
- Adequate confinement exists between the overlying Brule Formation and the Basal Chadron production zone as evidenced by no discernable drawdown in Brule Formation observation wells.
- The hydrologic properties of the Basal Chadron Sandstone have been adequately characterized to proceed with Class III UIC permitting and a NRC License Amendment Application for the Marsland Expansion Area.

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# Tables

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# Marsland Regional Hydrologic Testing Report - Test # 8
## Crow Butte Project, Marsland Expansion Area

### TABLE 1
**GENERALIZED STRATIGRAPHIC SECTION, MARSLAND EXPANSION AREA**

| Depth (feet bgs) | Geologic Description |
|---|---|
| 0 – 25 | Topsoil and alluvial deposits |
| 25 - 150 | Arikaree Formation – calcareous sandstone, siltstone and claystone (no wells) |
| 150 - 550 | Brule Formation – interbedded siltstone and clayey sandstone (BOW wells) |
| 550 - 1,000 | Upper/Middle Chadron Formation – siltstone and claystone confining unit (no wells) |
| 1,000 - 1,050 | Basal Chadron Sandstone – CPW and Monitor wells |
| 1,050+ | Pierre Shale (no wells) |

Note:
1.bgs = below ground surface

# Marsland Regional Hydrologic Testing Report - Test # 8
## Crow Butte Project, Marsland Expansion Area

### TABLE 2
**PREVIOUS TESTING RESULTS, BASAL CHADRON SANDSTONE**

| Parameter | Class III Permit Area Tests #1 - #3 (mean) | Class III Permit Area Test #4 (south) (mean) | North Trend Tests #5 and #6 (mean) | Three Crow Test # 7 (mean) |
|---|---|---|---|---|
| Transmissivity ($ft^2$/day) | 363 | 826 | 60 | 480 |
| Hydraulic Conductivity (ft/day) | 9.3 | 20.6 | 2.3 | 7.5 |
| Storativity | $9.7 \times 10^{-5}$ | $6.2 \times 10^{-5}$ | $5.3 \times 10^{-5}$ | $8.8 \times 10^{-5}$ |

Note:
1. $ft^2$/day = square feet per day
2. ft/day = feet per day

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## Marsland Regional Hydrologic Testing Report - Test # 8
**Crow Butte Project, Marsland Expansion Area**

### TABLE 3
**MARSLAND PUMING TEST #8 WELL COMPLETION DETAILS**

| Well ID | Northing (ft) | Easting (ft) | Section | Twp/Rng | TOC Elevation (feet amsl) | Total Depth (feet bgs) | Well Diameter (OD) (Inches) | Screen Slot Size (inches) | Top of Screen (feet bgs) | Bottom of Screen (feet bgs) | Screen Intervals (feet bgs) | Screen Length (feet) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Basal Chadron Sandstone Pumping Well** | | | | | | | | | | | | |
| CPW-1A | 446202 | 1121450 | 1 | T29N/R51W | 4262.7 | 1,055 | 4.95 | 0.015 | 1022 | 1052 | 1022-1052 | 30 |
| **Basal Chadron Sandstone Observation Wells** | | | | | | | | | | | | |
| CPW-1 | 446225 | 1121528 | 1 | T29N/R51W | 4261.85 | 1,070 | 4.95 | 0.020 | 1015 | 1048 | 1015-1048 | 33 |
| Monitor-2* | 439439 | 1126362 | 18 | T29N/R50W | 4198.40 | 1,027 | 4.95 | 0.020 | 970 | 1010 | 970-1010 | 40 |
| Monitor-3 | 446288 | 1121519 | 1 | T29N/R51W | 4261.30 | 1,069 | 4.95 | 0.020 | 1016 | 1043 | 1016-1043 | 27 |
| Monitor-4A | 450084 | 1121344 | 1 | T29N/R51W | 4332.10 | 1,134 | 4.95 | 0.020 | 1088 | 1110 | 1088-1110 | 22 |
| Monitor-5 | 447734 | 1119236 | 1 | T29N/R51W | 4339.50 | 1,120 | 4.95 | 0.020 | 1070 | 1120 | 1070-1120 | 50 |
| Monitor-6 | 442856 | 1124385 | 12 | T29N/R51W | 4215.00 | 1,050 | 4.95 | 0.020 | 990 | 1023 | 990-1023 | 33 |
| Monitor-7 | 440358 | 1120757 | 12 | T29N/R51W | 4244.38 | 1,050 | 4.95 | 0.020 | 1000 | 1043 | 1000-1013, 1023-1043 | 33 |
| Monitor-8* | 450974 | 1117005 | 2 | T29N/R51W | 4353.70 | 1,180 | 4.95 | 0.020 | 1085 | 1125 | 1085-1125 | 40 |
| **Brule Formation Observation Wells** | | | | | | | | | | | | |
| BOW-1 | 446250 | 1121572 | 1 | T29N/R51W | 4260.10 | 370 | 4.95 | 0.020 | 285 | 365 | 285-305, 325-365 | 60 |
| BOW-2 | 450154 | 1121367 | 1 | T29N/R51W | 4323.40 | 400 | 4.95 | 0.020 | 339 | 399 | 339-369, 389-399 | 40 |
| BOW-3 | 450974 | 1117056 | 2 | T29N/R51W | 4350.30 | 415 | 4.95 | 0.020 | 345 | 415 | 345-365, 385-415 | 50 |

Note:
1. * Wells Monitor-2 and Monitor-8 were monitored and analyzed as described in the original Plan, but are not part of the formal monitoring network
2. Twp = Township
3. Rng = Range
4. amsl = above mean sea level
5. OD = outer diameter
6. bgs = below ground surface

# Marsland Regional Hydrologic Testing Report - Test # 8

## Crow Butte Project, Marsland Expansion Area

### TABLE 4
**MONITORING EQUIPMENT LAYOUT**

| Well ID | Completion Sand | Monitoring Equipment | Logging Interval |
|---|---|---|---|
| | | | |
| CPW-1A | Basal Chadron Sandstone | Level Troll 700 (100 PSI) | Linear Event (30 sec if water level changes by >0.5 ft , 4 min if <0.5 ft of change |
| | | | |
| CPW-1 | Basal Chadron Sandstone | Level Troll 500 (30 PSI) | Linear Event (30 sec if water level changes by >0.1 ft , 4 min if <0.1 ft of change |
| Monitor-2 | Basal Chadron Sandstone | Level Troll 500 (30 PSI) | Linear (4 min) |
| Monitor-3 | Basal Chadron Sandstone | Level Troll 500 (30 PSI) | Linear (4 min) |
| Monitor-4A | Basal Chadron Sandstone | Level Troll 500 (30 PSI) | Linear (4 min) |
| Monitor-5 | Basal Chadron Sandstone | Level Troll 500 (30 PSI) | Linear (4 min) |
| Monitor-6 | Basal Chadron Sandstone | Level Troll 500 (30 PSI) | Linear (4 min) |
| Monitor-7 | Basal Chadron Sandstone | Level Troll 500 (30 PSI) | Linear (4 min) |
| Monitor-8 | Basal Chadron Sandstone | Level Troll 500 (30 PSI) | Linear (4 min) |
| | | | |
| BOW-1 | Brule Formation | Level Troll 500 (30 PSI) | Linear (4 min) |
| BOW-2 | Brule Formation | Level Troll 500 (30 PSI) | Linear (4 min) |
| BOW-3 | Brule Formation | Level Troll 500 (30 PSI) | Linear (4 min) |
| | | | |
| BAR-1 | Atmosphere | Baro Troll | Linear (4 min) |

Notes:
1. min = minute
2. ft = feet
3. PSI = pounds per square inch

# Marsland Regional Hydrologic Testing Report - Test # 8

## Crow Butte Project, Marsland Expansion Area

### TABLE 5
**PUMPING FLOW RATE VS. TIME**

| | | METER 1 | METER 2 | | | |
|---|---|---|---|---|---|---|
| Date | TIME | GPM | GPM | PSI | AMPS | Total Gallons (meter 1/meter 2) |
| 5/16/2011 | 5:00 | 27.90 | 28.4 | 50 | 12 | 0/0 |
| 5/16/2011 | 6:00 | 27.10 | 27.9 | 49 | 12 | 1579/1601 |
| 5/16/2011 | 7:00 | 26.90 | 27.1 | 49 | 12 | 3138/3170 |
| 5/16/2011 | 8:00 | 26.70 | 27.1 | 45 | 12 | 4824/4880 |
| 5/16/2011 | 9:00 | 26.70 | 27.1 | 45 | 12 | 6545/6621 |
| 5/16/2011 | 10:00 | 26.90 | 27.1 | 46 | 12 | 8163/8258 |
| 5/16/2011 | 11:00 | 26.50 | 26.8 | 45 | 12 | 9720/9831 |
| 5/16/2011 | 12:00 | 26.40 | 26.8 | 46 | 12 | 11341/11481 |
| 5/16/2011 | 13:00 | 26.50 | 26.8 | 46 | 12 | 12869/13039 |
| 5/16/2011 | 14:00 | 26.40 | 26.9 | 46 | 12 | 14518/14713 |
| 5/16/2011 | 15:00 | 26.40 | 26.9 | 46 | 12 | 16255/16484 |
| 5/16/2011 | 16:00 | 26.40 | 26.9 | 46 | 12 | 17560/18000 |
| 5/16/2011 | 17:00 | 26.70 | 27 | 46 | 12 | 19337/19614 |
| 5/16/2011 | 18:00 | 26.70 | 27.2 | 46 | 12 | 20933/21240 |
| 5/16/2011 | 19:00 | 26.60 | 27.1 | 46 | 12 | 22588/22922 |
| 5/16/2011 | 20:00 | 26.70 | 27.3 | 46 | 12 | 24257/24622 |
| 5/16/2011 | 21:00 | 26.70 | 27.2 | 46 | 12 | 25814/26206 |
| 5/16/2011 | 22:00 | 26.70 | 27.1 | 46 | 12 | 27384/27806 |
| 5/16/2011 | 23:00 | 26.50 | 27.2 | 46 | 12 | 29094/29498 |
| 5/17/2011 | 0:00 | 26.90 | 27.3 | 46 | 12 | 30660/31136 |
| 5/17/2011 | 1:00 | 26.80 | 27.3 | 46 | 12 | 32286/32795 |
| 5/17/2011 | 2:00 | 26.40 | 27.2 | 46 | 12 | 33895/34431 |
| 5/17/2011 | 3:00 | 26.60 | 27.2 | 46 | 12 | 35533/36107 |
| 5/17/2011 | 4:00 | 26.70 | 27.1 | 46 | 12 | 37236/37843 |
| 5/17/2011 | 5:00 | 26.60 | 27.3 | 46 | 12 | 38781/39420 |
| 5/17/2011 | 6:00 | 26.70 | 27.4 | 46 | 12 | 40434/40997 |
| 5/17/2011 | 7:00 | 26.80 | 27.3 | 46 | 12 | 41829/42530 |
| 5/17/2011 | 8:00 | 26.79 | 27.25 | 46 | 13 | 43637/44373 |
| 5/17/2011 | 9:00 | 26.73 | 27.19 | 46 | 13 | 45229/46012 |
| 5/17/2011 | 10:00 | 26.73 | 27.19 | 46 | 13 | 46904/47733 |
| 5/17/2011 | 11:00 | 26.59 | 27.12 | 46 | 13 | 48480/49328 |
| 5/17/2011 | 12:00 | 26.66 | 27.06 | 46 | 13 | 50184/51061 |
| 5/17/2011 | 13:00 | 26.66 | 27.06 | 46 | 13 | 51735/52632 |
| 5/17/2011 | 14:00 | 26.59 | 27.19 | 46 | 13 | 53334/54270 |
| 5/17/2011 | 15:00 | 26.59 | 27.19 | 46 | 13 | 54968/55945 |
| 5/17/2011 | 16:00 | 26.53 | 27.12 | 46 | 13 | 56615/57612 |
| 5/17/2011 | 17:00 | 26.79 | 27.25 | 46 | 13 | 58180/59210 |
| 5/17/2011 | 18:00 | 26.92 | 27.39 | 46 | 13 | 59728/60788 |
| 5/17/2011 | 19:00 | 26.99 | 27.52 | 46 | 13 | 61422/62516 |
| 5/17/2011 | 20:00 | 26.92 | 27.58 | 46 | 13 | 63218/64388 |

# Marsland Regional Hydrologic Testing Report - Test # 8

## Crow Butte Project, Marsland Expansion Area

### TABLE 5

**PUMPING FLOW RATE VS. TIME**

| | | METER 1 | METER 2 | | | |
|---|---|---|---|---|---|---|
| Date | TIME | GPM | GPM | PSI | AMPS | Total Gallons (meter 1/meter 2) |
| 5/17/2011 | 21:00 | 26.99 | 27.43 | 46 | 13 | 64670/65839 |
| 5/17/2011 | 22:00 | 26.92 | 27.65 | 46 | 13 | 66283/67481 |
| 5/17/2011 | 23:00 | 26.94 | 27.45 | 46 | 13 | 67907/69143 |
| 5/18/2011 | 0:00 | 26.92 | 27.45 | 46 | 13 | 69508/70780 |
| 5/18/2011 | 1:00 | 27.06 | 27.46 | 46 | 13 | 71181/72490 |
| 5/18/2011 | 2:00 | 26.86 | 27.45 | 46 | 13 | 72804/74152 |
| 5/18/2011 | 3:00 | 26.79 | 27.39 | 46 | 13 | 74443/75824 |
| 5/18/2011 | 4:00 | 26.79 | 27.39 | 46 | 13 | 76053/77474 |
| 5/18/2011 | 5:00 | 26.66 | 27.32 | 46 | 13 | 77684/79137 |
| 5/18/2011 | 6:00 | 26.59 | 27.45 | 46 | 13 | 79283/80777 |
| 5/18/2011 | 7:00 | 26.46 | 27.32 | 46 | 13 | 80908/82445 |
| 5/18/2011 | 8:00 | 26.46 | 27.32 | 46 | 12 | 82532/84112 |
| 5/18/2011 | 9:00 | 27.98 | 27.43 | 46 | 12 | 84302/85927 |
| 5/18/2011 | 10:00 | 26.59 | 27.32 | 46 | 12 | 85838/87502 |
| 5/18/2011 | 11:00 | 26.66 | 27.32 | 46 | 12 | 87397/89104 |
| 5/18/2011 | 12:00 | 26.79 | 27.39 | 46 | 12 | 89019/90769 |
| 5/18/2011 | 13:00 | 26.53 | 27.32 | 46 | 12 | 90664/92458 |
| 5/18/2011 | 14:00 | 26.73 | 27.19 | 46 | 12 | 92385/94212 |
| 5/18/2011 | 15:00 | 26.59 | 27.32 | 46 | 12 | 93845/85706 |
| 5/18/2011 | 16:00 | 26.92 | 27.32 | 46 | 12 | 95537/97438 |
| 5/18/2011 | 17:00 | 26.86 | 27.52 | 46 | 12 | 97124/99061 |
| 5/18/2011 | 18:00 | 26.79 | 27.39 | 46 | 12 | 98727/100302 |
| 5/18/2011 | 19:00 | 26.79 | 27.52 | 46 | 12 | 100350/102361 |
| 5/18/2011 | 20:00 | 26.99 | 27.65 | 46 | 12 | 101944/104000 |
| 5/18/2011 | 21:00 | 26.92 | 27.52 | 46 | 12 | 103574/105667 |
| 5/18/2011 | 22:00 | 26.86 | 27.52 | 46 | 12 | 105215/107355 |
| 5/18/2011 | 23:00 | 26.99 | 27.58 | 46 | 12 | 106857/108542 |
| 5/19/2011 | 0:00 | 26.99 | 27.65 | 46 | 12 | 108521/110734 |
| 5/19/2011 | 1:00 | 26.99 | 27.72 | 46 | 12 | 110161/112415 |
| 5/19/2011 | 2:00 | 26.99 | 27.65 | 46 | 12 | 111965/114270 |
| 5/19/2011 | 3:00 | 26.94 | 27.72 | 46 | 12 | 113333/115667 |
| 5/19/2011 | 4:00 | 26.94 | 27.65 | 46 | 12 | 114978/117308 |
| 5/19/2011 | 5:00 | 26.94 | 27.58 | 46 | 12 | 116623/118951 |
| 5/19/2011 | 6:00 | 26.92 | 27.65 | 46 | 12 | 118246/120689 |
| 5/19/2011 | 7:00 | 27.06 | 27.72 | 46 | 12 | 119860/122351 |
| 5/19/2011 | 8:00 | 27.00 | 27.65 | 48 | 12 | 121626/124162 |
| 5/19/2011 | 9:00 | 27.06 | 27.52 | 48 | 12 | 123245/125826 |
| 5/19/2011 | 10:00 | 26.86 | 27.52 | 48 | 12 | 124871/127490 |
| 5/19/2011 | 11:00 | 26.92 | 27.58 | 48 | 12 | 126491/129137 |
| 5/19/2011 | 12:00 | 26.79 | 27.52 | 48 | 12 | 128125/130828 |
| 5/19/2011 | 13:00 | 26.59 | 27.58 | 48 | 12 | 129745/132498 |
| 5/19/2011 | 14:00 | 26.94 | 27.65 | 48 | 12 | 131369/134145 |
| 5/19/2011 | 15:00 | 26.92 | 27.45 | 48 | 12 | 132973/135792 |

