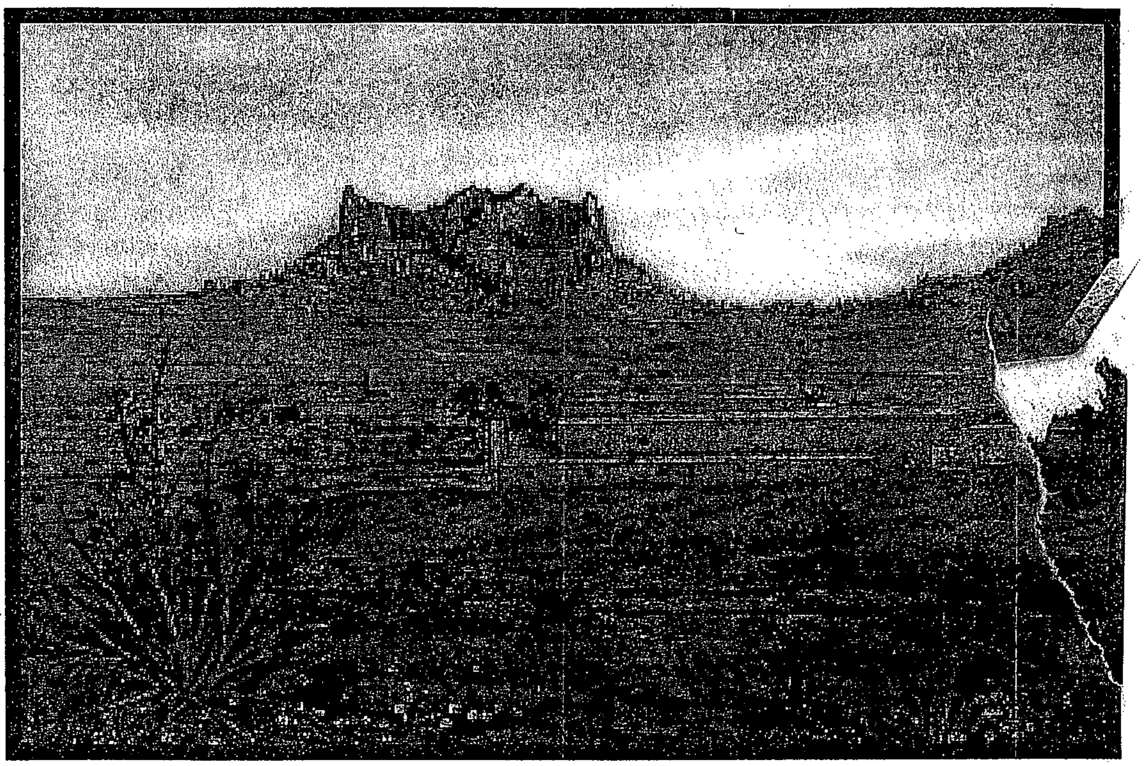
Crow Butte Resources, Inc.

Three Crow Expansion Area

Petition for Aquifer Exemption



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May 2010

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1. Introduction

Crow Butte Resources, Inc. (CBR) currently operates a uranium in-situ leach (ISL) extraction mine in Dawes County, Nebraska. This operation, called the Crow Butte Project, is located in portions of Sections 11, 12, 13, and 24 of Township 31 North, Range 52 West and Sections 18, 19, 20, 29, and 30 of Township 31 North, Range 51 West (Figure 1). Uranium oxide is extracted from the Chamberlain Pass Formation (herein referred to as the Basal Chadron Sandstone for continuity with historical permitting) via Class III mineral extraction wells, and has been permitted and operated since 1991.

1.1 Proposed Activities

CBR seeks to expand mining activities west of the current production area. The proposed Three Crow Expansion Area (TCEA) is located in Sections 28, 29, 30, and 33 of Township 31 North, Range 52 West and in Section 25 of Township 31 North, Range 53 West, and is about 3.5 miles southwest of the city of Crawford, Nebraska (Figures 1 and 2). The TCEA encompasses about 1,643 acres and 100 percent of the minerals leased in the TCEA are on private lands. As in the current Class III production area, the Basal Chadron Sandstone contains the uranium to be extracted. The proposed TCEA will be used as a satellite facility to the existing CBR production facility.

1.2 Ore/Site Amenability to the ISL Mining Method

Amenability of the uranium deposits in the Basal Chadron Sandstone in the Crow Butte Project to ISL mining was demonstrated initially through core studies at the original Crow Butte Study Area (CSA) where mining is currently being conducted. Results of core studies were confirmed in the Research and Development (R&D) phase of the project at the Crow Butte site using bicarbonate/carbonate leaching solutions with oxygen. Reports concerning the results of the R&D activities, including restoration of affected groundwater, have been submitted to the Nuclear Regulatory Commission (NRC) and the Nebraska Department of Environmental Quality (NDEQ). Similar to the CSA currently being mined by ISL, the TCEA exhibits the following conditions:

- For containment of solution, the Basal Chadron Sandstone ore body is relatively horizontal (within the permit boundary) and is underlain and overlain by very low permeability strata.
- The Basal Chadron Sandstone ore body is below the static water table and has sufficient permeability to achieve solution flow.

- The permeability, porosity, and hydrology of the Basal Chadron Sandstone is favorable to the ISL process.
- A pump test has verified the favorable hydrologic conditions in the Basal Chadron Sandstone at the site (Petrotek, August 2008).
- The uranium ore is similar to that of the current Crow Butte ISL operation and, therefore, is mineralogically suitable for solution mining.

The information and experience gained during past R&D programs formed the basis for the existing commercial uranium ISL mining operations. CBR believes that the current commercial project, including the successful restoration of groundwater in Mine Unit 1, demonstrates that such a program can be implemented with minimal short-term environmental impacts and with no significant risk to the public health or safety.

Figure 3 depicts the distribution of the nine designated mine units within the TCEA. Assuming favorable regulatory action by the NRC and State of Nebraska regulatory agencies, initial construction of the Three Crow facilities will begin in 2014. An approved expansion of the current production facility will handle production for the TCEA. As shown in Table 1, production is scheduled to begin in late 2014 and is projected to last for approximately 7 years. Groundwater restoration activities at TCEA are expected to begin in late 2017 with Mine Unit 1. Groundwater restoration will extend for approximately 6 years with final site reclamation completed by late 2025.

2. Summary of Regulatory Requirements

Water quality information for the TCEA indicates that the Basal Chadron Sandstone groundwater exhibits a Total Dissolved Solids (TDS) concentration of less than 10,000 milligrams per liter (mg/L), and therefore can be considered an underground source of drinking water (USDW) as defined in Nebraska Administrative Code Title 122, Chapter 1. Title 122, Chapter 5 prohibits the movement of fluids during in-situ mining operations into a USDW, but an aquifer exemption may be granted if appropriate regulatory demonstrations are made (see Section 5 of this report for additional discussion regarding the regulatory basis of an aquifer exemption). The original operators of the Crow Butte Project Area, Wyoming Fuel Company, received an aquifer exemption in 1990 to allow in-situ extraction of uranium from the Basal Chadron Sandstone (Federal Register, Vol. 55, No. 100, May 23, 1990). Mining began in 1991 and continues to date by CBR. CBR seeks to expand this successful operation to the TCEA. Hence, an aquifer exemption for the TCEA is requested.

The Nebraska Administrative Code Title 122 presents rules and regulations for underground injection and mineral production wells. Chapter 4, Section 001 of the Code states: "*No owner or operator shall construct, operate, maintain, convert, plug or abandon any injection well or mineral production well or conduct any other injection activity in a manner that allows the movement of fluid containing any contaminant into underground sources of drinking water if the presence of that contaminant may cause a violation of any primary drinking water regulation...*".

However, Chapter 5 of Title 122, Section 002 states, "*Upon petition by permit applicant and after public notice and opportunity for a public hearing, the Director may designate an aquifer or a portion thereof as an exempted aquifer*". To facilitate this designation, Section 003 states that:

> 003 The petitioner must identify (by narrative description, illustrations, maps, or other means) and describe, in geographic and/or geometric terms (such as vertical and lateral limits and gradient) which is clear and definite, an aquifer or parts thereof which he or she proposes the Director designate an exempted aquifer and effects of the exemption of the aquifer from Nebraska Title 118 – Ground Water Standards and Use Classification....

Chapter 5 of Title 122, Section 004 specifies the criteria for making the aquifer exemption:

- 004 An Aquifer or a portion of an aquifer which meets the criteria for an underground source of drinking water may be designated as an exempted aquifer if the following criteria are met:
- 004.01 It does not currently serve as a source of drinking water; and
- 004.02 It cannot now and will not in the future serve as a source of drinking water because:
- 004.02A It is mineral, hydrocarbon, or geothermal energy bearing with production capability;
- 004.02B It is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical;
- 004.02C It is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption; or
- 004.02D It is located above a Class III well mining area subject to subsidence or catastrophic collapse

As indicated above, the petitioner must provide specific information pertinent to the aquifer or parts thereof which are proposed for the Director to designate as an exempted aquifer. The remaining sections of this Petition for Aquifer Exemption provide the required information; Sections 3 and 4 of this application present the required Chapter 5 Title 122 Section 003 narrative description about the portion of the aquifer for which an exemption is sought, including general hydrologic information about the aquifer, location, and related facility operations that impact the hydrologic setting. Section 5 of this application shows how the required aquifer exemption criteria presented in Chapter 5 Title 122 Section 004 are met, specifically that:

- The aquifer or a portion of the aquifer does not currently serve as a source of drinking water (004.01).
- It cannot and will not in the future serve as a source of drinking water because: 1) it is mineral-, hydrocarbon- or geothermal energy-bearing with production capability (004.2A) and 2) it is so contaminated that it would be economically or technically impractical to render that water fit for human consumption (004.02C).

Note that regulation does not mandate that all four aquifer exemption criteria specified under Section 004.02 be met; rather, only one of the four criteria need be demonstrated to successfully meet the regulatory requirement. Criteria under both 004.02A and 004.02C are met by the proposed exemption.

3. Description of Proposed Exemption

3.1 Background

Figure 1 presents the geographic location of the proposed exemption area. As shown on Figure 1, the proposed TCEA occurs approximately 3.5 miles southwest of the city of Crawford, Nebraska in Sections 28, 29, 30, and 33 of Township 31 North, Range 52 West and in Section 25 of Township 31 North, Range 53 West. Table 2 presents the regional stratigraphic section that includes the White River Group (Brule Formation through Basal Chadron Sandstone).

The Basal Chadron Sandstone contains both the aquifer for which an exemption is sought and the mining interval (ore bearing zone) in the TCEA. The lateral extent of the exemption area requested includes all of the proposed NRC permit area as shown on Figure 2. This figure shows the location of the commercially producible ore based on drilling conducted to date. However, because additional drilling will be conducted in the future, and uranium prices continue to increase, CBR requests that the entire TCEA be included in the aquifer exemption to allow for full development of the resource within the TCEA. Table 3 presents the legal description of the proposed exempted aquifer in the TCEA. Detailed information pertaining to the geologic and hydrologic characteristics of this aquifer is presented in Sections 3 and 4, respectively. The vertical extent of the exemption is discussed in Section 4.6.

The nearest major population center to the TCEA is the City of Crawford, which is approximately 3.5 miles northeast of the TCEA (Figure 1). In 2008, there were a total of 533 houses in the City of Crawford, with 468 occupied (345 owner occupied and 123 renter occupied) (City-Data 2010). The housing density was 467 houses/condos per square mile. The last US census was in 2000, with Crawford reported to contain 537 housing units, of which 473 were occupied (US Census 2004).

Land use of the TCEA and surrounding 2.25-mile area of review (AOR) is dominated by agricultural uses (i.e., cropland and rangeland), with a significant portion designated as recreational land (Fort Robinson State Park) to the north of the permit boundary (Figure 3).

The depth to the ore body within the Basal Chadron Sandstone in the TCEA ranges from approximately 580 to 940 feet below ground surface (bgs) (Table 4). The width of the ore body varies from approximately 2,100 to 4,000 feet. Indicated ore resources as U_3O_8 for the TCEA are 3,750,481 pounds (lbs) with an additional inferred estimate of 1,135,452 lbs. Total reserves are estimated at 4,900,000 lbs. The ore grade as U_3O_8

ranges from 0.05 to 5 percent with an average ore grade of 0.22 percent. The expected annual production rate is approximately 600,000 pounds per year. The average flow rate throughput is approximately 4,500 gallons per minute (gpm) excluding 1,500 gpm for restoration. The anticipated bleed rate is assumed to be 0.5 to 1.5 percent of the total mining flow. Initial estimates pertaining to the CSA Class III Permit area indicated 22.8 million pounds of U_3O_8 in that area, and that this uranium was present in a mineralogical form amenable to solution mining. This area has been successfully mined for more than 18 years.

Hansley, et al. (1989) conducted detailed geochemical analysis of the Crow Butte uranium ore to assess both ore genesis and composition. The Crow Butte deposits, including those at the TCEA, are roll-type deposits with coffinite being the predominant uranium mineral species present. The origin of the uranium is rhyolitic ash, which is abundant within the matrix of the Basal Chadron Sandstone (Hansley et al., 1989). Coffinite is associated with pyrite, and high silica activity due to dissolution of the rhyolitic ash favored formation of coffinite over uraninite in most parts of this sandstone. In addition, smectite is present in the samples examined, with the most common minerals in the sandstone being quartz, plagioclase, K-feldspar, coffininte, pyrite, marcasite, calcite, illite/spectite smectite, and tyuyamunite. The heavy mineral portion of the samples contained several minerals including those above as well as garnet, magnetite, marcasite, and illmenite. Vanadium was detected in the samples primarily as an amorphous species presumed to have originated from the in-situ ash. Hansley, et al. state that at least some uranium and vanadium remain bound to amorphous volcanic material and/or smectite rather than as discrete mineral phases.

Petrographic data obtained and examined by Hansley et al. (1989) suggest that uranium mineralization occurred before lithification of the Basal Chadron Sandstone. Hansley states: "*Dissolution of abundant rhyolitic volcanic ash produced uranium (U)- and silicon (Si)- rich ground waters that were channeled through permeable sandstone as at the base of the Chadron by relatively impermeable overlying and underlying beds. The precipitation of early authigenic pyrite created a reducing environment favorable for precipitation and accumulation of U in the basal sandstone. The U has remained in a reduced state, as evidenced by the fact that the unoxidized minerals, coffinite and uraninite, comprise the bulk of the ore.*"

Based on similar regional deposition, the TCEA ore body is expected to be similar mineralogically and geochemically to that of the CSA. The ore bodies in the two areas are within the same geologic unit (the Basal Chadron Sandstone) and have the same mineralization source. The sites are separated by only a few miles, and the cause of mineral deposition in the two areas appears to be similar. Neither site is anticipated to be significantly affected by recharge or other processes. The groundwater characteristics of the TCEA mineralized zone are discussed in detail in Section 4.0.

3.2 Geology of Three Crow Expansion Area

Table 2 summarizes the regional stratigraphic section for northwest Nebraska. A geologic map of bedrock in northwest Nebraska is shown on Figure 6. The bedrock map depicts the occurrence in northwest Nebraska of the Miocene Ogallala Group, Miocene Arikaree Group, the Eocene-Oligocene White River Group, and Upper Cretaceous strata belonging to the Montana Group and Colorado Group. The Upper Cretaceous Pierre Shale, the unconformably overlying White River Group (i.e, Brule Formation, Chadron Formation, and Chamberlain Pass Formation), and the Arikaree Group outcrop in the vicinity of the City of Crawford and TCEA (Figure 6, see inset).

The Crow Butte area is located near the northern limits of the High Plains section of the Great Plains physiographic province. Topography of the Crow Butte area includes gently sloping, rolling hills with outlying, broad ridges which are dissected by intermittent and perennial streams. The most prominent physiographic feature in the region is the Pine Ridge Escarpment, which rises roughly 300 to 900 feet above the basal plain. The escarpment bounds three sides of the Crawford Basin. Colluvial and alluvial deposits originating from this escarpment cover the permit area. The elevation of the Crow Butte Project area ranges from 3,600 to 4,400 feet above mean sea level (amsl).

The local stratigraphy present within the TCEA consists of the following geological units in descending order: alluvial sediments, Brule Formation, Chadron Formation, Basal Chadron Sandstone and Pierre Shale. The channel sandstone facies of the Basal Chadron Sandstone represents the production zone and target of solution mining in the TCEA. The general stratigraphic section for the TCEA is summarized in Table 4. Revised nomenclature for stratigraphic units within the White River Group is discussed in detail in Section 3.3. Figure 4 illustrates the locations of five north-south and east-west cross-sections through the TCEA depicted on Figures 5a through 5e.

Though a thick (approximately 1,200 to 1,500 feet), regionally extensive stratigraphic section of sedimentary units underlies the Pierre Shale, those units are not relevant to this petition. The absence of sandstone units for more than 1,000 feet below the top of the Pierre Shale precludes the need for monitoring zones below the surface of the Pierre Shale. Discussion in this report is limited to those formations immediately above and below the Basal Chadron Sandstone (Petrotek, 2008; Wyoming Fuel Company, 1983).

3.2.1 Borehole Geophysical Logs

Detailed analysis of a carefully chosen suite of borehole geophysics provides a method for interpreting lithology, stratigraphy and depositional environment, and for deriving porosity values, permeability index, and water salinity. The log curves used for interpretation and parameter derivation measure: resistivity, electron density, interval travel time, spontaneous potential, natural radioactivity, and hydrogen content. As of February 2010, there have been approximately 730 exploration holes drilled within the TCEA boundary.

Log interpretation and parameter evaluation involves analysis of the measured log curve values and responses. The measured curve and resultant analysis are affected by drilling processes, properties of the formation, and limitations of the logging tools themselves. However, the greatest complication to log interpretation is low quality logs, which can result from poor quality control in the field and a lack of understanding of borehole and formation conditions effecting log response.

Common hydrogeologic objectives of borehole geophysical logging include: (1) definition and correlation of aquifer or other lithologic units; (2) estimation of aquifer properties such as porosity and permeability; and (3) assessment of physical properties of formation water including conductivity, total dissolved solids, and total hardness. These objectives must be considered in the design, selection, and implementation of an effective logging program.

There are three basic parameters derived or interpreted from borehole geophysical logs: lithology, resistivity and porosity. From these basic parameters, there are numerous variations that can provide information regarding lithologic identification, correlation, facies evaluation, delineation of permeable and porous zones, and identification of pore fluids. The type of measurements used to determine this information are:

- spontaneous potential;
- natural gamma radiation (ray);
- resistivity/induction;
- acoustic velocity (sonic);
- electron density (bulk density);
- induced radiation effects (neutron);
- caliper (hole size).

Approximately 170 geophysical logs were reviewed for interpretation and correlation in the TCEA (Appendix A). Approximately 75 logs were correlated and utilized to generate five cross sections. An additional 20 logs were correlated near the six cross section lines. Logs from four oil and gas wells outside the TCEA were reviewed. The following represent the general log suite at each borehole location.

Gamma ray (GR) tools measure naturally occurring gamma ray radiation emitted spontaneously from the formation by uranium, thorium, and the potassium 40 isotope. Natural gamma logs are powerful tools in lithologic identification and correlation, identification of potential migration pathways, and evaluation of water quality with respect to radionuclides, such as uranium salts. GR logs usually show the clay content in sedimentary rocks, because heavy radioactive elements (potassium, thorium and uranium-radium) tend to concentrate in clays. While clays and clayey sands are higher in radioactivity, clean sands (no clay content) and carbonates usually exhibit low levels of radioactivity. In these situations, the GR curve can differentiate between sands, clays, and the gradation between the two. As radioactive elements tend to concentrate in shale and clays, high gamma ray readings reflect high shale or clay content in sedimentary units. Very low levels of radioactive elements or isotopes are present in clean formations (sands, gypsum, and anhydrite); unless contaminants are present, such as dissolved potassium or uranium salts, volcanic ash, or granite wash. Within the TCEA, as with the rest of the Crow Butte Project, uranium- and vanadium-bearing minerals are relatively abundant in the Basal Chadron Sandstone and are readily identifiable with gamma logs. The tool records counts per second, which should be converted to American Petroleum Institute (API) units. Natural gamma logs should always be calibrated in API units.

The Spontaneous Potential (SP) log is a measurement of the electrical potential (voltage) that occurs in a boring when fluids of different salinities are in contact. The electrical potential is produced by the interaction of formation water, conductive drilling fluids, and certain ion-selective sediments (clay). The SP response to shale and mudstones lacking coarser interbeds is relatively constant and produces what is referred to as the "shale baseline". The shale baseline was originally recognized in thick marine shale sequences, but is also recognized in terrestrial deposits and is somewhat of a misnomer. Deviations from the shale base line are indicative of more permeable zones such as sandstones. In addition, the SP curve is also distorted (depressed or elevated) by permeable zones that contain clay, hydrocarbons, gas or contaminants.

Single point resistance tools measure the resistance to current flow between a tool electrode and a ground electrode (conventional single point resistance), or between an electrode in the tool and the shell of the tool (differential single point resistance). Response of the log curve is attributed to lithologic units of varying resistance. Resistance increases in freshwater-filled sands or gravels, and decreases in shale, clays, silts, and brine-filled sands. Curve values are recorded in ohms. Point resistance tools have a relatively small radius of investigation and poor thin bed resolution in comparison to other resistivity tools. These logs are mainly used for correlation of beds. Resistivity logs are primarily used to identify and distinguish between hydrocarbon- and water-bearing zones and to determine formation porosity.