# Marsland Regional Hydrologic Testing Report - Test # 8

## Crow Butte Project, Marsland Expansion Area

### TABLE 5

**PUMPING FLOW RATE VS. TIME**

| | | METER 1 | METER 2 | | | |
|---|---|---|---|---|---|---|
| **Date** | **TIME** | **GPM** | **GPM** | **PSI** | **AMPS** | **Total Gallons (meter 1/meter 2)** |
| 5/19/2011 | 16:00 | 27.45 | 27.58 | 48 | 12 | 134606/137470 |
| 5/19/2011 | 17:00 | 26.86 | 27.52 | 48 | 12 | 136270/139168 |
| 5/19/2011 | 18:00 | 26.86 | 27.65 | 48 | 12 | 137893/140832 |
| 5/19/2011 | 19:00 | 26.79 | 27.58 | 48 | 12 | 139550/142528 |
| 5/19/2011 | 20:00 | 26.86 | 27.58 | 48 | 12 | 141176/144192 |
| 5/19/2011 | 21:00 | 26.79 | 27.45 | 48 | 12 | 142803/145861 |
| 5/19/2011 | 22:00 | 26.86 | 27.45 | 48 | 12 | 144375/147470 |
| 5/19/2011 | 23:00 | 26.46 | 27.58 | 48 | 12 | 146010/149145 |
| 5/20/2011 | 0:00 | 26.92 | 27.39 | 48 | 12 | 147643/150817 |
| 5/20/2011 | 1:00 | 26.73 | 27.45 | 48 | 12 | 149285/152499 |
| 5/20/2011 | 2:00 | 26.99 | 27.58 | 48 | 12 | 150921/154172 |
| 5/20/2011 | 3:00 | 26.92 | 27.52 | 48 | 12 | 152550/155837 |
| 5/20/2011 | 4:00 | 27.06 | 27.58 | 48 | 12 | 154176/157504 |
| 5/20/2011 | 5:00 | 26.99 | 27.39 | 48 | 12 | 155820/159188 |
| 5/20/2011 | 6:00 | 26.92 | 27.45 | 48 | 12 | 157422/160827 |
| 5/20/2011 | 7:00 | 26.79 | 27.52 | 48 | 12 | 159048/162492 |
| 5/20/2011 | 8:00 | 26.73 | 27.32 | 47 | 12 | 160710/164208 |
| 5/20/2011 | 9:00 | 26.79 | 27.32 | 46 | 12 | 162426/165960 |
| 5/20/2011 | 10:00 | 26.59 | 27.19 | 46 | 12 | 163966/167537 |
| 5/20/2011 | 11:00 | 26.46 | 27.12 | 46 | 12 | 165526/169126 |
| 5/20/2011 | 12:00 | 26.46 | 27.06 | 46 | 12 | **167215/170855** |
| **Average Flow (GPM)** | | **26.80** | **27.37** | | | |
| **Combined Average Flow (GPM)** | | **27.08** | | | | |

Notes:

1. GPM = gallons per minute
2. Pumping started at 5:03 am on 5/16/2011 and ended at 12:00 pm on 5/20/11
3. PSI = pounds per square inch

# Marsland Regional Hydrologic Testing Report - Test # 8
## Crow Butte Project, Marsland Expansion Area

### TABLE 6
**GROUNDWATER LEVELS, NOVEMBER 12, 2010**

| Well ID | Measurement Date | Northing (feet) | Easting (feet) | TOC Elevation (feet amsl) | Depth to Water (feet btoc) | Groundwater Elevation (feet amsl) |
|---|---|---|---|---|---|---|
| **Basal Chadron Pumping Well** | | | | | | |
| CPW-1A | NM | 446202 | 1121450 | 4262.70 | NM | NM |
| **Basal Chadron Observation Wells** | | | | | | |
| CPW-1 | 11/12/2010 | 446225 | 1121528 | 4261.85 | 551.11 | 3710.75 |
| Monitor-2 | 11/12/2010 | 439439 | 1126362 | 4198.40 | 484.57 | 3713.83 |
| Monitor-3 | 11/12/2010 | 446288 | 1121519 | 4261.30 | 551.03 | 3710.27 |
| Monitor-4A | 11/12/2010 | 450084 | 1121344 | 4327.49 | 617.80 | 3709.69 |
| Monitor-5 | 11/12/2010 | 447734 | 1119236 | 4339.50 | 628.45 | 3711.05 |
| Monitor-6 | 11/12/2010 | 442856 | 1124385 | 4215.00 | 502.18 | 3712.83 |
| Monitor-7 | 11/12/2010 | 440358 | 1120757 | 4244.38 | 530.99 | 3713.39 |
| Monitor-8 | 11/12/2010 | 450974 | 1117005 | 4353.70 | 644.47 | 3709.23 |
| **Brule Observation Wells** | | | | | | |
| BOW-1 | 11/12/2010 | 446250 | 1121572 | 4260.10 | 126.13 | 4133.97 |
| BOW-2 | 11/12/2010 | 450154 | 1121367 | 4323.40 | 150.37 | 4173.04 |
| BOW-3 | 11/12/2010 | 450974 | 1117056 | 4350.30 | 137.49 | 4212.81 |

Notes:
1. TOC = top of casing
2. btoc = below top of casing
3. amsl = above mean sea level
4. NM = not measured

# Marsland Regional Hydrologic Testing Report - Test # 8

## Crow Butte Project, Marsland Expansion Area

### TABLE 7

**DISTANCES TO PUMPING WELL AND OBSERVED DRAWDOWN**

| Completion Type | Well ID | Distance to Pumping Well (feet) | Completion Sand | Respond to Pumping (Y/N) | Observed Drawdown at End of Pumping (5/20/2011) | Corrected Drawdown at End of Pumping (5/20/2011) |
|---|---|---|---|---|---|---|
| Pumping Well | CPW-1A | 0 | Basal Chadron Sandstone | Y | 23.40 | 23.50 |
| | | | | | | |
| Production Zone Observation Wells | CPW-1 | 67 | Basal Chadron Sandstone | Y | 6.22 | 6.32 |
| | Monitor-3 | 100 | Basal Chadron Sandstone | Y | 4.79 | 4.89 |
| | Monitor-5 | 2,800 | Basal Chadron Sandstone | Y | 1.29 | 1.39 |
| | Monitor-4A | 4,067 | Basal Chadron Sandstone | Y | 1.00 | 1.10 |
| | Monitor-6 | 4,667 | Basal Chadron Sandstone | Y | 1.05 | 1.15 |
| | Monitor-7 | 6,200 | Basal Chadron Sandstone | Y | 0.76 | 0.86 |
| | Monitor-8* | 6,800 | Basal Chadron Sandstone | Y | 0.66 | 0.76 |
| | Monitor-2* | 8,800 | Basal Chadron Sandstone | Y | 0.32 | 0.42 |
| | | | | | | |
| Overlying Observation Wells | BOW-1 | 133 | Brule Formation | N | - | - |
| | BOW-2 | 4,167 | Brule Formation | N | - | - |
| | BOW-3 | 6,867 | Brule Formation | N | - | - |

Note:

1. * Wells Monitor-2 and Monitor-8 were monitored and analyzed as described in the original Plan, but are not part of the formal monitoring network used to establish radius of influence.
2. Pumping started at 5:03 am on 5/16/2011 and ended at 12:00 pm on 5/20/11

# Marsland Regional Hydrologic Testing Report - Test # 8

## Crow Butte Project, Marsland Expansion Area

### TABLE 8
**SUMMARY OF TEST RESULTS**

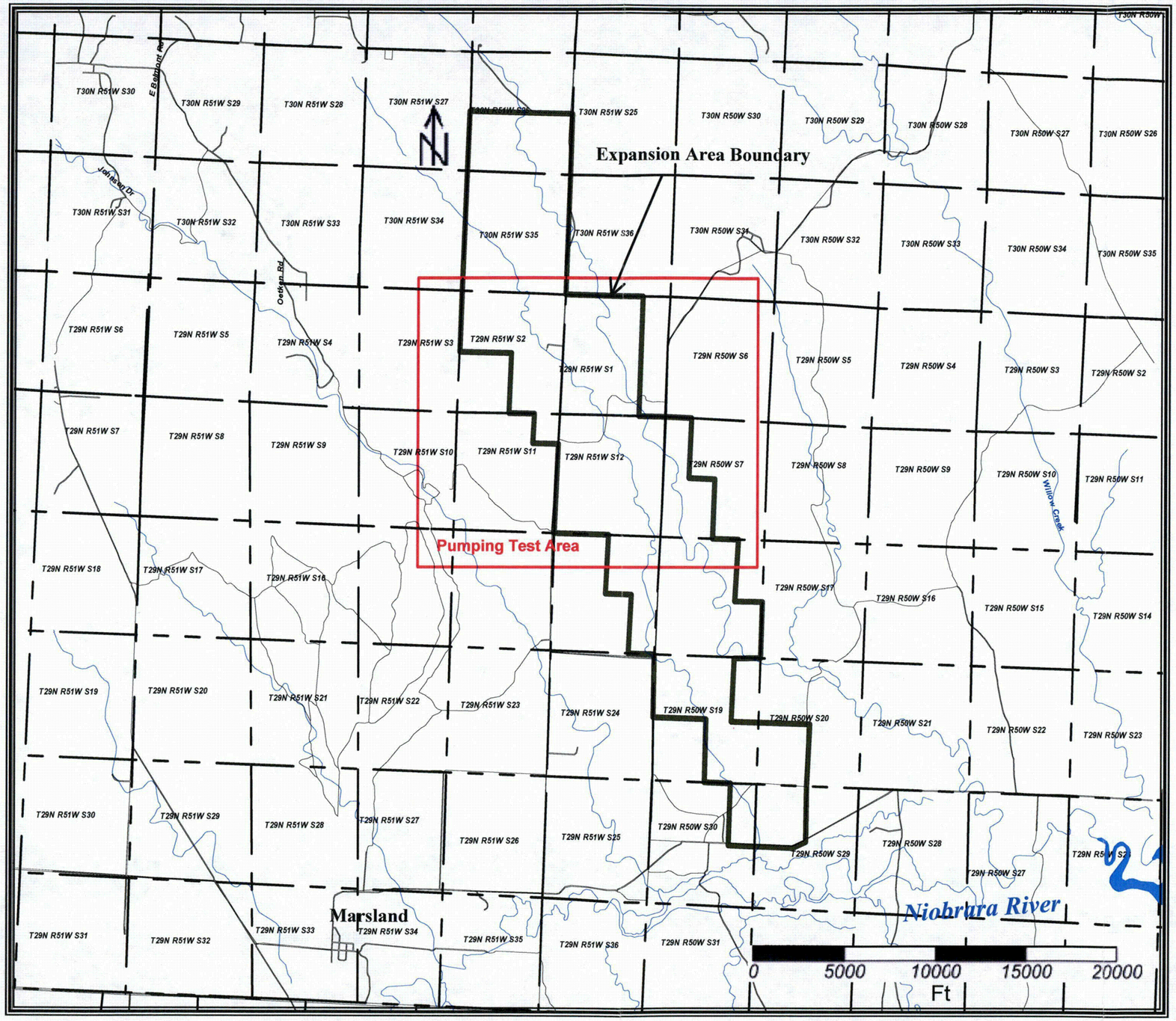
| Well ID | Distance to Pumping Well (feet) | Theis Drawdown | | | Theis Recovery | | |
|---|---|---|---|---|---|---|---|
| | | Transmissivity ($ft^2$/day) | Hydraulic Conductivity (ft/day) | Storativity | Transmissivity ($ft^2$/day) | Hydraulic Conductivity (ft/day) | Storativity |
| CPW-1A** | 0 | -- | -- | -- | 573 | 14 | -- |
| CPW-1** | 67 | 430 | 11 | 8.32E-05 | 523 | 13 | -- |
| Monitor-3 | 100 | 230 | 6 | 1.70E-03 | 299 | 7 | -- |
| Monitor-5 | 2,800 | 915 | 23 | 5.50E-05 | 971 | 24 | -- |
| Monitor-4A | 4,067 | 903 | 23 | 5.41E-05 | 1,377 | 34 | -- |
| Monitor-6 | 4,667 | 901 | 23 | 3.44E-05 | 1,063 | 27 | -- |
| Monitor-7 | 6,200 | 983 | 25 | 3.57E-05 | 1,315 | 33 | -- |
| Monitor-8* | 6,800 | 989 | 25 | 3.95E-05 | 1,596 | 40 | -- |
| Monitor-2* | 8,800 | 1,781 | 45 | 4.72E-05 | 2,469 | 62 | -- |
| | Averages | 892 | 22 | 7.46E-05 | 1,132 | 28 | -- |

| | |
|---|---|
| **Average Transmissivit ($ft^2$/day)** | **1,012** |
| **Average Hydraulic Conductivity (ft/day)** | **25** |
| **Average Storativity** | **7.46E-05** |

Note:

1. * = Monitor-2 and Monitor-8 were monitored and analyzed as described in the original Plan, but are not part of the formal monitoring network
2. ** = Water level data for CPW-1A and CPW-1 were not corrected for barometric variations due to the large drawdowns (greater than 6 feet) relative to much smaller barometric fluctuations
2. Pumping started at 5:03 am on 5/16/2011 and ended at 12:00 pm on 5/20/11
3. Hydraulic conductivity calculated based on a typical net sand thickness of 40 feet
4. ft2/day = square feet per day
5. ft/day = feet per day
6. -- = not applicable

# Figures

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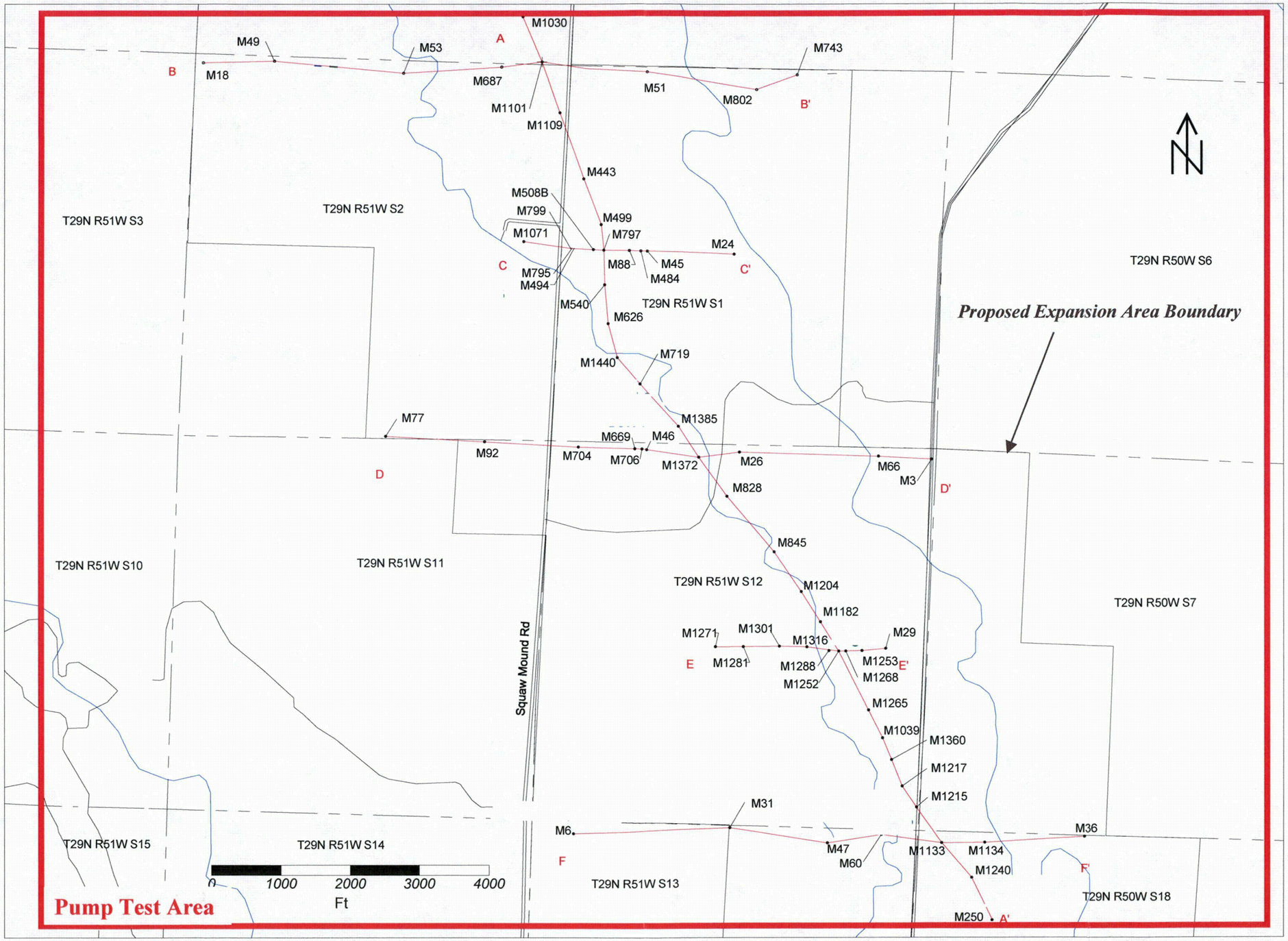
**Marsland Expansion Area and Vicinity**