The Neutron-Neutron (N-N) tool is a direct measurement of variations in the hydrogen content of the formation. Because hydrogen in a porous formation is concentrated in fluid-filled pores, this log is commonly used to determine formation porosity. The neutron probe contains a source of high-energy neutrons (commonly americium-beryllium) with thermal neutron detectors at fixed distance away from the source. Neutron logs are influenced by changes in the hole diameter. If a formation's lithology is known, tool-specific charts can be used to quantify porosity. This is necessary because neutron logs are not typically calibrated in basic physical units.

3.3 Stratigraphy

The general stratigraphy for northwest Nebraska is shown in Table 2. The regional stratigraphy consists of pre-Cambrian basement rocks that are overlain by a thick Phanerozoic stratigraphic sequence. This section provides a detailed description of the stratigraphy of the TCEA based on an extensive review of existing site-specific drilling logs and published literature. Geological units are described from stratigraphically youngest to stratigraphically oldest. Revised nomenclature for these stratigraphic units is discussed, where applicable, and referred to throughout this application. To be consistent with historical permitting, the stratigraphic nomenclature used in previous submittals to the NRC and the NDEQ has been preserved.

3.3.1 Alluvium

Alluvial deposits occur between the surface and the top of the Brule Formation and vary in thickness (depending upon topography) from 0 to 30 feet. In general, the alluvium consists of Miocene age rock fragments, sand, gravel and sandy soil horizons, and may also include weathered portions of the Brule Formation. Because alluvium is generally unconsolidated and contains either shallow groundwater or is within the vadose zone, log signatures within this unit may vary significantly when compared to signatures for underlying units. On most TCEA logs, resistivity is very high (beyond the log scale), indicating the presence of either soil vapor or fresh water. In general, shallow zones with elevated resistivity also indicated a negatively deflected SP curve, suggesting the presence of a permeable zone and formation fluid with lower resistivity than the fluid within the borehole. Although these log signatures suggest the base of the alluvium can be interpreted, this relationship has not been verified and the Alluvium-Brule Formation contact is not depicted on cross-sections included with this application.

3.3.2 White River Group

The Eocene-Oligocene White River Group consists of the Chamberlain Pass Formation overlain by the Chadron Formation, which is, in turn, overlain by the Brule Formation (Table 4). Strata assigned to this group were deposited within fluvial, lacustrine, and eolian environments (Terry and LaGarry, 1998). In northwest Nebraska, it rests unconformably on pedogenically modified Pierre Shale. The bulk of the White River Group is composed of airfall and reworked volcaniclastics derived from sources in Nevada and Utah (Larson and Evanoff, 1998; Terry and LaGarry, 1998).

The history of stratigraphic nomenclature for the White River Group of Nebraska and South Dakota has had various interpretations as described by Harksen and Macdonald (1969). The following stratigraphic nomenclature represents a preservation of formal and informal members based on nomenclature by Schultz and Stout (1955) with representation of more recent nomenclature (Terry and LaGarry, 1998; Terry, 1998; LaGarry, 1998; Hoganson et al., 1998).

3.3.2.1 Brule Formation

The Oligocene Brule Formation represents the youngest unit within the White River Group which outcrops throughout most of the Crow Butte area. The unit conformably overlies the Chadron Formation and is unconformably overlain by sandstones of the Arikaree Group (Figure 6). The White River Group was originally subdivided by Swinehart (1985) and later revised by LaGarry (1998) into three members, from youngest to oldest: the "brown siltstone" member, the Whitney Member, and underlying Orella Member (Table 4). The "brown siltstone" member consists of pale brown and brown, nodular, cross-bedded eolian volcaniclastic siltstones and sandy siltstones. The contact with the underlying Whitney Member varies from gradational to a sharp unconformity where the brown siltstone fills valleys and depressions. The Whitney Member consists of pale brown, massive, typically nodular eolian siltstones with occasional thin interbeds of brown and bluish-green sandstone, and volcanic ash. In contrast, the lowest 10 meters consist of white or green laminated fluvial siltstones, sheet sandstones, and channel sandstones. The contact between the Whitney Member and the underlying Orella Member is intertonguing. The Orella Member consists of pale brown, brown, and brownish-orange volcaniclastic overbank clayey siltstones and silty claystones, brown and bluish-green overbank sheet sandstones, and volcanic ash. Occasional thick, fine- to medium-grained, channelized sandstones occur throughout the Orella Member. These sandstones appear to have very limited lateral extent. The overall thickness of the Brule Formation within the TCEA is generally less than 200 feet and ranges from approximately 120 to 180 feet. The majority of the Brule Formation present at the TCEA consists of the Orella Member, as the entire "brown siltstone" member and most of the Whitney Member have been erosionally removed.

The contact between the Brule Formation and underlying Chadron Formation is sometimes difficult to ascertain, as the contact between the two formations is intertonguing (LaGarry 1998). Regionally, the contact is recognized as the lithologic change from thinly interbedded and less pedogenically-modified brown, orange, and tan volcaniclastic clayey siltstones and sheet sandstones of the Orella Member to pedogenically-modified green, red, and pink volcaniclastic silty claystones of the Upper Chadron (Big Cottonwood Creek Member) (Terry and LaGarry 1998). On geophysical logs, the Brule Formation is characterized by rapidly fluctuating log curves, or "log chatter" (Figure 7). This response is recognized in resistivity curves, and to a lesser extent SP curves, throughout the TCEA. The fluctuations are produced by resistivity contrasts between the thinly interbedded siltstones and sandstones of the Orella Member. Because the sandstones are porous and part of the regional aquifer, the contacts with the interbedded, dry siltstones are sharp and easily recognized on logs. Lateral correlation of beds within the Brule Formation is very difficult due to generally thin bed thicknesses and limited lateral extent.

The contact between the interbedded siltstones and sandstone of the Brule Formation and the silty claystones of the Upper Chadron Formation is distinguished by a drop off of "log chatter' and establishment of relatively flat or straight curves (i.e., the shale baseline) on both resistivity and SP logs (Figure 7). Because of the intertonguing nature of the Lower Brule and Upper Chadron Formations, thin, isolated sandstones and siltstones may be present in the Upper Chadron, making it appear that the formation contact is deeper in some wells.

3.3.2.2 Chadron Formation

The Eocene-Oligocene Chadron Formation is a member of the lower White River Group (Table 4). The Chadron Formation conformably overlies the Basal Chadron Sandstone and is conformably overlain by the Brule Formation. From top to bottom, the Chadron Formation historically consists of the following stratigraphic units: Big Cottonwood Creek Member (herein referred to as the Upper Chadron and Upper/Middle Chadron to be consistent with historical permitting), Peanut Peak Member (herein referred to as the Middle Chadron to also be consistent with historical permitting), and Basal Chadron Sandstone. The Basal Chadron Sandstone represents the production zone and target of ISL mining within the TCEA. Figures 5a through 5e depict the subsurface geology of the Chadron Formation within the TCEA.

Upper Chadron and Upper/Middle Chadron

The Upper Chadron and Upper/Middle Chadron are composed primarily of volcaniclastic overbank silty claystones interbedded with tabular and lenticular channel sandstones, lacustrine limestones, pedogenic calcretes, marls, volcanic ashes, and gypsum (Terry and LaGarry, 1998). Tuffs in the Toadstool Park area that occur in the Upper Chadron were dated by $^{40}Ar/^{39}Ar$ methods as late Eocene (~34 Ma) in age (Terry and LaGarry, 1998). The lower boundary of this member is an intertonguing contact with the underlying Middle Chadron of the Chadron Formation, or is a local unconformity where the Upper/Middle Chadron fills valleys and depressions (Terry and LaGarry, 1998) (Table 4). The upper boundary is recognized by a lithologic change from pedogenically modified green, red, and pink volcaniclastic silty claystones of the Upper Chadron to thinly interbedded and less pedogenically modified brown, orange, and tan volcaniclastic clayey siltstones and sheet sandstones of the Orella Member of the Brule Formation (Terry and LaGarry, 1998) (Table 4).

The Upper Chadron is the youngest member of the Chadron Formation (Table 4). The upper part of the Upper Chadron is light green-gray bentonitic clay grading downward to green and frequently red clay, though interbedded sandstones also occur. Based on the predominance of fine-grained lithologies that comprise the Upper Chadron, this unit represents a distinct and rapid facies change from the coarse-grained lithologies present in the underlying Upper/Middle Chadron and Basal Chadron Sandstone. Based on available well control data, the Upper Chadron is continuous across the TCEA. The Upper Chadron ranges in stratigraphic thickness from approximately 270 to 380 feet in the TCEA (Figures 5a through 5e).

Four core samples (T-1050c Run 1, T-1050c Run 2, T-1051c Run1, and T-1051c Run 2) were collected from the Upper Chadron by CBR at boreholes T-1050c and T-1051c in Section 30 of the TCEA (Figure 4 and Appendix B). X-ray diffraction analyses of both the T-1050c Run 1 and T-1050c Run 2 samples indicate compositions of primarily montmorillonite with minor amounts of calcite, quartz, plagioclase, K-feldspar, and illite/mica. Particle grain size distribution analyses of the T-1050c Run 1 and T-1050c Run 2 samples indicate siltstones composed of approximately 82 percent silt and clay particles (i.e., approximately 70 percent silt and 12 percent clay particles) and approximately 73 percent silt and clay particles (i.e., approximately 56 percent silt and 16 percent clay particles), respectively. X-ray diffraction analysis of the T-1051c Run 1 sample indicates a composition of primarily montmorillonite with minor amounts of quartz, plagioclase, K-feldspar, and illite/mica. Particle grain size distribution analysis of the T-1051c Run 1 sample indicates a sandy siltstone composed of approximately 72 percent silt and clay particles (i.e., approximately 58 percent silt and 14 percent clay particles). X-ray diffraction analysis of the T-1051c Run 2 sample indicates a composition of primarily montmorillonite with minor amounts of gypsum, calcite, quartz, plagioclase, K-feldspar, and illite/mica. Particle grain size distribution analysis of the T-1051c Run 2 sample indicates a clayey siltstone composed of approximately 95 percent silt and clay particles (i.e., approximately 66 percent silt and 29 percent clay particles).

Typical GR, SP, and resistivity log signatures for the Upper Chadron exhibit curves representative of the relatively flat shale baseline (Figure 7). Fluctuations are present among Upper Chadron log curves, representing interbedded siltstones, sandstones, limestones, and volcanic ash deposits that occur less commonly than in the overlying Brule Formation.

The Upper/Middle Chadron is directly overlain by the Upper Chadron (Table 4). At some locations, the Upper/Middle Chadron is similar in appearance to the channel sandstone facies of the upper portion of the Basal Chadron Sandstone (described later in this section) and is typically a very fine to fine grained, well-sorted, poorly cemented sandstone. An isopach map of the Upper/Middle Chadron is shown on Figure 8. Extensive review of available data from the TCEA and vicinity strongly indicates that the extent of the sandstone is limited to the southern half of the central and eastern portions of the TCEA (Figures 5a through 5e and 8). The unit is completely absent in the western, northern, and southernmost portions of the TCEA (Figure 8). The available data suggest that the Upper/Middle Chadron, where present, typically ranges in thickness from approximately 0 to 50 feet across the TCEA.

The GR curve distinctly marks the top and bottom of the Upper/Middle Chadron (Figure 7). The curve responses of the logs are not as large as those seen in the Basal Chadron Sandstone (discussed below), indicating lower concentrations of radioactive materials. The GR shifts distinctly to the right at the lower boundary, most likely indicating a sandstone containing uranium. The GR curve can also shift to the left within this unit, indicating sandstone with no uranium. The resistivity curve shift described for the Upper/Middle Chadron at the North Trend Expansion Area (NTEA) is not recognized at the TCEA.

For unknown reasons, possibly the continued or renewed uplift of the Black Hills or Chadron Dome, reworked sediment and fluvial deposits of the Upper and Upper/Middle Chadron were concentrated in northwestern Nebraska (Terry and LaGarry, 1998). At some locations, initial deposition of the Upper/Middle Chadron occurred within paleovalleys incised into the underlying Middle Chadron (Terry and LaGarry, 1998). At other locations (e.g., Toadstool Park), the lower boundary is intertonguing (Terry and LaGarry, 1998).

Middle Chadron

The Middle Chadron is described as a clay-rich interval that grades from brick red to grey in color with interbedded bentonitic clay and sands. A light green-gray "sticky" clay within this unit serves as an excellent marker bed in drill cuttings and has been observed in virtually all regional test holes both within the TCEA, NTEA and the CSA. The Middle Chadron unconformably overlies the Basal Chadron Sandstone (Chamberlain Pass Formation) in South Dakota and Nebraska (Terry 1998) (Table 4). As described above, the upper boundary is variable and is overlain either by the Upper/Middle Chadron, where present, or by the Upper Chadron (Table 4). The Middle Chadron differs from the overlying Upper/Middle and Upper Chadron in that the Middle Chadron is composed of bluish-green, smectite-rich mudstone and claystone, weathers into hummocky, "haystack-shaped" hills and slopes with a popcorn-like surface, is less variegated in color, and has less silt (Terry 1998). The predominantly clay lithology of the Middle Chadron represents a distinct and rapid facies change from the underlying Basal Chadron Sandstone. Within the TCEA, the unit ranges in stratigraphic thickness from about 130 to 190 feet. A "red clay" horizon that occurs at the base of the Middle Chadron is indicated on more than half of the geophysical logs and driller's notes that were reviewed (Appendix A). This "red clay" is formally referred to as the Upper Interior Paleosol and is discussed in more detail below.

Two core samples (T-1050c Run 3 and T-1051c Run 3) were collected from the Middle Chadron by CBR at boreholes T-1050c and T-1051c in Section 30 of the TCEA (Figure 4 and Appendix B). X-ray diffraction analysis of the T-1050c sample indicates a composition of primarily mixed-layered illite/smectite with minor amounts of quartz plagioclase, K-feldspar, gypsum and illite/mica. Particle grain size distribution analysis indicates a clayey siltstone composed of approximately 85 percent silt and clay particles (i.e., approximately 58 percent silt and 27 percent clay particles). X-ray diffraction analysis of the T-1051c sample indicates a composition of primarily montmorillonite with minor amounts of quartz, plagioclase, and K-feldspar. Particle grain size distribution analysis indicates a silty claystone composed of 100 percent silt and clay particles (i.e., approximately 62 percent clay and 38 percent silt particles). Typical GR, SP, and resistivity log signatures for the Middle Chadron exhibit curves representative of the shale baseline (Figure 7). The top of the Middle Chadron is noted where the curves break either distinctly to the left or to the right, representing the sandstone of the Upper/Middle Chadron, where present. Where overlain by the Upper Chadron, the contact between units is very difficult to ascertain due to similarities in grain size.

The Upper, Upper/Middle and Middle Chadron units represent the upper confining zone for the Basal Chadron Sandstone within the TCEA (see detailed discussion in Section 4.4). An isopach map of the upper confining zone is shown in Figure 9. The thickness of the upper confining zone ranges from approximately 400 to 560 feet in the vicinity of the TCEA. The zone appears to generally thicken toward the south and southwest across the permit boundary with a narrow northwest-trending high ridge in the central northern portion of the TCEA.

Basal Chadron Sandstone

The Basal Chadron Sandstone is the oldest unit in the White River Group. The lower section is a coarse-grained, arkosic sandstone with frequent interbedded thin silt and clay lenses of varying thickness and continuity that lies on a marked regional unconformity with the underlying Yellow Mounds Paleosol (Terry 1998). The lower contact is easily recognized by a change in color and lithology from the underlying black or bright yellow, pedogenically modified surface of the Pierre Shale (i.e., the Yellow Mounds Paleosol) to white channel sandstone. Occasionally, the Basal Chadron Sandstone grades upward to fine-grained sandstone containing varying amounts of interstitial clay material and persistent clay interbeds. Vertebrate fossils from the Basal Chadron Sandstone in northwestern Nebraska and South Dakota indicate a late Eocene age (Chadronian) (Clark et al. 1967; LaGarry 1996; Lillegraven 1970; Vondra 1958). The Upper Interior Paleosol, occurring as a persistent clay horizon, typically brick red in color, developed on top of the Basal Chadron Sandstone and generally marks the upper limit of the Basal Chadron Sandstone (Table 4).

The Basal Chadron Sandstone occurs at depths ranging from about 580 to 940 feet bgs and was encountered at all exploration holes. An isopach map of the Basal Chadron Sandstone in the vicinity of the TCEA is presented on Figure 10. Stratigraphic thickness of the unit within the TCEA ranges from approximately 70 to 250 feet. The thickest sections of the unit occur in the central and western portions of the TCEA (Figure 10). Up to four distinct sandstone units are present in the thickest portions of this unit and are separated by variable amounts of interbedded clay. The Basal Chadron Sandstone thins significantly to the north and east where only two sandstone units appear to be present on the outermost edges of the TCEA. This observation is consistent with the occurrence of only two distinct channel sandstone intervals at the CSA located approximately 3 miles to the east. Structure contour maps of the top of the Basal Chadron Sandstone indicate that the unit dips slightly to the west-northwest across the TCEA (Figures 11 and 14). This shallow dip is also depicted on selected cross sections (Figures 5a, 5b, and 5d). Regionally, the unit ranges in thickness from 0 to 250 feet (Figure 15).

The greenish-white channel sandstones of the Basal Chadron Sandstone that overlie the Yellow Mounds Paleosol are the target of ISL mining activities in the TCEA. Regionally, deposition of the Basal Chadron Sandstone has been attributed to large, high-energy braided streams. In this regard, the Basal Chadron Sandstone is lenticular with numerous facies changes occurring within short distances. The interbedded thin silt and clay lenses most likely represent flood plain or low velocity deposits normally associated with fluvial sedimentation.

Mineralogical investigations within the TCEA indicate that the Basal Chadron Sandstone is comprised of 50 to 95 percent clear quartz and minor chert, 2 to 15 percent variably-colored (white, green and pink) feldspars, trace to 30 percent lithics (primarily mudstone and shale fragments), and trace weakly altered to fresh pyrite. An increase in organic matter and pyrite appears to be associated with mineralization. A change was noted in overall composition of the sandstones from arkosic in oxidized or unaltered sandstones to a notably less feldspathic, cleaner sandstone in the mineralized intervals, which may indicate better permeability and porosity that was favorable for transport of mineralizing fluids and deposition of uranium. The sandstones that comprise the Basal Chadron Sandstone within the CSA are dominated by quartz (50% monocrystalline) and feldspar (30-40% undifferentiated feldspar) with the remainder made up of chert, pyrite, and various heavy metals and polycrystalline and chalcedonic quartz (Collings and Knode, 1984). X-ray diffraction analyses indicate that the Basal Chadron Sandstone within the CSA is 75 percent quartz with the remaining composition composed of potassium feldspar and plagioclase and the following clay minerals: illite, smectite, expandable mixed layer illite-smectite, and minor amounts of kaolinite (Collings and Knode, 1984).

Geophysical logs record a unique signature for the Basal Chadron Sandstone (Figure 7). A distinct GR spike is present at the base of the unit in most of the TCEA exploration boreholes, indicating an abundance of radioactive material. Increased resistivity (i.e., log curve shift to the right), decreased N-N count (i.e., log curve shift to the left), and decreased SP (i.e., log curve shift to the left) are typically associated with GR spikes. These log signatures support interpretations of a uranium-bearing, fluid-filled sandstone interval. Overlying channel sandstone intervals that are present in the middle and upper portions of the unit typically have lower GR readings, indicative of both lower amounts of radioactive materials and potentially non-uranium bearing intervals. Such intervals are typically marked by increased resistivity (i.e., higher porosity and fluid-filled) and lower N-N counts and, in contrast to the uranium-bearing units, typically have positive SP curve deviations. This log response indicates that within the higher uranium-bearing units, mud filtrate resistivity is higher than formation water resistivity, which may be the result of the presence of higher salinity waters in uranium-bearing units. Pervasive interbedded clay intervals are indicated by high GR responses accompanied by lower resistivity (i.e., reduced porosity and decrease in water content), an interpretation that is further supported by driller or geologist's notes. The high radioactivity of these clay units likely suggests the presence of rhyolitic ash. The top of the formation is marked by a gradual return of SP and resistivity curves to the shale baseline.

3.3.3 Montana Group

Interior Paleosol (Upper Interior Paleosol and Yellow Mounds Paleosol)

The Interior Paleosol of Schultz and Stout (1955) was subsequently divided into the younger Eocene Upper Interior Paleosol and the Cretaceous Yellow Mounds Paleosol (Pierre Shale) (Terry, 1991; Evans and Terry, 1994; Terry and Evans, 1994; Terry, 1998) (Table 4). The Upper Interior Paleosol represents pedogenically modified distal overbank deposits of a distinct fluvial system developed on the surface of the Basal Chadron Sandstone which predates deposition of the Chadron Formation. The Yellow Mounds Paleosol developed on the Cretaceous Pierre Shale and altered the normally black marine shale to bright yellow, purple, lavender, and orange. Review of available data for the TCEA indicates that neither of the two paleosol units could be consistently interpreted based solely on geophysical logs. For simplicity, these units are not represented on the type log or cross-sections.