Marsland Regional Hydrologic Testing Report – Test # 8
Crow Butte Project, Marsland Expansion Area,
Dawes County, NE

Cameco

FIGURE:

1

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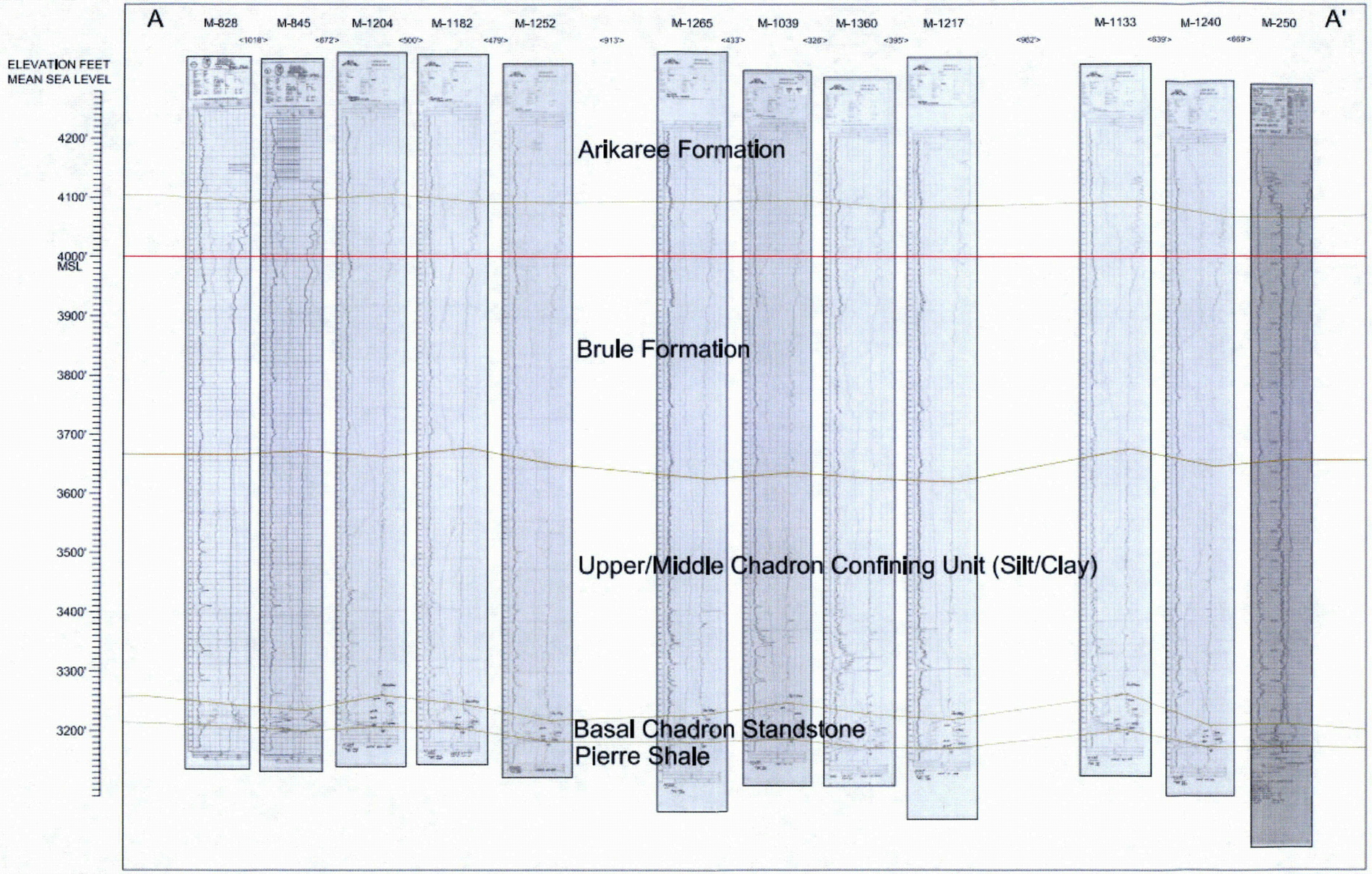
## Cross-Section Location Map

Marsland Regional Hydrologic Testing Report – Test # 8
Crow Butte Project, Marsland Expansion Area,
Dawes County, NE

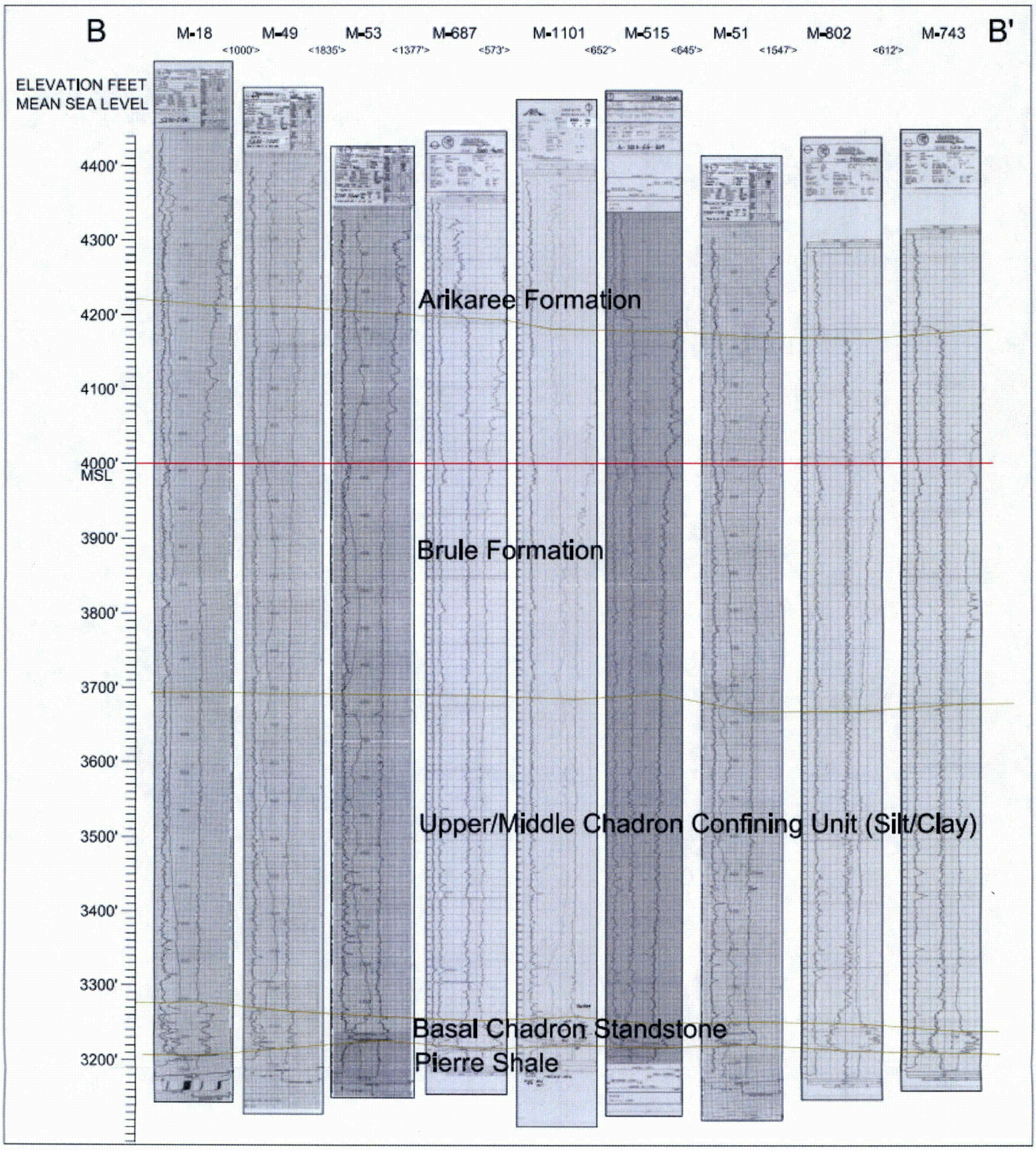
Cameco

FIGURE:

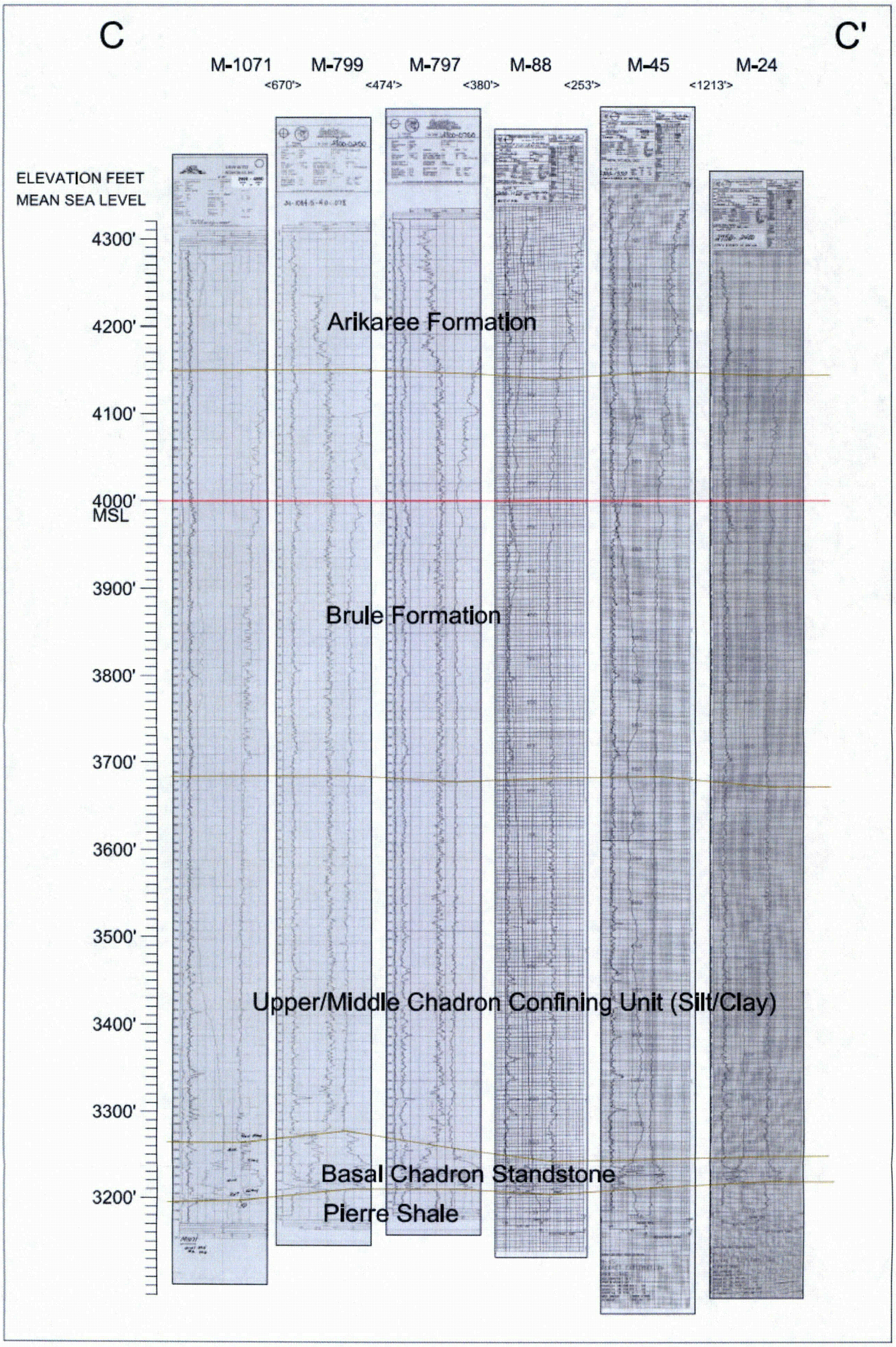
2



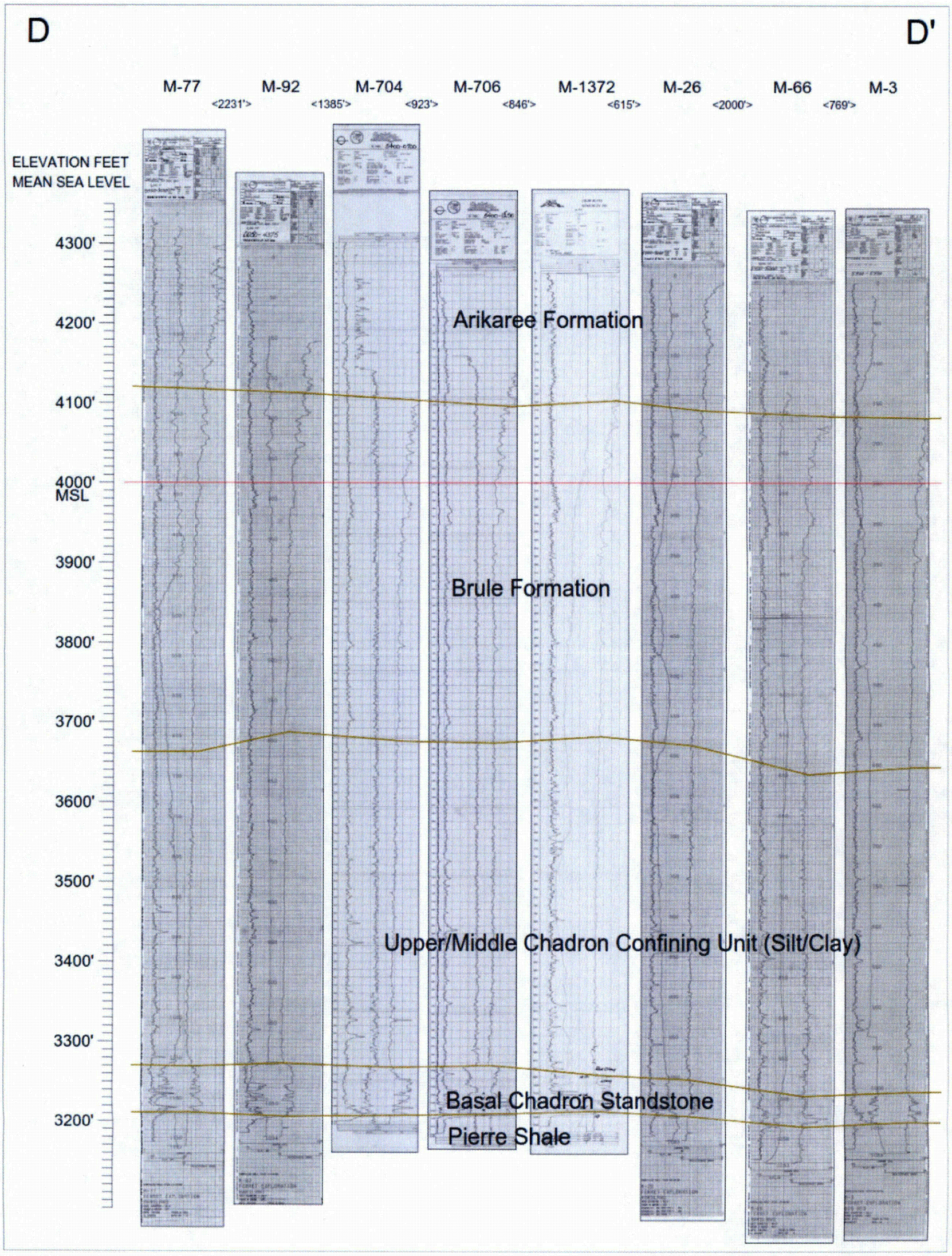

| | | | |
|---|---|---|---|
| **AQUI-VER, INC.**<br>*Hydrogeology, Water Resources & Data Services* | **Cross-Section A-A'** | Marsland Regional Hydrologic Testing Report – Test # 8<br>Crow Butte Project, Marsland Expansion Area,<br>Dawes County, NE<br>Cameco | FIGURE:<br>3 |