Pierre Shale

The Cretaceous Interior Seaway resulted in the offshore deposits of the late Cretaceous Pierre Shale (Table 4). The Pierre Shale is a thick, homogenous black marine shale with low permeability that represents one of the most laterally extensive formations of northwest Nebraska. Regional geologic data indicate that this formation can be up to 1,500 feet thick in the Dawes County area (Wyoming Fuel Company 1983; Petrotek, 2004). The southward retreat of the Cretaceous Interior Seaway resulted in the subaerial exposure and weathering of rock units from Early Cretaceous to Eocene age across the northern Great Plains (Lisenbee, 1988). This event resulted in the erosion and pedogenic modification of the surface of the Pierre Shale to form the brightly-colored Yellow Mounds Paleosol (Terry and LaGarry, 1998) (Table 4). Consequently, the pedogenically modified surface of the Pierre Shale marks a major unconformity with the overlying White River Group and exhibits a paleotopography with considerable relief (DeGraw, 1969). The Pierre Shale is underlain by organic-rich shale and marl with minor amounts of sandstone, siltstone, limestone, and chalk of the Niobrara Formation (Table 2). Structure contour maps of the top of the Pierre Shale indicate that the unit dips slightly to the west across the TCEA (Figures 12 and 16). This shallow dip is also depicted on selected cross sections (Figures 5a and 5b).

Two core samples (T-1050c Run 5 and T-1051c Run 5) were collected from the Pierre Shale by CBR at boreholes T-1050c and T-1051c in Section 30 of the TCEA (Figure 4 and Appendix B). X-ray diffraction analysis of the T-1050c sample indicates a composition of primarily quartz and mixed-layered illite/smectite with minor amounts of illite/mica, K-feldspar, kaolinite, and chlorite. Particle grain size distribution analysis indicates a silty claystone composed of approximately 99 percent silt and clay particles (i.e., approximately 58 percent clay and 42 percent silt particles). X-ray diffraction analysis of the T-1051c sample indicates a composition of primarily quartz and montmorillonite with minor amounts of plagioclase, K-feldspar, dolomite, chlorite, and illite/mica. Particle grain size distribution analysis indicates a clayey siltstone composed of approximately 97 percent silt and clay-sized particles (i.e., approximately 57 percent silt and 40 percent clay particles).

Typical geophysical log responses for the Pierre Shale exhibit curves that are relatively flat or straight and represent the shale/clay log signature (Figure 7; Appendix A). The GR has established the shale/clay baseline. The top of the Pierre Shale is noted where the curves break either sharply to the left or to the right and represent the occurrence of the Basal Chadron Sandstone. Spontaneous potential and resistivity curves qualitatively indicate a lack of permeable, water-bearing zones within the Pierre Shale.

Eight deep oil and gas exploration wells were drilled in the vicinity of the TCEA (Farner 1, Federal 1, Hamaker, Heath 1, Heckman 1, Homrighausen, Roby 3, and Sikorski) (Appendix A). Oil and gas exploration wells have typically been drilled to depths much greater than on-lease uranium exploration wells. The character of the entire Pierre Shale in the vicinity of the TCEA can best be observed in geophysical logs from five of the eight nearby abandoned oil and gas wells (Federal, Heath 1, Homrighausen, Roby 3, and Sikorski) and the CBR deep disposal well (CBR UIC #1), as these wells were completed through the entire thickness of the unit. Based on observations from logging, the thickness of the Pierre Shale in the vicinity of the TCEA ranges from approximately 600 to 740 feet. The top of the Pierre Shale was encountered in all wells at depths ranging from approximately 600 to 1,300 feet bgs. The Farner 1 well is located approximately 2 miles east of the TCEA permit boundary (T31N, R52W, Section 26) and has a total depth of 3,463 feet bgs. The Federal 1 well (W030995) is located approximately 2 miles north of the TCEA permit boundary (T31N, R52W, Section 17) and has a total depth of 3,818 feet bgs. The Hamaker well is located approximately 5 miles south of the TCEA permit boundary and has a total depth of 4,037 feet bgs. The Heath 1 well is located within approximately 1 mile of the southeastern corner of the TCEA permit boundary (T30N, R52W, Section 26) with a total depth of 3,348 feet bgs. The Heckman 1 well is located approximately 3 miles northeast of the TCEA permit boundary (T31N, R52W, Section 24) and has a total depth of 4,590 feet bgs. The Homrighausen well is located approximately 2.5 miles southeast of the TCEA permit boundary (T30N, R52W, Section 10) and has a total depth of 2,749 feet bgs. The Roby 3 well is located approximately 4 miles east of the TCEA permit boundary (T31N, R51W, Section 31) and has a total depth of 3,399 feet bgs. The Sikorski 1 well is located approximately 2 miles southeast of the TCEA permit boundary (T30N, R52W, Section 10) and has a total depth of 3,626 feet bgs. Deep disposal well CBR UIC #1 is located approximately 4.5 miles east of the TCEA permit boundary (T31N, R51W, Section 19) and has a total depth of 3,910 feet bgs. At UIC #1, the Pierre Shale was encountered from 925 to 1,560 feet bgs, where the base of the Pierre Shale is indicated by an increase in resistivity at the contact with the underlying Niobrara Formation (Appendix A).

Pre-Pierre Shale Stratigraphy

Underlying the Pierre Shale is a thick sequence of Mississippian through Cretaceous age strata that unconformably overlie pre-Cambrian granite (Table 2). Together with the Pierre Shale, the underlying Niobrara Formation, Carlile Shale, Greenhorn Limestone, and Graneros Shale compose a composite lower confining interval approximately 2,500 feet thick which immediately underlies the Basal Chadron Sandstone. There do not appear to be significant sandstone units within this thick sequence of low-permeability strata.

All geologic units encountered during the drilling of oil and gas exploration wells in the vicinity of the TCEA appear to be consistent with known regional stratigraphy. Geologic units that are consistently identified in all wells include the Niobrara Formation, Carlile Shale, Greenhorn Limestone, "D" and "J" sands of the Dakota Group, and the Skull Creek Formation (Table 2).

3.4 Structural Geology

Regional uplift during the Laramide Orogeny forced the southward retreat of the Cretaceous Interior Seaway, resulting in the subaerial exposure and weathering of rock units from Early Cretaceous to Eocene age across the northern Great Plains (including the Pierre Shale). The depositional basin associated with deformation of the Wyoming thrust belt and initial Laramide uplifts to the west of Nebraska, represented a structural foredeep. The greatest uplift occurred in the Black Hills, which lie north of Sioux and Dawes Counties in southwestern South Dakota. Lisenbee (1988) provides a comprehensive summary of the tectonic history of the Black Hills uplift. The pre-Oligocene Black Hills uplift (<37 Ma) occurred prior to the deposition of the Eocene-Oligocene strata of the White River Group. Strata of the White River Group cover most of the eroded roots of the Black Hills uplift as well as the syntectonic sedimentary rocks in the Powder River and Williston basins. The Hartville, Laramie, and Black Hills uplifts supplied sediment for rivers that flowed east-southeast across the study area (Clark, 1975; Stanley and Benson, 1979; Swinehart et al., 1985).

The most prominent structural expression in northwest Nebraska is the Chadron Arch (Figure 13). Together with the Chadron Arch, the Black Hills Uplift produced many of the prominent structural features presently observed in the region. The Chadron Arch represents an anticlinal feature that strikes roughly northwest-southeast along the northeastern boundary of Dawes County. Swinehart et al. (1985) suggested multiple phases of probable uplift in northwestern Nebraska near the Chadron Arch between c.a. 28 Ma and <5 Ma. The only known surficial expressions of the Chadron Arch are outcroppings of Cretaceous rocks that predate deposition of the Pierre Shale in the northeastern corner of Dawes County, as well as in small portions of Sheridan County, Nebraska and Shannon County, South Dakota. The general locations of faults in northwest Nebraska are depicted on the State Geologic Map shown on Figure 6.

The Crow Butte area, including the CSA and North Trend, lie in what has been named the Crawford Basin (DeGraw, 1969). DeGraw (1969) substantiated known structural features and proposed several previously unrecognized structures in western Nebraska based on detailed studies of primarily deep, oil test hole data collected from pre-Tertiary subsurface geology. The Crawford Basin was defined by DeGraw (1969) as a triangular asymmetrical basin about 50 miles long in an east-west direction and 25 to 30 miles wide. The basin is bounded by the Toadstool Park Fault on the northwest, the Chadron Arch and Bordeaux Fault to the east, and the Cochran Arch and Pine Ridge Fault to the south (Figure 13). *The Crawford Basin is structurally folded into a* westward-plunging syncline that trends roughly east-west. Note that the Bordeaux Fault, Pine Ridge Fault, and Toadstool Park Fault proposed by DeGraw (1969) are not presented on the State Geologic Map (Figure 6). The Toadstool Park Fault has been mapped at one location (T33N, R53W) and is estimated to have had approximately 60 feet of displacement (Singler and Picard, 1980). The City of Crawford is located near the axis of the Crawford Basin. More recent fault interpretations by Hunt (1990) for northwest Nebraska are also shown on Figure 13, which include the Whetstone Fault, Eagle Crag Fault, Niobrara Canyon Fault and Ranch 33 Fault in the vicinity of the Town of Harrison in Sioux County. The faults identified by Hunt (1990) all trend to the northeast-southwest, sub-parallel to the Pine Ridge Fault (Figure 13).

Former drilling activities at the Crow Butte Project identified a structural feature referred to as the White River Fault located between the current CSA Class III permit area and the NTEA (Figure 13). Evidence of a fault was identified during the exploration drilling phase of the Crow Butte Project (Collings and Knode, 1984). The fault is manifested in the vicinity of the NTEA as a significant northeast-trending, subsurface fold. The detailed kinematics of the White River Fault were investigated during preparation of the NTEA Petition for Aquifer Exemption. Based on an extensive review of drilling and logging data, it was determined that while the White River Fault may cut the Pierre Shale at depth along with stratigraphically lower units, there is no evidence that a fault offsets the geologic contact between the Pierre Shale and overlying White River Group nor individual members of the White River Group. This fault does not appear to be present in the vicinity of the TCEA.

Pine Ridge Fault

Approximately one mile south of the TCEA is the inferred Pine Ridge Fault, located along the northern edge of the Pine Ridge escarpment (Figure 13). The 230-mile long Pine Ridge escarpment exhibits an average of 1,200 feet of topographic relief (Nixon, 1995). The Pine Ridge is an arc roughly concentric to the Black Hills Dome, which suggests an apparent structural relationship. The escarpment has been interpreted to represent the southern outermost cuesta of the Black Hills Dome (Nixon, 1995). The escarpment is capped by sandstone of the Arikaree Group with exposed deposits of the White River Group mapped along the topographically lower, northern side of the escarpment.

The Pine Ridge Fault is inferred from several lines of evidence, though detailed studies are currently unavailable. The fault was initially proposed by DeGraw (1969) based on subsurface data. The fault trends east to west across both Sioux and Dawes Counties, is sub-parallel to the Cochran Arch, and has a reported north side down displacement of roughly 300 feet (Figure 13). Swinehart and others (1985) reported normal faulting along the feature that post-dates the deposition of the Upper Harrison beds of the Arikaree Group. This interpretation would confine that age of inferred fault slip to post-early Miocene.