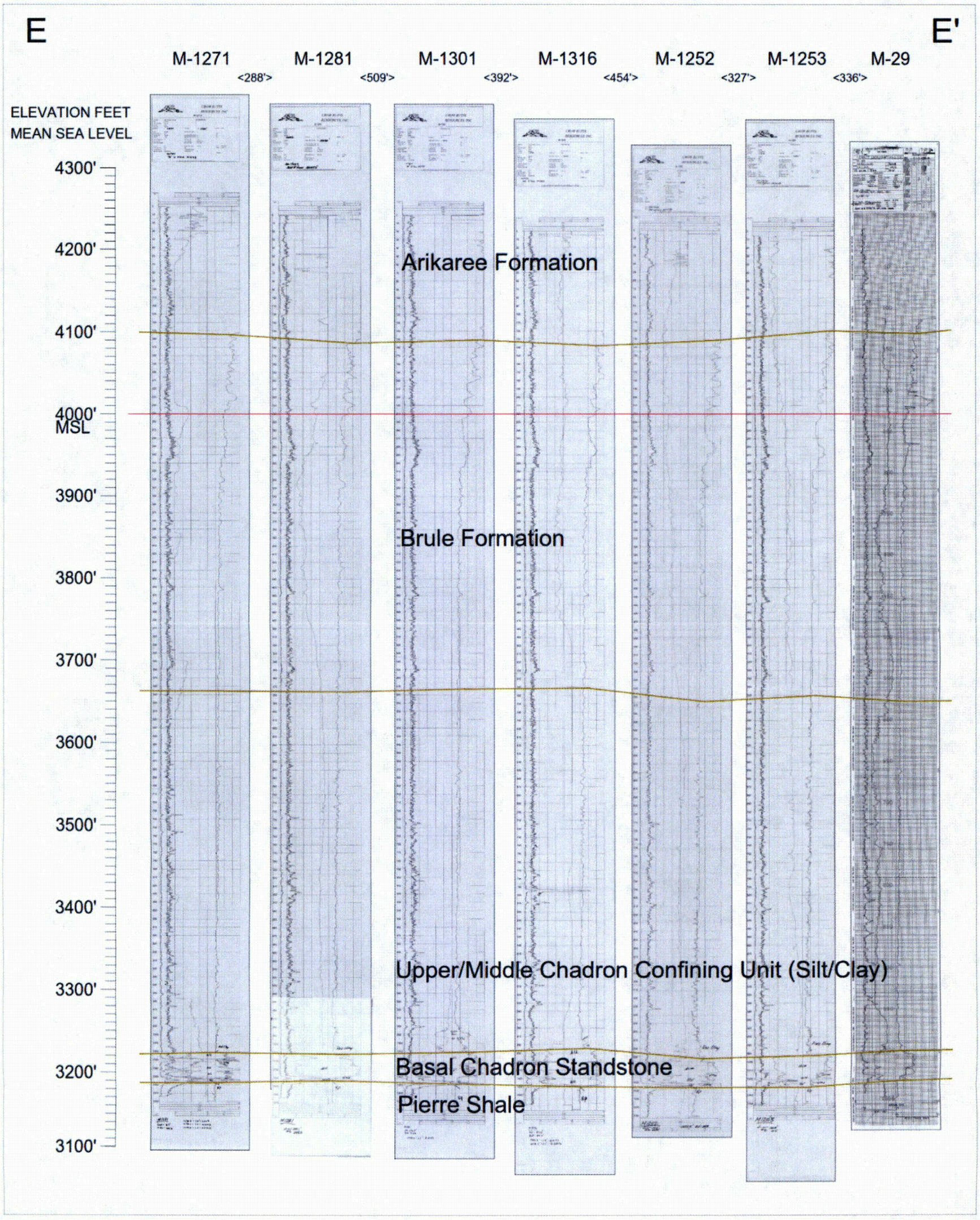

| | | |
|---|---|---|
| **AQUI-VER, INC.**<br>*Hydrogeology, Water Resources & Data Services* | **Geologic Cross Section B-B'**<br>Marsland Regional Hydrologic Testing Report – Test # 8<br>Crow Butte Project, Marsland Expansion Area,<br>Dawes County, NE<br>Cameco | FIGURE:<br>4 |




| | | |
|---|---|---|
| **AQUI-VER, INC.**<br>*Hydrogeology, Water Resources & Data Services* | **Geologic Cross Section C-C'**<br>Marsland Regional Hydrologic Testing Report – Test # 8<br>Crow Butte Project, Marsland Expansion Area,<br>Dawes County, NE<br>Cameco | FIGURE:<br>5 |




| | | |
|---|---|---|
| **AQUI-VER, INC.**<br>*Hydrogeology, Water Resources & Data Services* | **Geologic Cross Section D-D'**<br>Marsland Regional Hydrologic Testing Report – Test # 8<br>Crow Butte Project, Marsland Expansion Area,<br>Dawes County, NE<br>Cameco | FIGURE:<br>6 |

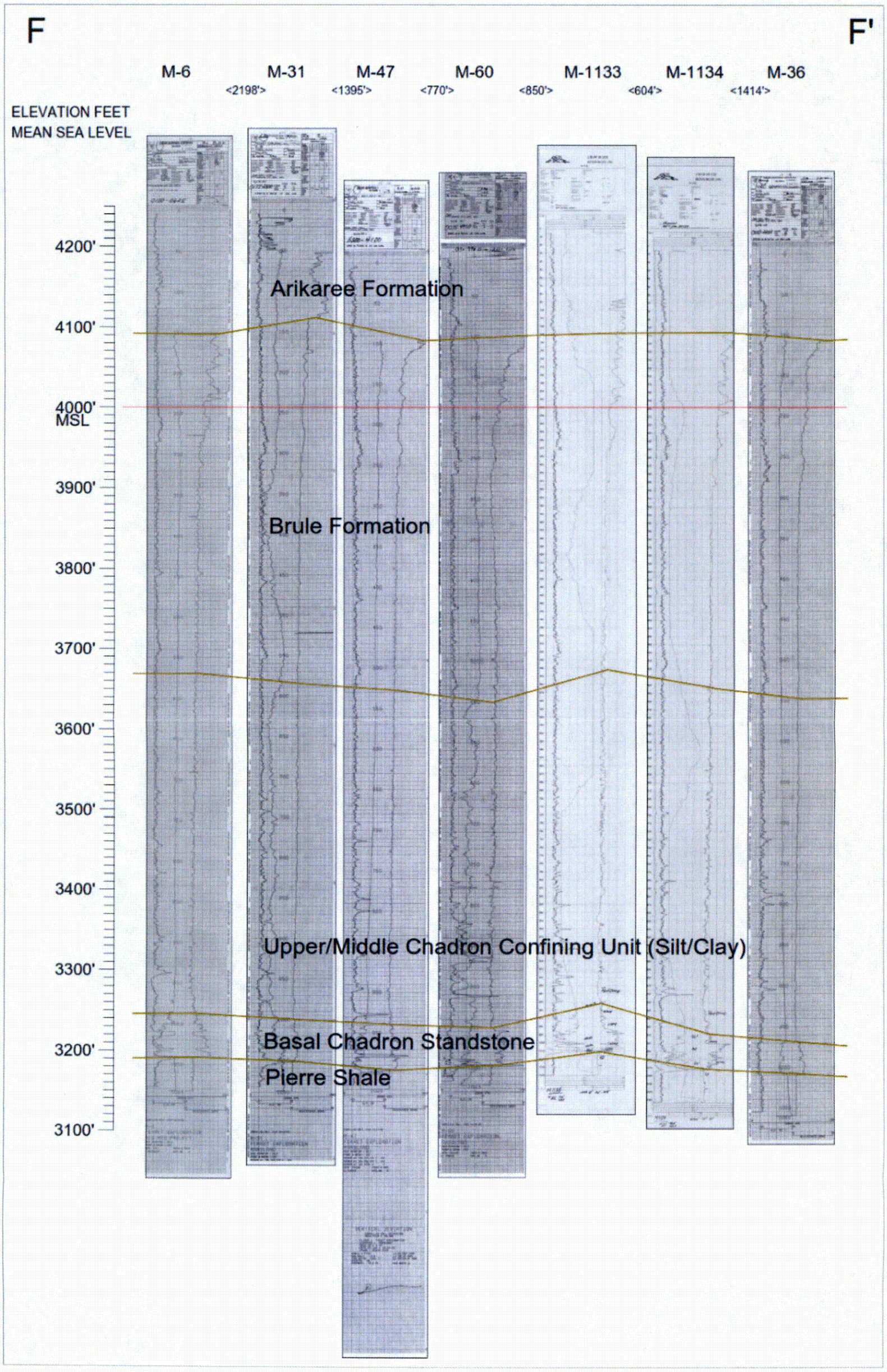



**AQUI-VER, INC.**
*Hydrogeology, Water Resources & Data Services*

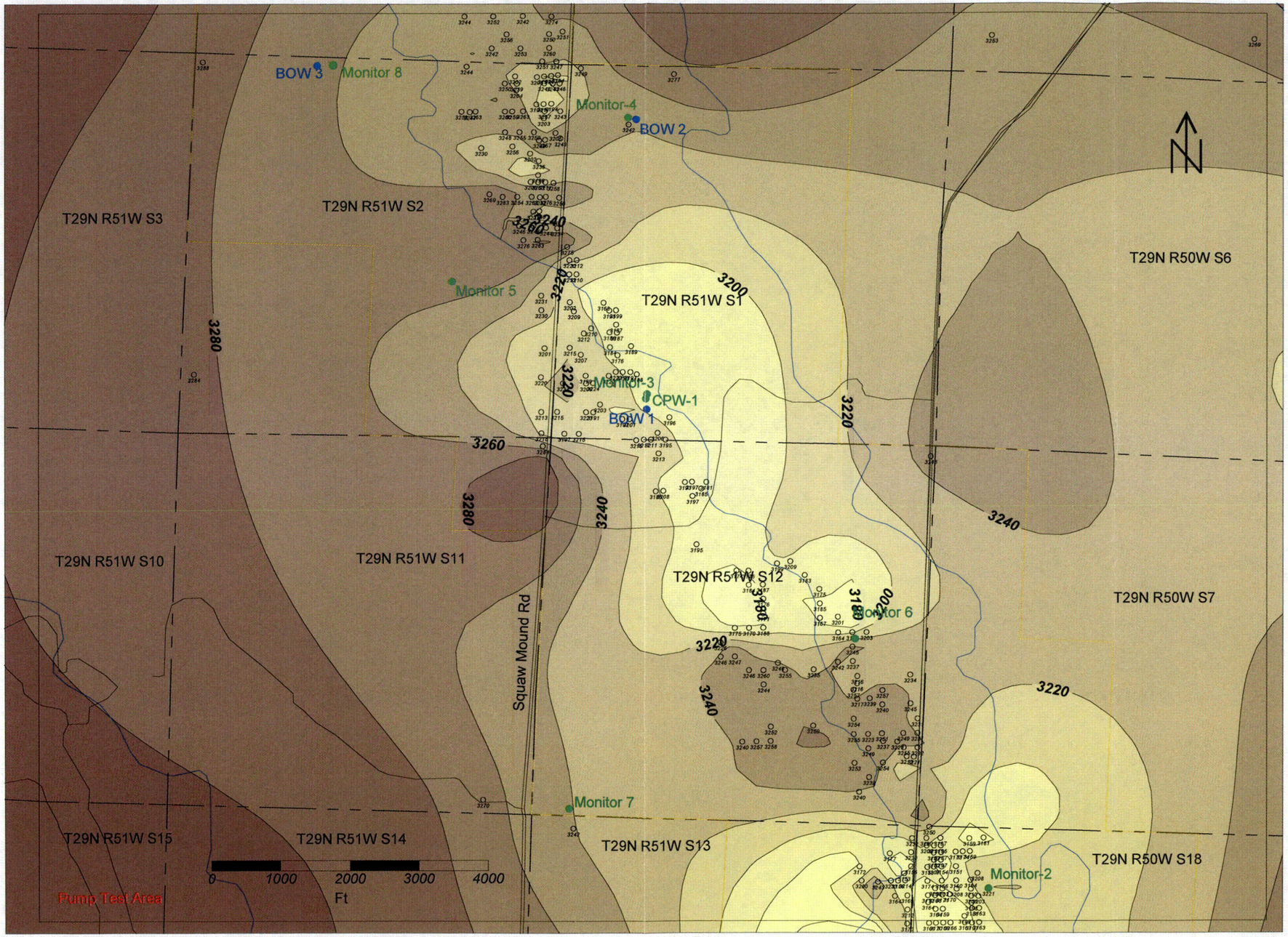
**Geologic Cross Section E-E'**
Marsland Regional Hydrologic Testing Report – Test # 8
Crow Butte Project, Marsland Expansion Area,
Dawes County, NE