Diffendal (1994) performed lineament analyses based on a mosaic of synthetic-aperture radar data of the Alliance, Nebraska area prepared by the United States Geological Survey (USGS). Observed landforms and lineaments were reported to align well with known faults in the vicinity of Chadron. Lineaments in the radar image along Pine Ridge, located to the south of Chadron, are attributed to jointing or faulting and trend N40E and N50W (Diffendal, 1982). Similar features are also noted west of Fort Robinson. Swinehart and others (1985) report that these features are likely an extension of the Whalen trend in Wyoming (Hunt, 1981).

The Pine Ridge Fault, as inferred by DeGraw (1969), trends across the southeast corner of the 2.25-mile AOR at approximately 1.5 miles south of the TCEA permit boundary (Figure 17). Borehole data is sparse in the southern third of the AOR, making identification and characterization of the fault difficult. Using the single point resistance on geophysical logs, the depth to the contact between the Pierre Shale and overlying Chadron Formation was determined. As discussed below, cross sections have been prepared using this data to show the contact surface elevations.

Cross sections which transect the inferred location of the Pine Ridge Fault are shown in Figure 17. Because of the limited amount of drill data, four of the cross sections are located to the east of the TCEA boundary, but are significant in that they provide the closest spaced drill data available for fault characterization. Sections F-F', G-G', H-H' and I-I' are located approximately 5 miles, 2 miles, 1 mile and 0.5 miles east of the TCEA boundary respectively. Section J-J' along the western side of the TCEA, consists of boreholes that are widely spaced, particularly in the area of the proposed fault. Such widely spaced data makes definitive interpretation in this area difficult.

Cross section F-F' shown in Figure 18 provides the most reliable close spaced data for interpreting the fault. Located approximately five miles east of the TCEA, cross section F-F' consists of 20 boreholes along a 6.3-mile trend. The drill holes that comprise this cross section are located along the main axis of the current license area. Moving southward along F-F', this section shows a gentle rise in elevation from R-831 to E-19 that is likely a result of the presence of the Cochran Arch to the south (DeGraw, 1969). From E-19 to Wa-5, a decline of 63 feet is observed over a distance of approximately three quarters of a mile that is roughly in line with the Pine Ridge Fault inferred by DeGraw (1969). The 63 feet of potential displacement is well short of DeGraw's reported 300-feet. It is plausible that this decline may represent the eroded surface of the Pierre Formation prior to deposition of the overlying units. The top surface of the Pierre Shale rises southward from Wa-5 towards the Cochran arch.

Cross section G-G' shown in Figure 18 is located approximately 2 miles east of the TCEA and is comprised of nine drill holes along an approximately 9-mile traverse. Cross section G-G' shows a structural low at drill hole RSm-2 that is in line with the westward-plunging synclinal axis of the Inner Crawford Basin (Collings and Knode 1983). Similar structural lows have been observed in cross sections within the TCEA, which coincide with the thickest intervals of Basal Chadron Sandstone. Cross section G-G' does not show definitive evidence of faulting; however, the south end of the cross section does show a slight increase in elevation that is likely due to the presence of the Cochran Arch to the south.

Cross sections H-H' and I-I' shown in Figure 19 are located approximately 1.0 miles and 0.5 miles east of the TCEA boundary respectively. These two sections show the Inner Crawford Basin structural low in the northern portions of the cross sections. The top surface of the Pierre Shale rises out of the basin at the northern end of the cross section and then decreases in elevation southward. The observed southward decrease in the top surface of the Pierre Shale does not match well with observations from cross sections to the east and west or with the concept of north side down displacement along the inferred Pine Ridge Fault. Due to the distance between drill locations along the southern extent of cross sections H-H' and I-I', potential errors in estimates of the top surface of the Pierre Shale, topographic lows on the eroded surface of the Pierre Shale, or flexing related to the Crawford Basin may account for the observed southward decrease in elevation. The Pine Ridge Fault, as inferred by DeGraw (1969), would be located in the vicinity of borehole C-7; however, there is no observed displacement in this location on the order of magnitude suggested by DeGraw (1969) (Figure 17).

Cross section J-J' shown in Figure 19 is the westernmost cross section that transects the inferred fault. This cross section is located along the western edge of the TCEA and extends nearly six miles southward. Similar to previously described cross sections, the north end of cross section J-J' shows the synclinal axis of the Inner Crawford Basin and the gradual rise in elevation southward. Due to the sparse drilling data and distance between drill locations, the interpreted cause for the approximately 200 feet of elevation change between C-14 and C-27 is speculative. The elevation change may be due to the presence of the Pine Ridge Fault, the Cochran Arch, or both.

Based on the available information, the existence the Pine Ridge Fault within the AOR, as inferred by DeGraw (1969), cannot be confirmed. Furthermore, cross sections F-F' through J-J' do not substantiate the reported vertical displacement of 300 feet within the AOR. It is possible, however, that the displacement within the AOR was significantly less than reported. In general, available information for the top surface of the Pierre Shale in the vicinity of the inferred fault does indicate a rise in elevation to the south of the AOR. Given the magnitude of folding observed elsewhere in the Crawford Basin, it is entirely feasible that displacement along an inferred fault would not be required to explain these observations. In addition, the inferred fault, if present, is located well to the south of the TCEA permit boundary and would have minimal impact upon mining activities.

4. Hydrology of the Three Crow Expansion Area

4.1 Surface Water

The TCEA is drained by small tributaries that discharge to the White River, which flows northeast along the northern boundary of the proposed TCEA (Figure 1). The White River is used to support agricultural production, wildlife habitat and both warm and cold-water fish. For the period of record from 1931 to 1991, United States Geological Survey (USGS) data indicate that the average monthly mean flow ranged from 6.3 to 122 cubic feet per second (cfs), with a mean value of 20.4 cfs (USGS, 2004). Based on data from the Nebraska Department of Natural Resources (NDNR), the flow of the White River from 1999 to 2007 ranged from 4.1 to 29.1 cfs, with an annual mean of 20.2 cfs (NDNR, 2010). Average flow measurements by the NDEQ for this sampling location from 2003 to 2009 averaged approximately 20.6 cfs (Lund, J. 2010). Historical precipitation and flow data for the White River are presented in Tables 5 and 6.

The TCEA lies within the watersheds of Bozle, Cherry, and the eastern portion of Dead Man's Creek, all of which are small southern tributaries to the White River (Figure 20). The headwaters for each of these creeks is in the Pine Ridge located to the south of the TCEA. From the headwaters, these creeks flow north over range and agricultural land to the White River. Contributions to flow come from springs in the Arikaree Group, snowmelt, runoff and the shallow sands of the Brule Formation. The latter may receive inflow from the creek during periods of high flow. It should be noted that these watersheds are dry for considerable periods of time. Due to the time variable nature of these water sources, discharges at various points along the creeks may experience wide fluctuations on a monthly and yearly basis.

There are no surface water impoundments within the TCEA, but there are four impoundments located outside the permit boundary within the AOR. The Grabel Ponds, Cherry Creek Pond and Ice House Ponds are located on the Fort Robinson State Park. The Sulzbach Pond is located on private property.

4.2 Groundwater

4.2.1 Groundwater Occurrence and Flow Direction

Within the Crawford Basin, the alluvium, Brule Formation, and Basal Chadron Sandstone are considered water-bearing intervals. The alluvial deposits are not typically considered to be a reliable water source. Sandy siltstones, overbank sheet sandstones and occasional thick channelized sandstones that occur throughout the Orella Member of the Brule Formation may be locally water-bearing units. These sandstone and siltstone units are difficult to correlate over any large distance and are discontinuous lenses, rather than laterally continuous strata. Although the Brule Formation is a local water- bearing unit, it does not always produce usable amounts of water. Despite this characteristic, the Brule Formation has historically been considered the shallowest aquifer above the Basal Chadron Sandstone aquifer and water supply wells have been completed in this unit.

Locations of all groundwater monitoring wells in the vicinity of the TCEA are shown on Figure 20. There are seven active monitoring wells screened in the Brule Formation (BOW 2006-1, BOW 2006-2, BOW 2006-3, BOW 2006-4, BOW 2006-5, BOW 2006-6, and BOW 2006-7). The Miller Well (W-273) is also being utilized as a monitoring well for the Brule Formation. Ten active monitoring wells are screened in the Basal Chadron Sandstone (CPW 2006-1, COW 2006-1, COW 2006-2, COW 2006-3, COW 2006-4, COW 2006-5, COW 2006-6, COW 2006-7, UBCOW 2006-1, and UBCOW 2006-2) (Figure 20). Well completion reports for these monitoring wells are included in Appendix C. No completion report is available for W-273.

Water-level measurement events for the Brule Formation were conducted at four monitoring wells (BOW 2006-1, BOW 2006-2, BOW 2006-3, and BOW 2006-4) during two water level measurement events in January 2009 and at seven monitoring wells and W-273 in January 2010 (Table 7). The static water level for wells screened in the Brule Formation in the vicinity of the TCEA typically ranges from 30 to 80 feet bgs. Water levels measured during the January 2010 ranged from approximately 3,819 to 3,913 feet amsl (Figure 22). Groundwater flow in the Brule Formation is directed to the north and northeast across the entire TCEA. Groundwater elevations for all events indicate groundwater flow is convergent with the White River. The average hydraulic gradient within the TCEA is 0.0168 ft/ft. Regional water level information for the Brule Formation is currently only available in the vicinity of the current production facility.

Water-level measurement events for the Basal Chadron Sandstone were conducted at all ten monitoring wells (CPW 2006-2, COW 2006-1, COW 2006-2, COW 2006-3, COW 2006-4, COW 2006-5, COW 2006-6, COW 2006-7, UBCOW 2006-1, and UBCOW 2006-2) during three water level measurement events during the months of January 2009 and January 2010 (Table 7). The static water level for wells screened in the Basal Chadron Sandstone in the vicinity of the TCEA typically ranges from 180 to 270 feet bgs. Groundwater elevations from the more recent January 2010 measurement event are shown on Figure 23. Water levels ranged from approximately 3,707 to 3,720 feet amsl. Groundwater flow is directed predominantly toward the east-northeast across the entire TCEA (Figure 23). The average hydraulic gradient within the TCEA is 0.0012 ft/ft. Regional water level information for the Basal Chadron Sandstone is currently only available in the vicinity of the current production facility.

Strong vertically downward gradients exist at all locations within the TCEA, indicating minimal, if any, risk for potential impacts to the Brule Formation from the underlying Basal Chadron Sandstone under natural conditions (Figures 5a through 5e). Observed head differences between the two water-bearing zones at three well pairs (BOW 2006-5 and COW 2006-1, BOW 2006-1 and CPW 2006-2, and BOW 2006-3 and COW 2006-4) ranged from approximately 86 to 196 feet during the January 2010 measurement event. Head differences between well pairs screened in the upper and lower Basal Chadron Sandstone (UBCOW 2006-1 and CPW 2006-2, UBCOW 2006-2 and COW 2006-4) were less than 1.0 feet for all water level measurement events, indicating favorable hydraulic communication between the two intervals.

Available groundwater data for both the Brule Formation and Basal Chadron Sandstone at the TCEA do not indicate any documented flow rate variations or recharge issues that would impact groundwater quality as a result of ISL mining operations in the Basal Chadron Sandstone. There are no surface-water ponds within the TCEA permit boundary and only limited stream flow. The Brule Formation, while considered an overlying aquifer, is not an extensive or exceptionally productive system. The available monitoring data do not indicate any seasonality or pumping effects by domestic wells within this zone.

4.2.2 Groundwater Quality Data

Groundwater quality within the White River drainage generally is poor (Engberg and Spalding, 1978). Groundwater obtained from the Basal Chadron Sandstone aquifer has a strong sulfur odor as a result of localized reducing conditions associated with the ore body (Figure 2). A summary of groundwater quality data collected in 2007, 2008 and 2009 to establish background conditions in the vicinity of the TCEA is presented in Table 8. The data are presented for the two water-bearing zones at the TCEA: the Brule Formation and the Basal Chadron Sandstone. Four of the private wells that are monitored are located within the TCEA permit boundary (Wells 270, 272, 273, and 277) and the remaining wells (Wells 269, 274, 275, 313, and 314) are located less than 0.5 mile from the permit boundary (Figure 20). Well 313 will be replaced by Well 312 for future monitoring of private water supply wells. Well 313 and 314 are located close together, so additional data are only needed from one of these wells. Well 312 will allow for more representative sampling of the area north of the permit boundary.

Water quality results indicate that total dissolved solids (TDS) for the Brule Formation ranged from 215 to 448 milligrams per liter [mg/L], while TDS for the Basal Chadron Sandstone is generally greater than 1,000 mg/L (Table 8). Similarly, conductivity for the Brule Formation ranged from 239 to 633 micromhos per centimeter [• mhos/cm], while conductivity for the Basal Chadron Sandstone is generally greater than 1,000 • mhos/cm. Major ion concentrations of the most common cations and anions in groundwater were slightly higher in the Basal Chadron Sandstone than the Brule Formation, as would be expected by the concentrations of TDS. Uranium concentrations in the Brule Formation for private wells and monitoring wells ranged from 0.008 to 0.0272 mg/L and from 0.0032 to 0.0176 mg/L, respectively. Uranium concentrations in the Basal Chadron Sandstone ranged from 0.0004 to 0.0385 mg/L. Radium-226 concentrations for private wells in the Brule Formation ranged from 0.006 to 0.500 mg/L. Background and restoration values are discussed in the Underground Injection Control (UIC) Class III Permit Application for the TCEA.

Table 9 reports the detailed results of three bi-weekly sampling events for the Brule Formation and Basal Chadron Sandstone monitoring wells within the TCEA, which were included in the range of concentrations reported on Table 8. The bi-weekly sampling events were conducted at four Brule Formation monitoring wells (BOW 2006-1, BOW 2006-2, BOW 2006-3, BOW 2006-4, BOW 2006-5, BOW 2006-6, and BOW 2006-7) in November 2008 through February 2009 and at ten Basal Chadron Sandstone monitoring wells (CPW 2006-2, COW 2006-1, COW 2006-2, COW 2006-3, COW 2006-4, COW 2006-5, COW 2006-6, COW 2006-7, UBCOW 2006-1, and UBCOW 2006-2) between December 2008 and February 2009. TDS concentrations for the Brule Formation ranged from 237 to 327 mg/L, whereas TDS for the Basal Chadron Sandstone ranged from 980 to 1,300 mg/L. Alkalinity for the Brule Formation was detected up to 172 mg/L, while alkalinity in the Basal Chadron Sandstone was consistently detected above 300 mg/L. Conductivity for the Brule Formation was detected up to 466 • mhos/cm, while conductivity for the Basal Chadron Sandstone was detected above 1,690 • mhos/L at all sampling locations. Major ion concentrations for the Brule Formation ranged from 527 to 589 mg/L, while concentrations for the Basal Chadron Sandstone ranged from 1,547 to 1,967 mg/L. Uranium concentrations detected in the Brule Formation ranged from 0.0032 to 0.0176 mg/L (average of 0.0120 mg/L) and from 0.0004 to 0.0385 mg/L (average of 0.0087 mg/L) for the Basal Chadron Sandstone. Similar trends in relative concentrations were observed in water quality sampling at the NTEA for these two water-bearing zones.

In general, concentrations of TDS, specific conductance and major ions in the Basal Chadron Sandstone appear to be an order of magnitude larger than observed in the Brule Formation at the TCEA. To date, water quality sampling indicates that the Brule

Formation and the Basal Chadron Sandstone have unique geochemical signatures within the TCEA.

4.3 Aquifer Testing and Hydraulic Parameter Identification Information

Prior to initiation of ISL mining activities, the NDEQ UIC regulations require hydrologic testing and baseline water quality sampling. During the initial permitting and development activities within the TCEA, an aquifer pump test was performed on April 7, 2008. The final report on pump test activities in the TCEA (Three Crow Regional Hydrologic Testing Report – Test #7 (Petrotek, 2008)) was submitted as an appendix to the UIC Class III Permit Application. Testing activities and findings from pump test activities in the TCEA are summarized below.

Prior to testing activities, CBR installed eight new monitoring wells in the Basal Chadron Sandstone (CPW 2006-2, COW 2006-1, COW 2006-2, COW 2006-3, COW 2006-4, COW-2006-5, UBCOW 2006-1, and UBCOW 2006-2) and three wells in the Brule Formation (BOW 2006-1, BOW 2006-2, and BOW 2006-3) (Figure 21). Well information for wells used during the 2008 pump test is summarized in Table 10. CPW 2006-1 was abandoned in place due to breakage of the screen during well construction (Appendix C). Static water levels were collected from all eleven wells in the monitoring network on April, 21 2008 from the Brule Formation and the Basal Chadron Sandstone (6 days after completion of the pump test), following recovery from pump test activities. Water levels ranged from approximately 3,863 to 3,879 feet amsl in the Brule Formation and 3,719 to 3,725 feet amsl in the Basal Chadron Sandstone (Table 10). The static water level at CPW 2006-2 was approximately 3,722 feet amsl, indicating that there was 108 feet of hydraulic head above the pump.

The 2008 pump test was designed to assess the following:

- The degree of hydraulic communication between the pumping well installed in the Basal Chadron Sandstone and the surrounding Basal Chadron Sandstone monitoring wells;
- The presence or absence of hydraulic boundaries within the Basal Chadron Sandstone over the test area;
- The hydraulic characteristics of the Basal Chadron Sandstone within the test area; and
- The degree of hydraulic isolation between the Basal Chadron Sandstone and the overlying Brule Formation.

The 2008 pump test was conducted while pumping at CPW 2006-2 at an average of 44.7 gpm for 183 hours (7.63 days). The radius of influence (ROI) was estimated to be in excess of approximately 4,600 feet. More than 113 feet of drawdown was achieved during testing and all Basal Chadron Sandstone wells monitored during the test indicated adequate drawdown of more than 2 feet, confirming hydrologic communication with the Basal Chadron Sandstone aquifer. The one exception was 1.2 feet of drawdown at COW 2006-1, which was the farthest monitoring well from the pumping well. No responses attributed to the pump test were observed in monitoring wells installed in the Brule Formation.

Results of the 2008 pump test indicate a mean hydraulic conductivity of 7.5 feet per day [ft/day] (ranging from 4.1 to 11.6 ft/day) or 2.65 x 10^{-3} centimeters per second [cm/sec], a mean transmissivity of 477 square feet per day (ft^2/day; ranging from 267 to 743 ft^2/day), and a mean permeability of approximately 2,990 millidarcies (md) based on an assumed water viscosity of 1.35 centipoise (cP) (at 50 degrees Fahrenheit) and a density of 1.0 (Table 11). The mean storativity was 8.8 x 10^{-4} (ranging from 4.8 x 10^{-5} to 1.6 x 10^{-4}) (Table 11). Estimated hydraulic parameters for individual well locations for the 2008 pump test are summarized in Table 12. The hydrologic parameters observed at the TCEA are consistent with, although slightly higher than, the aquifer properties determined for the CSA. No water-level changes of concern were observed in any of the overlying wells during testing. The pump test results demonstrate the following important conclusions:

- All Basal Chadron Sandstone monitoring wells and the pumping well are in communication throughout the TCEA pump test area;
- The upper and lower Basal Chadron Sandstone wells are in communication;
- The Basal Chadron Sandstone has been adequately characterized with respect to hydrogeologic conditions within the majority of the proposed TCEA test area;
- Adequate confinement exists between the Basal Chadron Sandstone and the overlying Brule Formation throughout the proposed TCEA test area; and
- The 2008 pump testing was sufficient to proceed with UIC Class III permitting and a NRC license amendment application for the TCEA.

These conclusions indicate that though variance in thickness and hydraulic conductivity may impact mining operations (e.g., well spacing, completion interval, and injection/production rates), it is not anticipated to impact regulatory issues. It should be noted that cross-sections presented in the Three Crow Regional Hydrologic Testing Report - Test #7 (Petrotek, 2008) differ from cross-sections presented in this petition.

Cross-sections presented in this petition are revised interpretations based on a recent extensive review of available site-specific drilling logs and published literature.

4.4 Hydrologic Conceptual Model for the Three Crow Expansion Area

Tables 2 and 4 present the regional and local stratigraphic columns in the vicinity of TCEA. The water-bearing units within the stratigraphic section present at the TCEA include alluvial deposits (rarely), permeable intervals in the Orella Member of the shallow Brule Formation, and the deeper confined Basal Chadron Sandstone. Sections 4.4.1 and 4.4.2 describe the upper and lower confining units and the hydrologic conditions for the water-bearing intervals present at the TCEA.

4.4.1 Confining Layers

Upper confinement for the Basal Chadron Sandstone within the TCEA is represented by 400 to 560 feet of smectite-rich mudstone and claystones of the Upper Chadron and Middle Chadron (Figures 5a through 5e and 9). Particle grain-size analyses of six core samples from the upper confining layer within the TCEA indicate all samples were either silty claystone or clayey siltstone (Appendix B). X-ray diffraction analyses indicate compositions of mudstone and claystone intervals of core samples from the Middle Chadron are highly similar to the Pierre Shale (e.g., predominantly mixed-layered illite/smectite or montmorillonite with quartz), which would be expected if the Pierre Shale was a source of materials for the overlying Middle Chadron (Appendix B). The limited lateral extent and hydraulic isolation of sandstones of the Upper/Middle Chadron within the TCEA, which range from 0 to 50 feet thick, is insignificant as a productive water-bearing zone (Figure 8). As a result, the Brule Formation is vertically and hydraulically isolated from the underlying aquifer proposed for exemption.