Cameco

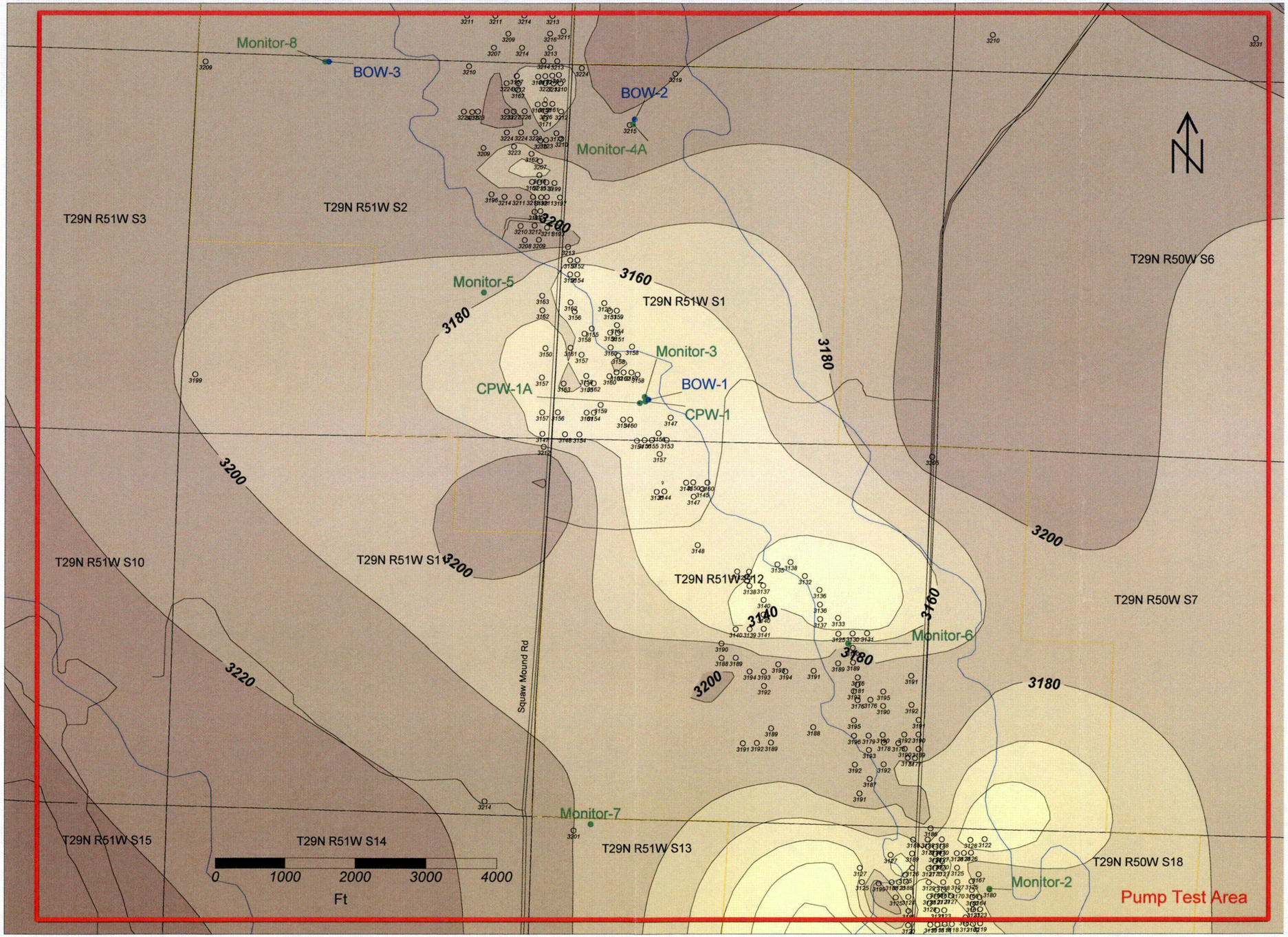
FIGURE:
7



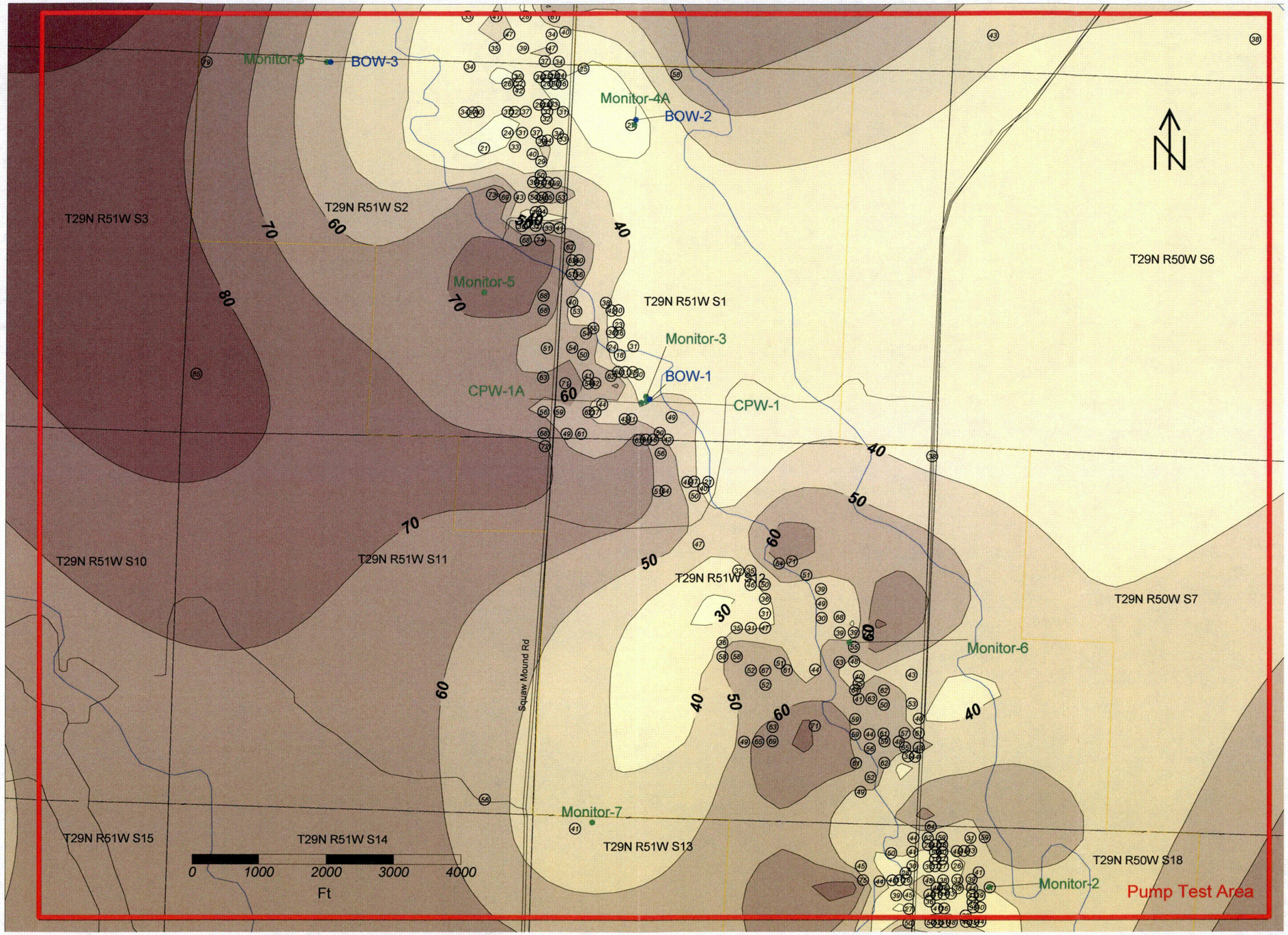

| | | |
|---|---|---|
| **AQUI-VER, INC.**<br>*Hydrogeology, Water Resources & Data Services* | **Geologic Cross Section F-F'**<br>Marsland Regional Hydrologic Testing Report – Test # 8<br>Crow Butte Project, Marsland Expansion Area,<br>Dawes County, NE<br>Cameco | FIGURE:<br>8 |




| | | | |
|---|---|---|---|
| **AQUI-VER, INC.**<br>*Hydrogeology, Water Resources & Data Services* | **Structure Contour Map**<br>**Top of the Basal Chadron Sandstone (ft-MSL)** | Marsland Regional Hydrologic Testing Report – Test # 8<br>Crow Butte Project, Marsland Expansion Area,<br>Dawes County, NE<br>Cameco | FIGURE:<br>9 |




| | | | |
|---|---|---|---|
| **AQUI-VER, INC.**<br>*Hydrogeology, Water Resources & Data Services* | **Structure Contour Map**<br>**Top of the Pierre Shale (ft-MSL)** | Marsland Regional Hydrologic Testing Report – Test # 8<br>Crow Butte Project, Marsland Expansion Area,<br>Dawes County, NE<br>Cameco | FIGURE:<br>10 |



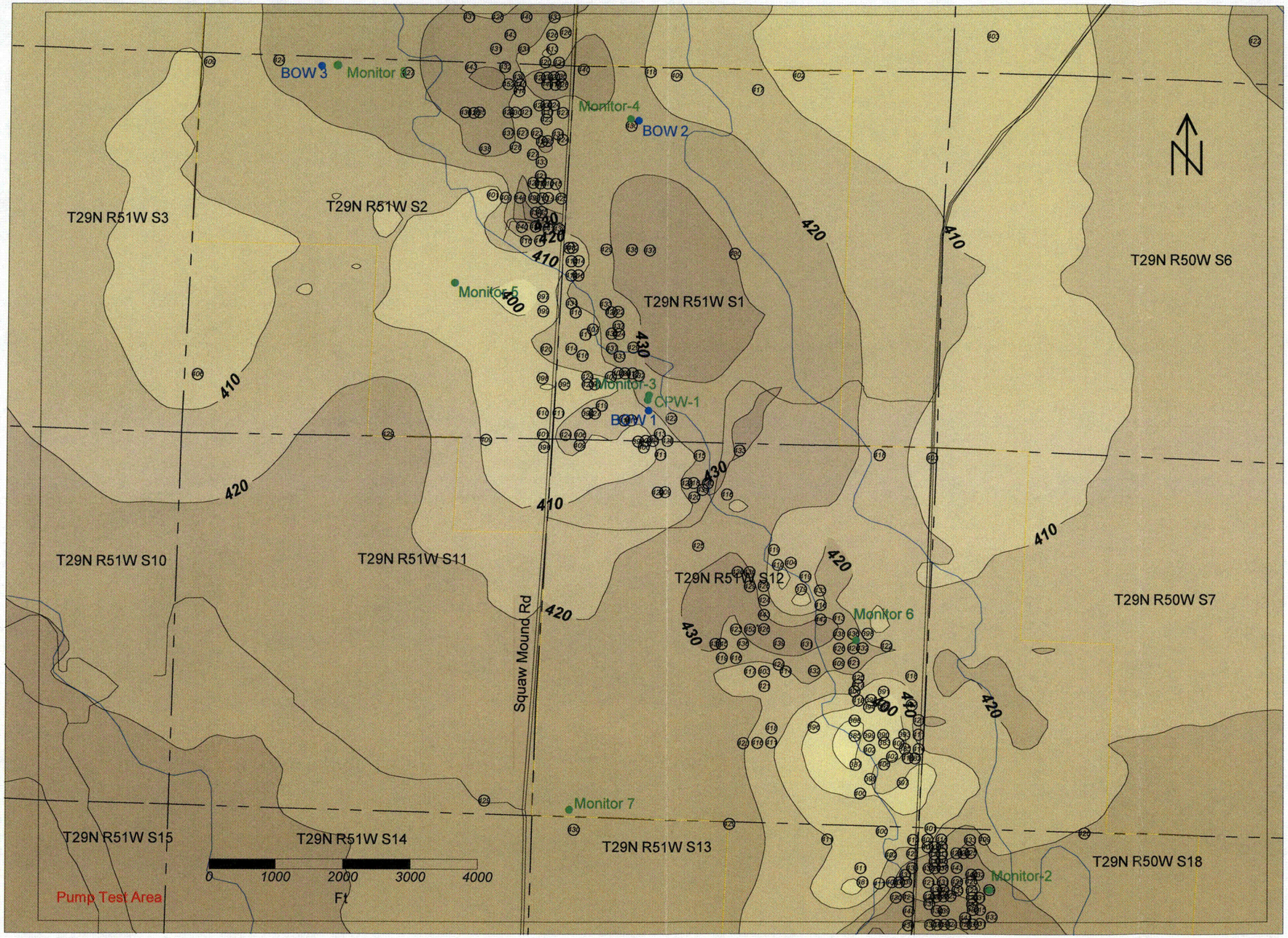

**AQUI-VER, INC.**
*Hydrogeology, Water Resources & Data Services*

**Isopach (Thickness) Map**
**Basal Chadron Sandstone (ft-MSL)**

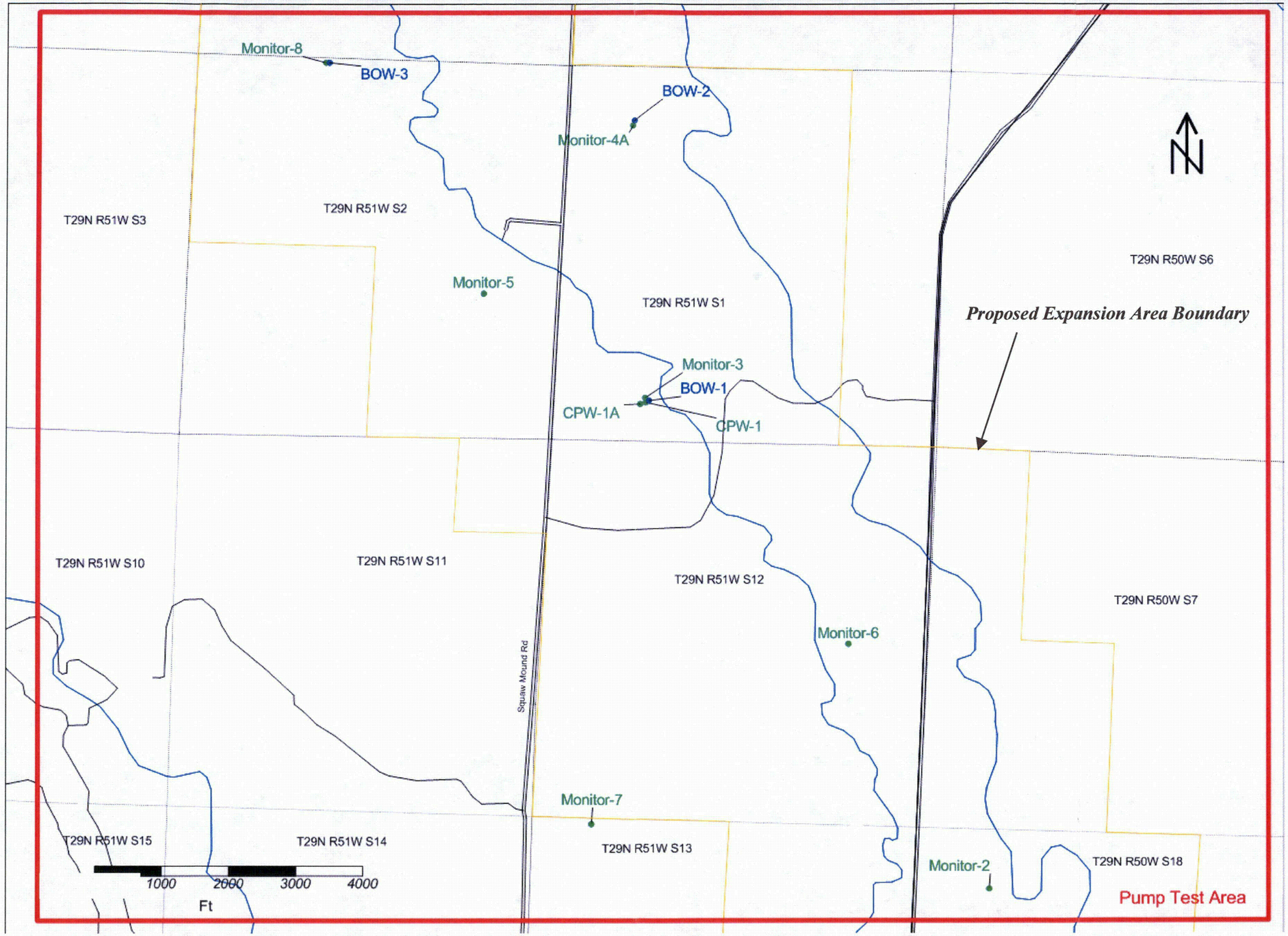
Marsland Regional Hydrologic Testing Report – Test # 8
Crow Butte Project, Marsland Expansion Area,
Dawes County, NE

Cameco

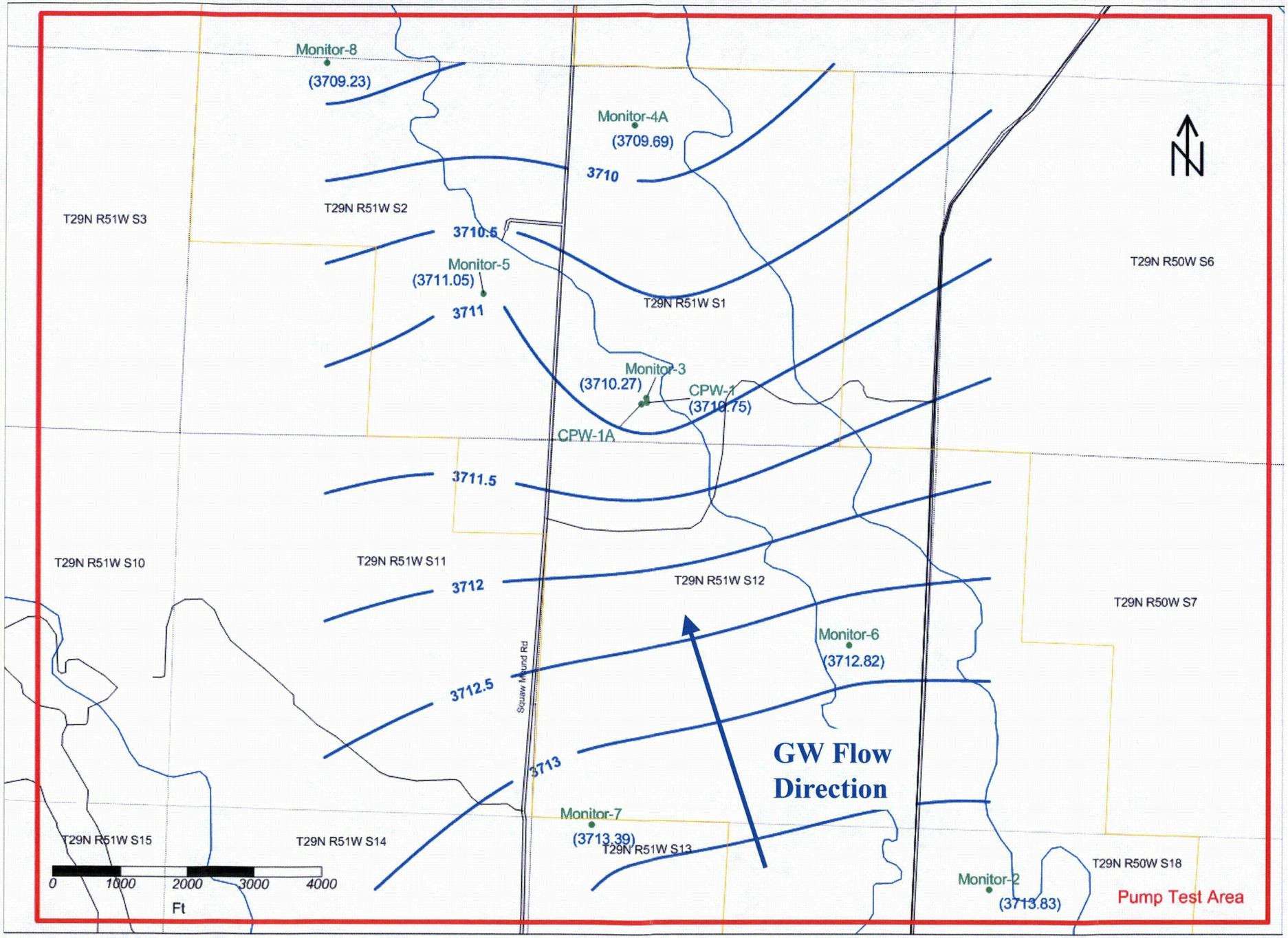
FIGURE:
11



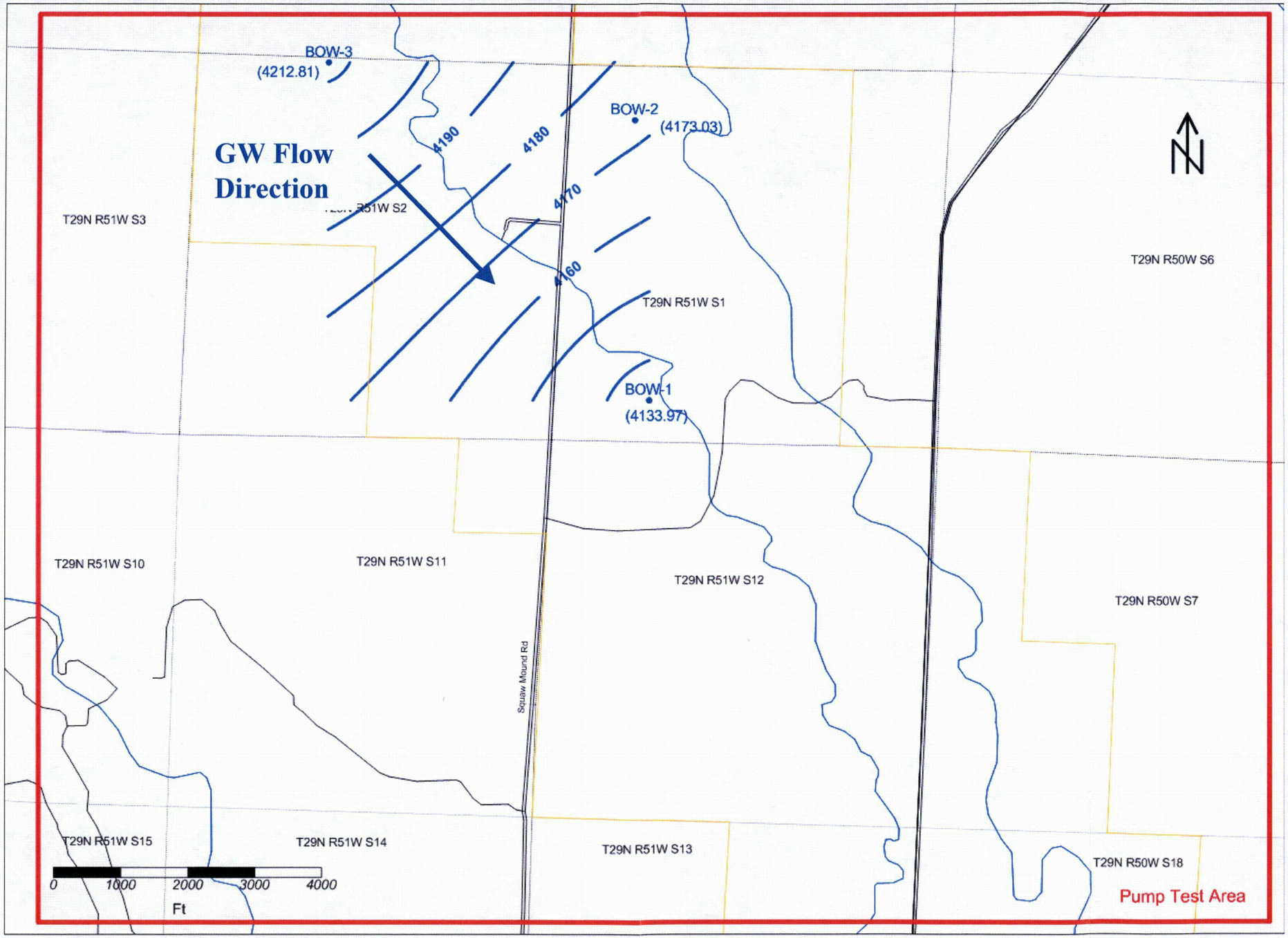

| | | | |
|---|---|---|---|
| **AQUI-VER, INC.**<br>*Hydrogeology, Water Resources & Data Services* | **Isopach (Thickness) Map**<br>**Upper/Middle Chadron Confining Unit (ft-MSL)** | Marsland Regional Hydrologic Testing Report – Test # 8<br>Crow Butte Project, Marsland Expansion Area,<br>Dawes County, NE<br>Cameco | FIGURE:<br>12 |




| | | | |
|---|---|---|---|
| **AQUI-VER, INC.**<br>*Hydrogeology, Water Resources & Data Services* | **Marsland Pumping Test #8 Well Locations** | Marsland Regional Hydrologic Testing Report – Test # 8<br>Crow Butte Project, Marsland Expansion Area,<br>Dawes County, NE<br>Cameco | FIGURE:<br>13 |




| | | | |
|---|---|---|---|
| **AQUI-VER, INC.**<br>*Hydrogeology, Water Resources & Data Services* | **Potentiometric Surface Map – Basal Chadron Sandstone (Production Zone), November 12, 2010** | Marsland Regional Hydrologic Testing Report – Test # 8<br>Crow Butte Project, Marsland Expansion Area,<br>Dawes County, NE<br>Cameco | FIGURE:<br>14 |




**AQUI-VER, INC.**

*Hydrogeology, Water Resources & Data Services*

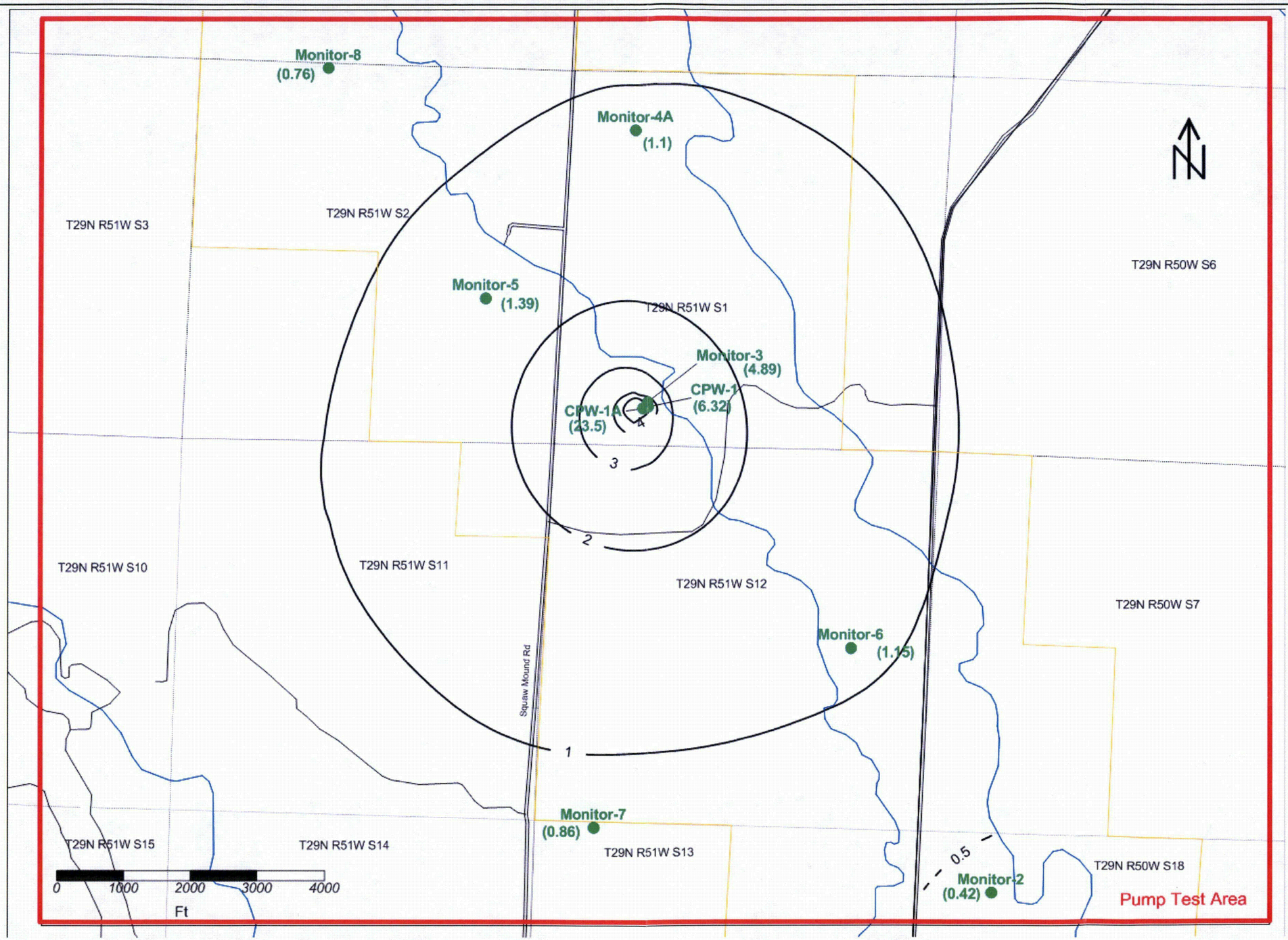
**Potentiometric Surface Map – Brule Formation, November 12, 2010**

Marsland Regional Hydrologic Testing Report – Test # 8
Crow Butte Project, Marsland Expansion Area,
Dawes County, NE

Cameco

FIGURE:

15




**AQUI-VER, INC.**

*Hydrogeology, Water Resources & Data Services*

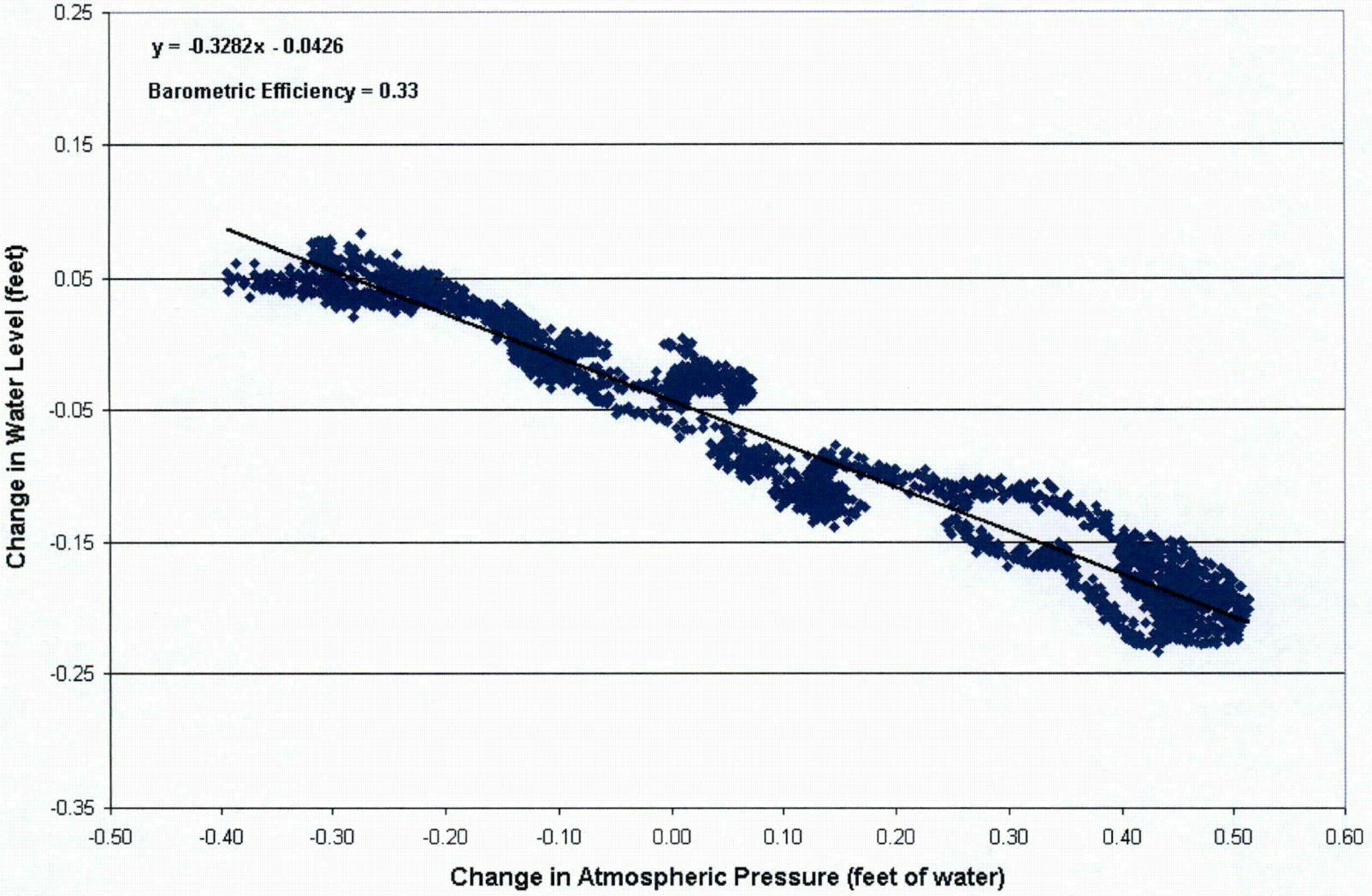
**Drawdown in the Basal Chadron Sandstone at the End of the Test**

Marsland Regional Hydrologic Testing Report – Test # 8
Crow Butte Project, Marsland Expansion Area,
Dawes County, NE

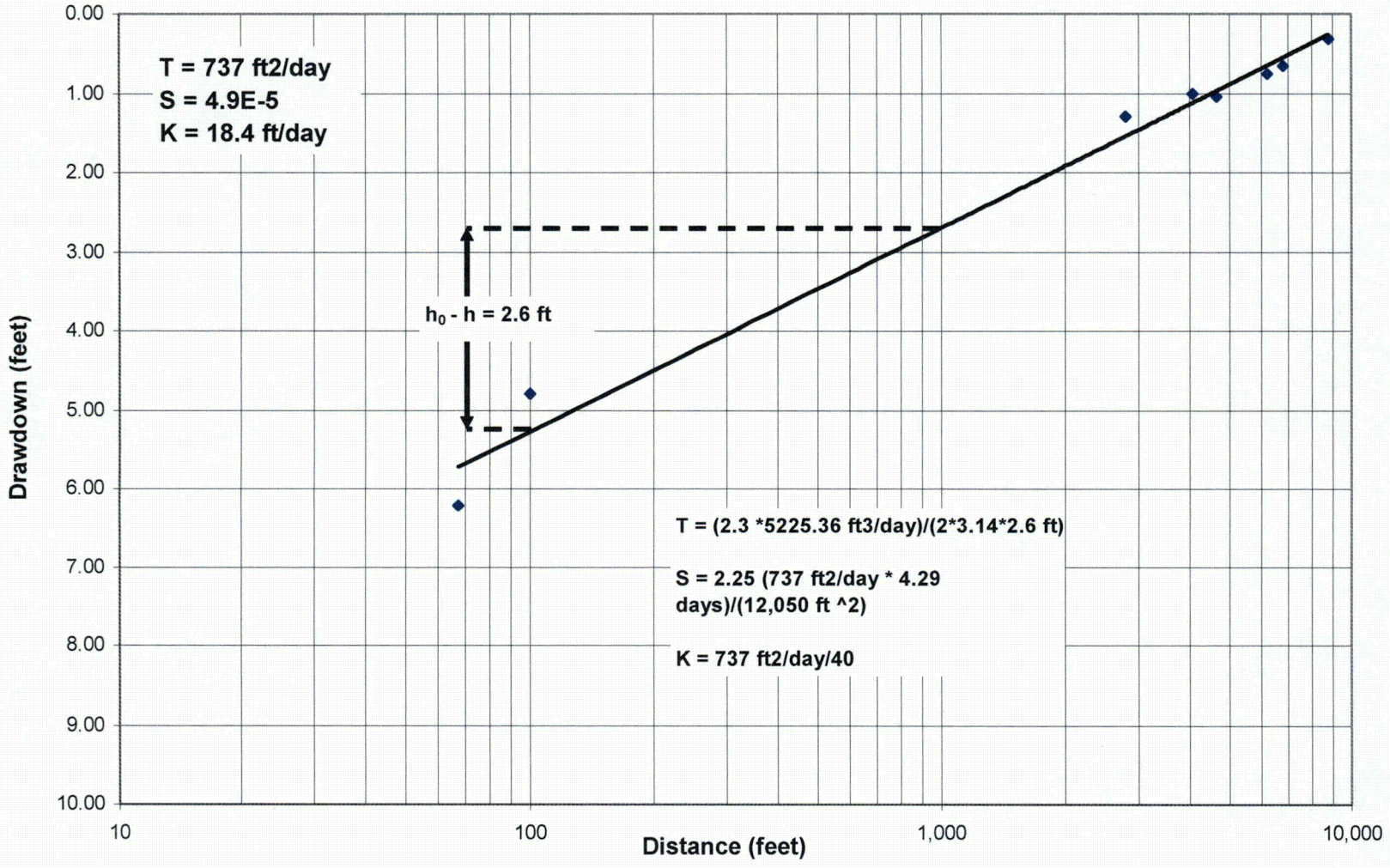
Cameco

FIGURE:

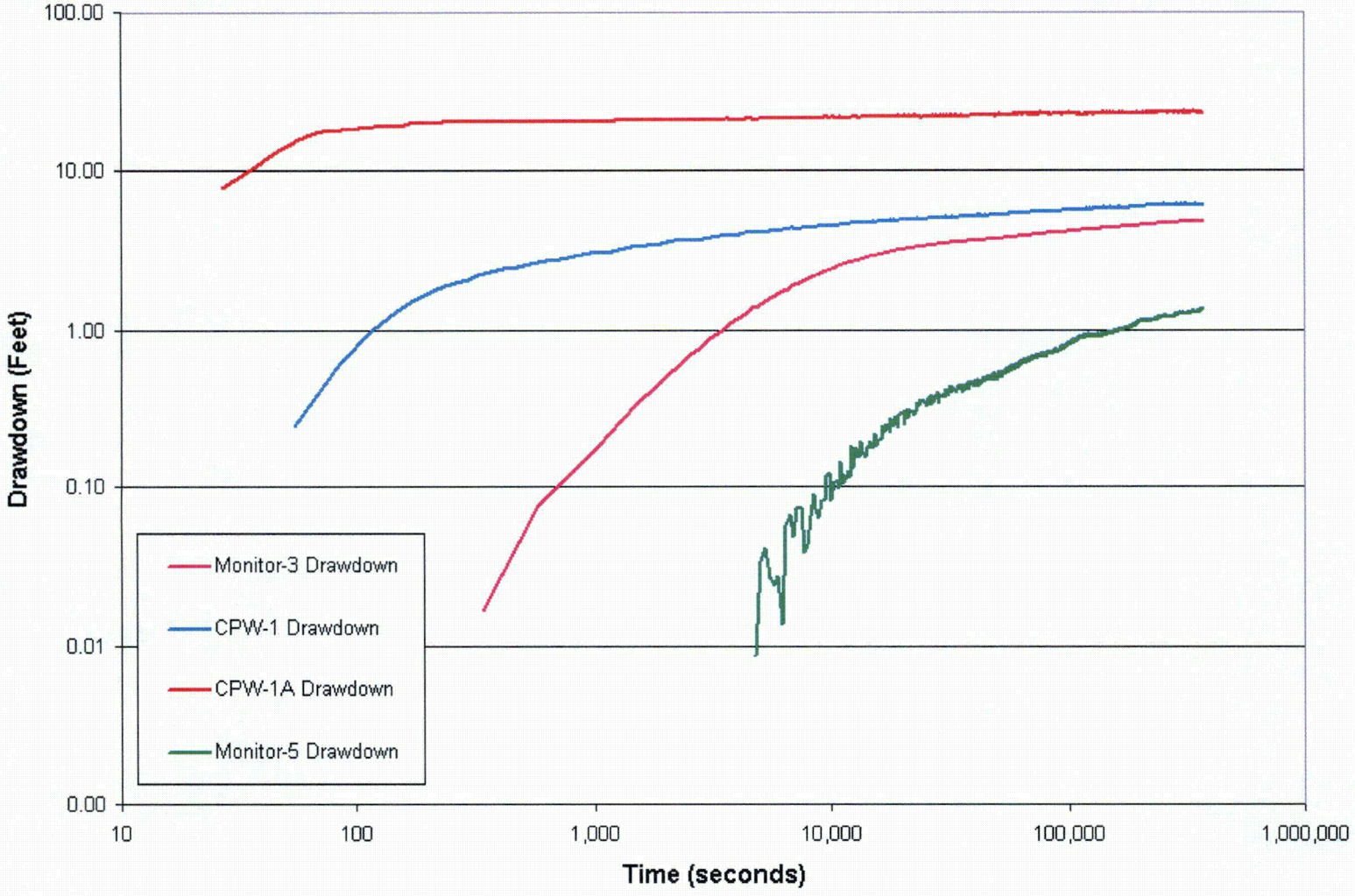
16



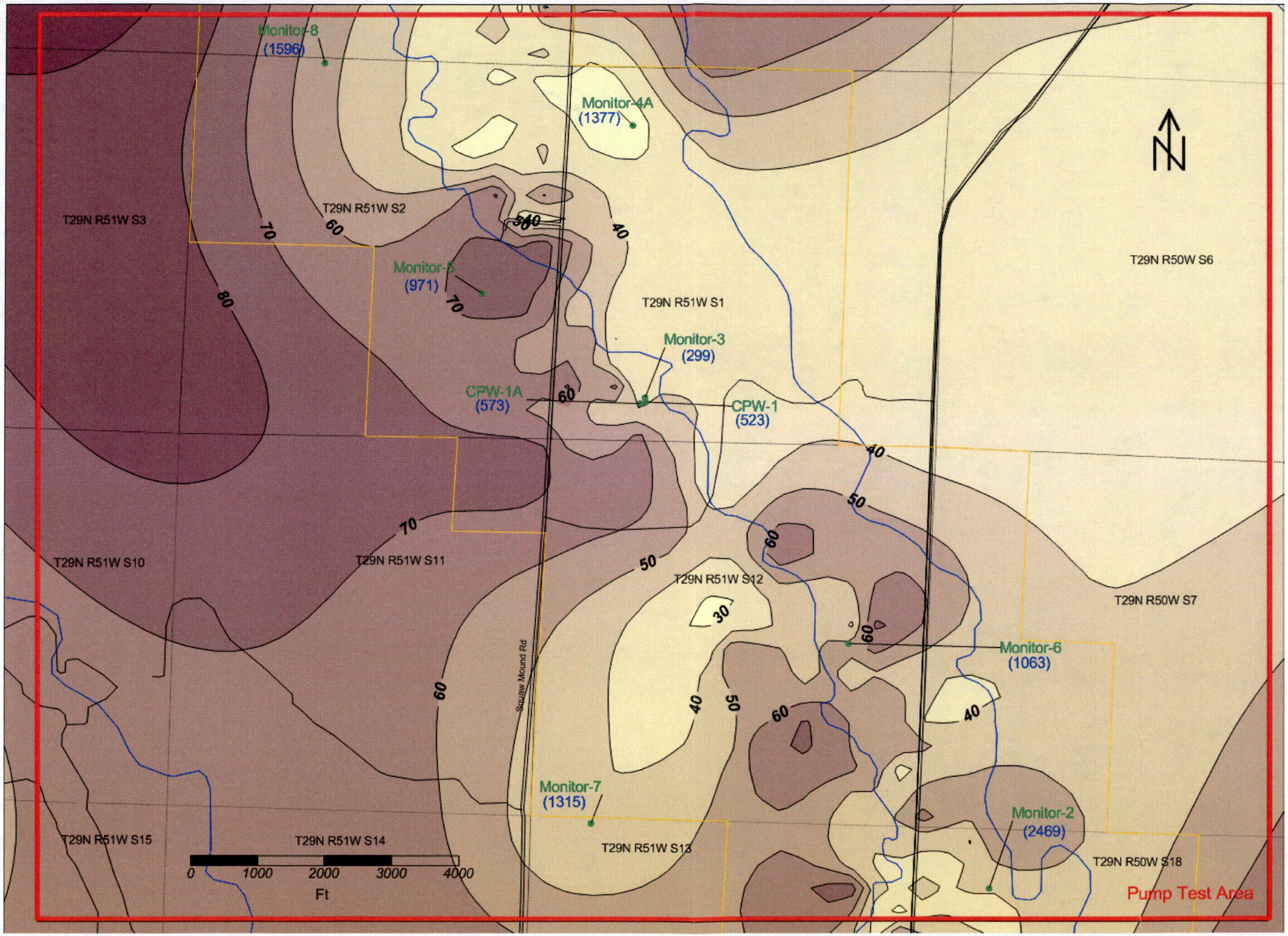

| | | | |
|---|---|---|---|
| AQUI-VER, INC.<br>*Hydrogeology, Water Resources & Data Services* | **Change in Barometric Pressure vs. Change in Water Level** | Marsland Regional Hydrologic Testing Report – Test # 8<br>Crow Butte Project, Marsland Expansion Area,<br>Dawes County, NE<br>Cameco | FIGURE:<br>17 |




| | | | |
|---|---|---|---|
| AQUI-VER, INC.<br>*Hydrogeology, Water Resources & Data Services* | **Distance Drawdown Plot** | Marsland Regional Hydrologic Testing Report – Test # 8<br>Crow Butte Project, Marsland Expansion Area,<br>Dawes County, NE<br>Cameco | FIGURE:<br>18 |




| | | | |
|---|---|---|---|
| AQUI-VER, INC.<br>*Hydrogeology, Water Resources & Data Services* | **Drawdown vs. Time for Selected Wells** | Marsland Regional Hydrologic Testing Report – Test # 8<br>Crow Butte Project, Marsland Expansion Area,<br>Dawes County, NE<br>Cameco | FIGURE:<br>19 |




**AQUI-VER, INC.**
*Hydrogeology, Water Resources & Data Services*

**Basal Chadron Sandstone Isopach Showing Transmissivity Distribution**

Marsland Regional Hydrologic Testing Report – Test # 8
Crow Butte Project, Marsland Expansion Area,
Dawes County, NE

Cameco

FIGURE:
20

# Appendix A

## WELL COMPLETION REPORTS

**Nebraska Department of Environmental Quality** **Permit No. NE0122611**

**Well Completion Report**

Company: Crow Butte Resources. Inc.
Project: Crow Butte
Well Type: Production/Injection ____ Monitor X
Well No. BOW-2010-1
Ground Elevation: 4259 ft.
Wellhead Elevation: 4260 ft.
Drilling Contractor: Landrill Exploration
Driller: J. Lemmon
Mud Products: 6 Bags Super Gel 2 Quart Polymer 2 Bags Lost Circulation Material
Bit Size: 8 Inch
Drilling Begun: 8/24/2010
Drilling Completed On: 8/26/2010
Completed Formation: Brule
Depth Drilled: 420 ft.
Casing Diameter: 4.95 inch O.D.
Casing Type: White Certalok
Casing Depth: 279 ft.
Basket Depth: N/A ft.
Packer Type: Johnson K-packer
Packer Depth: 275 ft.
Centralizer Depths: 20, 40, 100, 160, 220 Ft

Screen Size: 3 inch by .020 inch
Gravel Size:
Screened Interval(s): 285 ft. - 365 ft.
ft. - ft.
ft. - ft.
ft. - ft.
Completed Formation Upper Boundary: 270 ft.
Lower Boundary: 400 ft.
Cement Contractor: Crow Butte Resources
Operator: Klein
Estimated Cement Volume: 10.8 bbls.
Actual Cement Volume Used: 16.2 bbls.
Cement Density: 12.4 lbs/gal
Water Volume Used: 11.6 bbls.
Cement Type/Class: I/II API
Additives: 500 lbs. Salt 500 lbs. Bentonite
Cement Circulated to Surface: 0 bbls.
Density At Surface: 9 lbs/gal
Logging Contractor: Century Geophysical Corp.
Operator: Dunn
Unit No.: 0001
Probe No.: 9055C
Log Type: Gamma, SP, Resistance, Deviation
Well Deviation: 1.2 ft. at 342.2 degrees
Remarks: Tremmied 4 bbls to surface

This report was filled out by: Wade Beins
Representing: Crow Butte Resources, Inc.
On:

Certification:

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this form and all its attachments and that, based on inquiry of those individuals immediately responsible for obtaining information, I believe the information is true, accurate, and complete. Further, I certify awareness that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

By: Wade Beins Wade Beins Title : Senior Geologist

Date: May 27, 2011

**Nebraska Department of Environmental Quality** **Permit No. NE0122611**

**Well Completion Report**

Company: Crow Butte Resources. Inc.
Project: Crow Butte
Well Type: Production/Injection ____ Monitor X
Well No. BOW-2010-2
Ground Elevation: 4322 ft.
Wellhead Elevation: 4323 ft.
Drilling Contractor: Landrill Exploration
Driller: J. Lemmon
Mud Products: 7 Bags Super Gel 2 Quart Polymer 1 Bags Lost Circulation Material
Bit Size: 8 Inch
Drilling Begun: 8/25/2010
Drilling Completed On: 8/27/2010
Completed Formation: Brule
Depth Drilled: 420 ft.
Casing Diameter: 4.95 inch O.D.
Casing Type: White Certalok
Casing Depth: 339 ft.
Basket Depth: N/A ft.
Packer Type: Johnson K-packer
Packer Depth: 328 ft.
Centralizer Depths: 20, 40, 100, 160, 220, 280 Ft

Screen Size: 3 inch by .020 inch
Gravel Size:
Screened Interval(s): 338 ft. - 398 ft.
ft. - ft.
ft. - ft.
ft. - ft.
Completed Formation Upper Boundary: 330 ft.
Lower Boundary: 410 ft.
Cement Contractor: Crow Butte Resources
Operator: Klein
Estimated Cement Volume: 13.1 bbls.
Actual Cement Volume Used: 19.6 bbls.
Cement Density: 12.3 lbs/gal
Water Volume Used: 14.1 bbls.
Cement Type/Class: I/II API
Additives: 500 lbs. Salt 500 lbs. Bentonite
Cement Circulated to Surface: 0 bbls.
Density At Surface: 9.4 lbs/gal
Logging Contractor: Century Geophysical Corp.
Operator: Dunn
Unit No.: 0001
Probe No.: 9055C
Log Type: Gamma, SP, Resistance, Deviation
Well Deviation: 2.7 ft. at 300.1 degrees
Remarks: Tremmied 3 bbls to surface

This report was filled out by: Wade Beins
Representing: Crow Butte Resources, Inc.
On:

Certification:

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this form and all its attachments and that, based on inquiry of those individuals immediately responsible for obtaining information, I believe the information is true, accurate, and complete. Further, I certify awareness that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

By: Wade Beins Wade Beins Title : Senior Geologist

Date: May 27, 2011

**Nebraska Department of Environmental Quality** **Permit No. NE0122611**

**Well Completion Report**

Company: Crow Butte Resources. Inc.
Project: Crow Butte
Well Type: Production/Injection ____ Monitor X
Well No. BOW-2010-3
Ground Elevation: 4350 ft.
Wellhead Elevation: 4350 ft.
Drilling Contractor: Landrill Exploration
Driller: L. Corbin
Mud Products: 6 Bags Super Gel 1 Quart Polymer 2 Bags Lost Circulation Material
Bit Size: 8 Inch
Drilling Begun: 8/20/2010
Drilling Completed On: 8/24/2010
Completed Formation: Brule
Depth Drilled: 450 ft.
Casing Diameter: 4.95 inch O.D.
Casing Type: White Certalok
Casing Depth: 339 ft.
Basket Depth: N/A ft.
Packer Type: Johnson K-packer
Packer Depth: 336 ft.
Centralizer Depths: 20, 40, 100, 160, 220, 280 Ft

Screen Size: 3 inch by .020 inch
Gravel Size:
Screened Interval(s): 346 ft. - 416 ft.
ft. - ft.
ft. - ft.
ft. - ft.
Completed Formation Upper Boundary: 330 ft.
Lower Boundary: 440 ft.
Cement Contractor: Crow Butte Resources
Operator: Klein
Estimated Cement Volume: 13.1 bbls.
Actual Cement Volume Used: 19.6 bbls.
Cement Density: 12.2 lbs/gal
Water Volume Used: 14.1 bbls.
Cement Type/Class: I/II API
Additives: 500 lbs. Salt 500 lbs. Bentonite
Cement Circulated to Surface: 4 bbls.
Density At Surface: 12.2 lbs/gal
Logging Contractor: Century Geophysical Corp.
Operator: Dunn
Unit No.: 0001
Probe No.: 9055C
Log Type: Gamma, SP, Resistance, Deviation
Well Deviation: 3.6 ft. at 320.7 degrees
Remarks:

This report was filled out by: Wade Beins
Representing: Crow Butte Resources, Inc.
On:

Certification:

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this form and all its attachments and that, based on inquiry of those individuals immediately responsible for obtaining information, I believe the information is true, accurate, and complete. Further, I certify awareness that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

By: Wade Beins Wade Beins Title : Senior Geologist

Date: May 27, 2011

**Nebraska Department of Environmental Quality** **Permit No. NE0122611**

**Well Completion Report**

Company: Crow Butte Resources. Inc.
Project: Crow Butte
Well Type: Production/Injection ____ Monitor X
Well No. CPW-2010-1
Ground Elevation: 4260 ft.
Wellhead Elevation: 4262 ft.
Drilling Contractor: Landrill Exploration
Driller: L. Corbin
Mud Products: 11 Bags Super Gel 4 Quart Polymer 2 Bags Lost Circulation Material
Bit Size: 8 Inch
Drilling Begun: 8/31/2010
Drilling Completed On: 9/2/2010
Completed Formation: Chadron
Depth Drilled: 1070 ft.
Casing Diameter: 4.95 inch O.D.
Casing Type: White Certalok
Casing Depth: 1009 ft.
Basket Depth: N/A ft.
Packer Type: Johnson K-packer
Packer Depth: 995 ft.
Centralizer Depths: 20, 40, 100, 160, 220, 280, 340, 400, 460, 520, 580, 640, 700, 760, 820, 880, 940 Ft

Screen Size: 3 inch by .020 inch
Gravel Size:
Screened Interval(s): 1015 ft. - 1048 ft.
ft. - ft.
ft. - ft.
ft. - ft.
Completed Formation Upper Boundary: 1016 ft.
Lower Boundary: 1046 ft.
Cement Contractor: Crow Butte Resources
Operator: Klein
Estimated Cement Volume: 38.8 bbls.
Actual Cement Volume Used: 58.2 bbls.
Cement Density: 12.4 lbs/gal
Water Volume Used: 41.7 bbls.
Cement Type/Class: I/II API
Additives: 500 lbs. Salt 500 lbs. Bentonite
Cement Circulated to Surface: 5 bbls.
Density At Surface: 11.6 lbs/gal
Logging Contractor: Century Geophysical Corp.
Operator: Dunn
Unit No.: 0001
Probe No.: 9055C
Log Type: Gamma, SP, Resistance, Deviation
Well Deviation: 4.1 ft. at 203.5 degrees
Remarks:

This report was filled out by: Wade Beins
Representing: Crow Butte Resources, Inc.
On:

Certification:

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this form and all its attachments and that, based on inquiry of those individuals immediately responsible for obtaining information, I believe the information is true, accurate, and complete. Further, I certify awareness that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

By: Wade Beins Wade Beins Title : Senior Geologist

Date: May 27, 2011

**Nebraska Department of Environmental Quality** **Permit No. NE0122611**

**Well Completion Report**

Company: Crow Butte Resources. Inc.
Project: Crow Butte
Well Type: Production/Injection ____ Monitor X
Well No. CPW-2010-1A
Ground Elevation: 4261 ft.
Wellhead Elevation: 4263 ft.
Drilling Contractor: Landrill Exploration
Driller: S. Osmotherly
Mud Products: 7 Bags Super Gel 2 Quart Polymer 3 Bags Lost Circulation Material
Bit Size: 8 Inch
Drilling Begun: 3/14/2011
Drilling Completed On: 3/16/2011
Completed Formation: Chadron
Depth Drilled: 1080 ft.
Casing Diameter: 4.95 inch O.D.
Casing Type: White Certalok
Casing Depth: 1019 ft.
Basket Depth: N/A ft.
Packer Type: Johnson K-packer
Packer Depth: 1005 ft.
Centralizer Depths: 20, 40, 100, 160, 220, 280, 340, 400, 460, 520, 580, 640, 700, 760, 820, 880, 940 Ft

Screen Size: 3 inch by .020 inch
Gravel Size:
Screened Interval(s): 1025 ft. - 1055 ft.
ft. - ft.
ft. - ft.
ft. - ft.
Completed Formation Upper Boundary: 1024 ft.
Lower Boundary: 1050 ft.
Cement Contractor: Crow Butte Resources
Operator: Klein
Estimated Cement Volume: 39.2 bbls.
Actual Cement Volume Used: 58.8 bbls.
Cement Density: 12.3 lbs/gal
Water Volume Used: 42.1 bbls.
Cement Type/Class: I/II API
Additives: 500 lbs. Salt 500 lbs. Bentonite
Cement Circulated to Surface: 4 bbls.
Density At Surface: 11 lbs/gal
Logging Contractor: Century Geophysical Corp.
Operator: Dunn
Unit No.: 0001
Probe No.: 9055C
Log Type: Gamma, SP, Resistance, Deviation
Well Deviation: 24.9 ft. at 153.3 degrees
Remarks:

This report was filled out by: Wade Beins
Representing: Crow Butte Resources, Inc.
On:

Certification:

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this form and all its attachments and that, based on inquiry of those individuals immediately responsible for obtaining information, I believe the information is true, accurate, and complete. Further, I certify awareness that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

By: Wade Beins Wade Beins Title : Senior Geologist

Date: May 27, 2011

**Nebraska Department of Environmental Quality** **Permit No. NE0122611**

**Well Completion Report**

Company: Crow Butte Resources. Inc.
Project: Crow Butte
Well Type: Production/Injection ____ Monitor X
Well No. Monitor 2
Ground Elevation: 4197 ft.
Wellhead Elevation: 4198 ft.
Drilling Contractor: Landrill Exploration
Driller: G. Land
Mud Products:
Bit Size: 8 Inch
Drilling Begun: 4/7/1989
Drilling Completed On: 4/9/1989
Completed Formation: Chadron
Depth Drilled: 1030 ft.
Casing Diameter: 4.95 inch O.D.
Casing Type: White Certalok
Casing Depth: 974 ft.
Basket Depth: N/A ft.
Packer Type: Johnson K-packer
Packer Depth: 974 ft.
Centralizer Depths: ###

Screen Size: 3 inch by .020 inch
Gravel Size:
Screened Interval(s): 980 ft. - 1015 ft.
ft. - ft.
ft. - ft.
ft. - ft.
Completed Formation Upper Boundary: 974 ft.
Lower Boundary: 1015 ft.
Cement Contractor: Crow Butte Resources
Operator: Klein
Estimated Cement Volume: 37.5 bbls.
Actual Cement Volume Used: 56.2 bbls.
Cement Density: Not Avai lbs/gal
Water Volume Used: bbls.
Cement Type/Class: I/II API
Additives: 500 lbs. Salt 500 lbs. Bentonite
Cement Circulated to Surface: Not Avai bbls.
Density At Surface: Not Availa lbs/gal
Logging Contractor: Century Geophysical Corp.
Operator: Dunn
Unit No.: 0001
Probe No.: 9055C
Log Type: Gamma, SP, Resistance, Deviation
Well Deviation: 14.6 ft. at 128 degrees
Remarks:

This report was filled out by: Wade Beins
Representing: Crow Butte Resources, Inc.
On:

Certification:

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this form and all its attachments and that, based on inquiry of those individuals immediately responsible for obtaining information, I believe the information is true, accurate, and complete. Further, I certify awareness that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

By: Wade Beins Wade Beins Title : Senior Geologist

Date: May 27, 2011

**Nebraska Department of Environmental Quality** **Permit No. NE0122611**

**Well Completion Report**

Company: Crow Butte Resources. Inc.
Project: Crow Butte
Well Type: Production/Injection ____ Monitor X
Well No. Monitor 3
Ground Elevation: 4260 ft.
Wellhead Elevation: 4261 ft.
Drilling Contractor: Landrill Exploration
Driller: G. Land
Mud Products:
Bit Size: 8 Inch
Drilling Begun: 4/14/1989
Drilling Completed On: 4/18/1989
Completed Formation: Chadron
Depth Drilled: 1070 ft.
Casing Diameter: 4.95 inch O.D.
Casing Type: White Certalok
Casing Depth: 1008 ft.
Basket Depth: N/A ft.
Packer Type: Johnson K-packer
Packer Depth: 1008 ft.
Centralizer Depths: ###

Screen Size: 3 inch by .020 inch
Gravel Size:
Screened Interval(s): 1015 ft. - 1050 ft.
ft. - ft.
ft. - ft.
ft. - ft.
Completed Formation Upper Boundary: 1014 ft.
Lower Boundary: 1046 ft.
Cement Contractor: Crow Butte Resources
Operator: Klein
Estimated Cement Volume: 38.8 bbls.
Actual Cement Volume Used: 58.1 bbls.
Cement Density: Not Avai lbs/gal
Water Volume Used: bbls.
Cement Type/Class: I/II API
Additives: 500 lbs. Salt 500 lbs. Bentonite
Cement Circulated to Surface: Not Avai bbls.
Density At Surface: Not Availa lbs/gal
Logging Contractor: Century Geophysical Corp.
Operator: Dunn
Unit No.: 0001
Probe No.: 9055C
Log Type: Gamma, SP, Resistance, Deviation
Well Deviation: 13.8 ft. at 72 degrees
Remarks:

This report was filled out by: Wade Beins
Representing: Crow Butte Resources, Inc.
On:

Certification:

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this form and all its attachments and that, based on inquiry of those individuals immediately responsible for obtaining information, I believe the information is true, accurate, and complete. Further, I certify awareness that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

By: Wade Beins Wade Beins Title : Senior Geologist

Date: May 27, 2011

**Nebraska Department of Environmental Quality** **Permit No. NE0122611**

**Well Completion Report**

Company: Crow Butte Resources. Inc.
Project: Crow Butte
Well Type: Production/Injection ____ Monitor X
Well No. Monitor 4A
Ground Elevation: 4326 ft.
Wellhead Elevation: 4328 ft.
Drilling Contractor: Landrill Exploration
Driller: L. Corbin
Mud Products: 6 Bags Super Gel 3 Quart Polymer
Bit Size: 8 Inch
Drilling Begun: 11/3/2010
Drilling Completed On: 11/5/2010
Completed Formation: Chadron
Depth Drilled: 1140 ft.
Casing Diameter: 4.95 inch O.D.
Casing Type: White Certalok
Casing Depth: 1079 ft.
Basket Depth: N/A ft.
Packer Type: Johnson K-packer
Packer Depth: 1060 ft.
Centralizer Depths: 20, 40, 100, 160, 220, 280, 340, 400, 460, 520, 580, 640, 700, 760, 820, 880, 940, 1000 Ft

Screen Size: 3 inch by .020 inch
Gravel Size:
Screened Interval(s): 1080 ft. - 1110 ft.
ft. - ft.
ft. - ft.
ft. - ft.
Completed Formation Upper Boundary: 1081 ft.
Lower Boundary: 1109 ft.
Cement Contractor: Crow Butte Resources
Operator: Klein
Estimated Cement Volume: 41.5 bbls.
Actual Cement Volume Used: 62.2 bbls.
Cement Density: 12.5 lbs/gal
Water Volume Used: 44.6 bbls.
Cement Type/Class: I/II API
Additives: 500 lbs. Salt 500 lbs. Bentonite
Cement Circulated to Surface: 8 bbls.
Density At Surface: 11.9 lbs/gal
Logging Contractor: Century Geophysical Corp.
Operator: Dunn
Unit No.: 0001
Probe No.: 9055C
Log Type: Gamma, SP, Resistance, Deviation
Well Deviation: 11.3 ft. at 53.7 degrees
Remarks:

This report was filled out by: Wade Beins
Representing: Crow Butte Resources, Inc.
On:

Certification:

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By: Wade Beins Wade Beins Title : Senior Geologist

Date: May 27, 2011

**Nebraska Department of Environmental Quality** **Permit No. NE0122611**

**Well Completion Report**

Company: Crow Butte Resources. Inc.
Project: Crow Butte
Well Type: Production/Injection ____ Monitor X
Well No. Monitor 5
Ground Elevation: 4337 ft.
Wellhead Elevation: 4340 ft.
Drilling Contractor: Landrill Exploration
Driller: J. Lemmon
Mud Products: 8 Bags Super Gel 7 Quart Polymer 3 Bags Lost Circulation Material
Bit Size: 8 Inch
Drilling Begun: 8/30/2010
Drilling Completed On: 9/1/2010
Completed Formation: Chadron
Depth Drilled: 1140 ft.
Casing Diameter: 4.95 inch O.D.
Casing Type: White Certalok
Casing Depth: 1069 ft.
Basket Depth: N/A ft.
Packer Type: Johnson K-packer
Packer Depth: 1060 ft.
Centralizer Depths: 20, 40, 100, 160, 220, 280, 340, 400, 460, 520, 580, 640, 700, 760, 820, 880, 940, 1000 Ft

Screen Size: 3 inch by .020 inch
Gravel Size:
Screened Interval(s): 1070 ft. - 1120 ft.
ft. - ft.
ft. - ft.
ft. - ft.
Completed Formation Upper Boundary: 1066 ft.
Lower Boundary: 1116 ft.
Cement Contractor: Crow Butte Resources
Operator: Klein
Estimated Cement Volume: 41.1 bbls.
Actual Cement Volume Used: 61.7 bbls.
Cement Density: 12.2 lbs/gal
Water Volume Used: 44.2 bbls.
Cement Type/Class: I/II API
Additives: 500 lbs. Salt 500 lbs. Bentonite
Cement Circulated to Surface: 3 bbls.
Density At Surface: 11.5 lbs/gal
Logging Contractor: Century Geophysical Corp.
Operator: Dunn
Unit No.: 0001
Probe No.: 9055C
Log Type: Gamma, SP, Resistance, Deviation
Well Deviation: 27 ft. at 142.1 degrees
Remarks:

This report was filled out by: Wade Beins
Representing: Crow Butte Resources, Inc.
On:

Certification:

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By: Wade Beins Wade Beins Title : Senior Geologist

Date: May 27, 2011

**Nebraska Department of Environmental Quality** **Permit No. NE0122611**

**Well Completion Report**

Company: Crow Butte Resources. Inc.
Project: Crow Butte
Well Type: Production/Injection ____ Monitor X
Well No. Monitor 6
Ground Elevation: 4214 ft.
Wellhead Elevation: 4215 ft.
Drilling Contractor: Landrill Exploration
Driller: L. Corbin
Mud Products: 13 Bags Super Gel 8 Quart Polymer 4 Bags Lost Circulation Material
Bit Size: 8 Inch
Drilling Begun: 8/16/2010
Drilling Completed On: 8/18/2010
Completed Formation: Chadron
Depth Drilled: 1050 ft.
Casing Diameter: 4.95 inch O.D.
Casing Type: White Certalok
Casing Depth: 989 ft.
Basket Depth: N/A ft.
Packer Type: Johnson K-packer
Packer Depth: 982 ft.
Centralizer Depths: 20, 40, 100, 160, 220, 280, 340, 400, 460, 520, 580, 640, 700, 760, 820, 880, 940 Ft

Screen Size: 3 inch by .020 inch
Gravel Size:
Screened Interval(s): 992 ft. - 1025 ft.
ft. - ft.
ft. - ft.
ft. - ft.
Completed Formation Upper Boundary: 982 ft.
Lower Boundary: 1023 ft.
Cement Contractor: Crow Butte Resources
Operator: Klein
Estimated Cement Volume: 38.1 bbls.
Actual Cement Volume Used: 57.1 bbls.
Cement Density: 12 lbs/gal
Water Volume Used: 40.9 bbls.
Cement Type/Class: I/II API
Additives: 500 lbs. Salt 500 lbs. Bentonite
Cement Circulated to Surface: 3 bbls.
Density At Surface: 10 lbs/gal
Logging Contractor: Century Geophysical Corp.
Operator: Dunn
Unit No.: 0001
Probe No.: 9055C
Log Type: Gamma, SP, Resistance, Deviation
Well Deviation: 17.1 ft. at 37.3 degrees
Remarks:

This report was filled out by: Wade Beins
Representing: Crow Butte Resources, Inc.
On:

Certification:

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By: Wade Beins Wade Beins Title : Senior Geologist

Date: May 27, 2011

**Nebraska Department of Environmental Quality** **Permit No. NE0122611**

**Well Completion Report**

Company: Crow Butte Resources. Inc.
Project: Crow Butte
Well Type: Production/Injection ____ Monitor X
Well No. Monitor 7
Ground Elevation: 4243 ft.
Wellhead Elevation: 4244 ft.
Drilling Contractor: Landrill Exploration
Driller: L. Corbin
Mud Products: 6 Bags Super Gel 6 Quart Polymer 3 Bags Lost Circulation Material
Bit Size: 8 Inch
Drilling Begun: 8/20/2010
Drilling Completed On: 8/23/2010
Completed Formation: Chadron
Depth Drilled: 1080 ft.
Casing Diameter: 4.95 inch O.D.
Casing Type: White Certalok
Casing Depth: 999 ft.
Basket Depth: N/A ft.
Packer Type: Johnson K-packer
Packer Depth: 993 ft.
Centralizer Depths: 20, 40, 100, 160, 220, 280, 340, 400, 460, 520, 580, 640, 700, 760, 820, 880, 940 Ft

Screen Size: 3 inch by .020 inch
Gravel Size:
Screened Interval(s): 1003 ft. - 1046 ft.
ft. - ft.
ft. - ft.
ft. - ft.
Completed Formation Upper Boundary: 1007 ft.
Lower Boundary: 1044 ft.
Cement Contractor: Crow Butte Resources
Operator: Klein
Estimated Cement Volume: 38.4 bbls.
Actual Cement Volume Used: 57.6 bbls.
Cement Density: 11.7 lbs/gal
Water Volume Used: 41.3 bbls.
Cement Type/Class: I/II API
Additives: 500 lbs. Salt 500 lbs. Bentonite
Cement Circulated to Surface: 2 bbls.
Density At Surface: 10.2 lbs/gal
Logging Contractor: Century Geophysical Corp.
Operator: Dunn
Unit No.: 0001
Probe No.: 9055C
Log Type: Gamma, SP, Resistance, Deviation
Well Deviation: 32.2 ft. at 159.9 degrees
Remarks:

This report was filled out by: Wade Beins
Representing: Crow Butte Resources, Inc.
On:

Certification:

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By: Wade Beins Wade Beins Title: Senior Geologist

Date: May 27, 2011

**Nebraska Department of Environmental Quality** **Permit No. NE0122611**

**Well Completion Report**

Company: Crow Butte Resources. Inc.
Project: Crow Butte
Well Type: Production/Injection ____ Monitor X
Well No. Monitor 8
Ground Elevation: 4352 ft.
Wellhead Elevation: 4354 ft.
Drilling Contractor: Landrill Exploration
Driller: L. Corbin
Mud Products: 10 Bags Super Gel 4 Quart Polymer 4 Bags Lost Circulation Material
Bit Size: 8 Inch
Drilling Begun: 8/27/2010
Drilling Completed On: 8/30/2010
Completed Formation: Chadron
Depth Drilled: 1150 ft.
Casing Diameter: 4.95 inch O.D.
Casing Type: White Certalok
Casing Depth: 1079 ft.
Basket Depth: N/A ft.
Packer Type: Johnson K-packer
Packer Depth: 1067 ft.
Centralizer Depths: 20, 40, 100, 160, 220, 280, 340, 400, 460, 520, 580, 640, 700, 760, 820, 880, 940, 1000 Ft

Screen Size: 3 inch by .020 inch
Gravel Size:
Screened Interval(s): 1087 ft. - 1127 ft.
ft. - ft.
ft. - ft.
ft. - ft.
Completed Formation Upper Boundary: 1085 ft.
Lower Boundary: 1123 ft.
Cement Contractor: Crow Butte Resources
Operator: Klein
Estimated Cement Volume: 41.5 bbls.
Actual Cement Volume Used: 62.2 bbls.
Cement Density: 12.8 lbs/gal
Water Volume Used: 44.6 bbls.
Cement Type/Class: I/II API
Additives: 500 lbs. Salt 500 lbs. Bentonite
Cement Circulated to Surface: 5 bbls.
Density At Surface: 11.5 lbs/gal
Logging Contractor: Century Geophysical Corp.
Operator: Dunn
Unit No.: 0001
Probe No.: 9055C
Log Type: Gamma, SP, Resistance, Deviation
Well Deviation: 38.5 ft. at 173.6 degrees
Remarks:

This report was filled out by: Wade Beins
Representing: Crow Butte Resources, Inc.
On:

Certification:

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Date: May 27, 2011