Lower confinement for the Basal Chadron Sandstone in the vicinity of the TCEA is represented by approximately 600 to 740 feet of black marine shale deposits of the Pierre Shale. Additional low permeability confining units are represented by the underlying Niobrara Formation, Carlile Shale, Greenhorn Limestone and Graneros Shale. Together with the Pierre Shale, these underlying low permeability units hydraulically isolate the Basal Chadron Sandstone from the underlying "D", "G", and "J" sandstones of the Dakota Group by more than 1,000 vertical feet (Table 2). The Pierre Shale is not a water-bearing unit, exhibits very low permeability, and is considered a regional aquiclude. Regional estimates of hydraulic conductivity for the Pierre Shale range from 10^{-7} to 10^{-12} cm/sec (Neuzil and Bredehoeft, 1980; Neuzil et al., 1982; Neuzil et al. 1984; Neuzil, 1993). The Pierre Shale has a measured vertical hydraulic conductivity in the CSA of less than 1×10^{-10} cm/sec (Wyoming Fuel Company, 1983), which is consistent with other studies in the region. Particle grain-size analyses of two samples collected from the Pierre Shale within the TCEA (see Section 3.3.3) indicate low permeability silty clay and clayey silt compositions (Appendix B). Regional studies also indicate there is no observed transmissivity between vertical fractures in the Pierre Shale, which appear to be short and not interconnected (Neuzil et al., 1984).

Estimates of hydraulic conductivity were developed using particle grain-size distribution data from the eight core samples collected within the Upper Chadron, Middle Chadron, and Pierre Shale. Results of the particle size distribution analyses indicate mostly silts and clays (Appendix B). Hydraulic conductivity estimates were developed using the Kozeny-Carman equation, which is appropriate for sands and silts, but not for clayey soils with a high degree of plasticity. Estimated hydraulic conductivities of the four core samples collected within the Upper Chadron ranged from 3.4×10^{-5} to 8.6×10^{-6} cm/sec. Estimated hydraulic conductivities of the two core samples collected within the Middle Chadron ranged from 1.1×10^{-5} to 2.7×10^{-6} cm/sec. Estimated hydraulic conductivities for the two core samples collected within the Pierre Shale ranged from 5.1×10^{-6} to 2.7×10^{-6} cm/sec. The vertical hydraulic conductivity across the upper and lower confining layers is likely to be even lower due to vertical anisotropy. Additionally, hydraulic resistance to vertical flow is expected to be low due to the significant thickness of the upper confining zone within the TCEA, which ranges between 400 and 560 ft (Figure 9).

4.4.2 Hydrologic Conditions

A potentiometric map and cross sections of the Basal Chadron Sandstone indicate confined groundwater flow (Figures 5a through 5e and 23). Elevations of the potentiometric surface of the Basal Chadron Sandstone indicate that the recharge zone must be located above a minimum elevation 3,720 feet amsl. Confined conditions exist at the TCEA as a result of an elevated recharge zone most likely located west or northwest of the TCEA. The top of the Basal Chadron Sandstone occurs at much lower elevations within the TCEA, ranging from approximately 3,190 to 3,320 feet amsl (Figure 11).

In the vicinity of the TCEA, groundwater flow in the Basal Chadron Sandstone aquifer is predominantly to the east-northeast, with an average hydraulic gradient of 0.0012 ft/ft. The elevation of the Basal Chadron Sandstone within the TCEA is typically more than 500 feet below the base of the White River, which flows to the northeast less than one mile from the northwestern corner of the permit boundary (Figures 1, 5a, and 5c). Regional water level information for the Basal Chadron Sandstone is currently only available in the vicinity of the current production facility and the NTEA, but suggest a discharge point at an elevation of at least 3,700 feet amsl (or below) located east of Crawford, presumably at a location where the Basal Chadron Sandstone is exposed.

Extensive review of available data from the TCEA and vicinity strongly indicates that the extent of the Upper/Middle Chadron sandstone is limited to the southern half of the central and eastern portions of the TCEA (Figures 5a through 5e and 8). The unit is completely absent in the western, northern, and southern-most portions of the TCEA (Figure 8). In contrast to the NTEA, where a strong resistivity curve shift was observed across this unit, the Upper/Middle Chadron does not appear to be a highly transmissive unit at the TCEA with no apparent curve shifts that might indicate an increase in porosity or water content (Figure 7). Monitoring wells have not been completed in this unit as a result of the lack of recoverable water. Therefore, the unit is not considered a regional aquifer.

Available regional water-level information for the Brule Formation indicates unconfined groundwater flow generally toward the White River (Figures 20 and 22). Within the TCEA, groundwater generally flows to the north and northeast across the entire TCEA, with an average hydraulic gradient of 0.0168 ft/ft. Though the Brule Formation is the primary groundwater supply in the vicinity of the TCEA, low production rates indicate that the discontinuous sandstone lenses of the Orella Member may not be hydraulically well-connected. Recharge to this unit likely occurs directly within the TCEA, as the unit is unconformably overlain by 0 to 30 feet of unconsolidated alluvial and colluvial deposits (depending on local topography) and is exposed throughout the vicinity (personal communication with CBR staff, March 2008). This unit is likely in direct hydraulic communication with the White River, as observed at the NTEA where groundwater elevations indicate apparent recharge in the vicinity of the White River. In that context, gaining and losing conditions along the White River are probably seasonally influenced. A sufficient number of monitoring wells will be installed in the Brule Formation between the permit boundary and the White River to monitor water quality in the event of failure of an injection well or production well, and to prevent potential communication of mining fluids with surface water (see Section 4.5 for a more detailed discussion). Installation of such monitoring wells is required under the Class III injection well permit. Alluvial deposits along the margins of the White River may offer limited groundwater storage depending on river levels.

The two water-bearing zones in the TCEA have distinct and differing water-level elevations (Figures 5a through 5e, Table 7). The available water-level data suggest hydrologic isolation of the Basal Chadron Sandstone with respect to the overlying water-bearing intervals in the TCEA. This inference is further supported by the difference in geochemical groundwater characteristics between the Basal Chadron Sandstone and the Brule Formation (see Section 4.2.2) (Tables 8 and 9).

In summary, the following multiple lines of evidence indicate adequate hydrologic confinement of the Basal Chadron Sandstone within the TCEA.

- Results of the April 2008 aquifer pump test demonstrate no observed drawdown in observation wells screened in overlying Brule Formation throughout the TCEA (see Section 4.3).
- Large differences in observed hydraulic head (86 to 196 feet) between the Brule Formation and the Basal Chadron Sandstone indicate strong vertically downward gradients and minimal risk of naturally-occurring impacts to the overlying Brule Formation (see Section 4.2.1).
- Significant historical differences exist in geochemical groundwater characteristics between the Basal Chadron Sandstone and the Brule Formation (Section 4.2.2).
- Site-specific x-ray diffraction analyses, particle grain-size distribution analyses and geophysical logging confirm the presence of a thick (up to 560 feet), laterally continuous upper confining layer consisting of low permeability mudstone and claystone, and a thick (up to 740 feet), regionally extensive lower confining layer composed of very low permeability black marine shale (see Section 4.4.1).
- Analyses of particle size distribution results suggest a maximum estimated hydraulic conductivity of 10^{-5} cm/sec for core samples from the upper confining layer and 10^{-6} cm/sec for core samples from the lower confining layer, implying that the vertical hydraulic conductivity across the upper and lower confining layers is likely to be even lower due to vertical anisotropy (see Section 4.4.1).

4.5 Description of the Proposed Mining Operation and Relationship to Site Geology and Hydrology

The Basal Chadron Sandstone is currently mined via ISL mining techniques in the CSA and represents the production zone and target of solution mining in the TCEA. Ore-grade uranium deposits underlying the TCEA are located in the Basal Chadron Sandstone (Figure 2). The ore body located within the TCEA is a stacked roll-front system, which occurs at the boundary between the up-dip and oxidized part of a sandstone body and the deeper down-dip and reduced part of the sandstone body. Stratigraphic thickness of the unit within the TCEA ranges from approximately 70 to 250 feet, with an average thickness of approximately 180 feet. Depending on the presence of up to four interbedded clay units, the vertical thickness of sandstone within the Basal Chadron Sandstone can vary depending on location (Figures 5a through 5e). The unit occurs at depths ranging from about 580 to 940 feet bgs within the TCEA (Figures 5a through 5e). A competent upper confining layer consists of the overlying Middle Chadron and Upper Chadron, which consist predominantly of clay, claystone, and siltstone. Based on extensive exploration hole data collected to date (more than 720 drill locations), the thickness of the upper confining layers in the TCEA range from 400 to 560 feet Figures 5a through 5e). Estimated hydraulic conductivities based on particle grain-size distribution analyses for site-specific core samples collected within the upper confining layer are on the order of 10^{-5} to 10^{-6} cm/sec (see Section 4.4.1). Geophysical logs from nearby oil and gas wells indicate that the thickness of the Pierre Shale lower confining layer ranges from approximately 600 to 740 feet (see Section 3.3.3). The full thickness of the Pierre shale is not depicted in Figures 5a through 5e, as the required scale would obscure stratigraphic details of the overlying White River Group. The Pierre Shale exhibits very low permeabilities on the order of 0.01 Millidarcies (md) (less than 1 x 10^{-10} cm/sec) (Wyoming Fuel Company, 1983). Estimated hydraulic conductivities based on particle grain-size distribution analyses for core samples collected from the Pierre Shale within the TCEA are on the order of 10^{-6} cm/sec (see Section 4.4.1).

Production of uranium by ISL mining techniques involves a mining step and a uranium recovery step. The ISL mining process involves contacting a mineral deposit with leaching fluids ("lixiviant solution") to dissolve the mineral without having to physically remove the ore from the subsurface. The ideal lixiviant solution is one that will oxidize the uranium in the ore and contains a complexing agent that will dissolve and form strong aqueous complexes that remain dissolved and interact little with the host rock. Typical lixiviants for in-situ leach mining are solutions of ions such as bicarbonate or carbonate that form stable complexes with the oxidized uranium, denoted as U(VI). Oxidants added to the lixiviant to cause the oxidation of uranium ore include oxygen or hydrogen peroxide. Mining is accomplished by installing a series of injection wells through which the leach solution is pumped into the ore body. Corresponding production wells and pumps promote flow through the ore body and allow for the collection and withdrawal of uranium-rich leach solution. At the current CBR production facility, uranium is removed from the leach solution by ion exchange, and then from the ion exchange resin by elution. The leach solution can then be reused for mining purposes. The elution liquid containing the uranium (the "pregnant" eluant) is then processed by precipitation, dewatering, and drying to produce a transportable form of uranium. Uranium will be removed from the Basal Chadron Sandstone in the TCEA in the same manner that it is removed from the ore zone in the CSA by injection and subsequent extraction of leaching solutions. The site-specific ISL mining process for the TCEA is described in the UIC Class III Permit Application.

Net withdrawal within the wellfield must be maintained in order to capture injected mining solutions (see discussion below). Under NDEQ Title 122, Chapter 19, Section 002.02, injection of mining solutions shall not exceed the formation fracture pressure (see UIC Class III Application), but must be significant enough to overcome existing pressure heads within the confined aquifer while assuring that the pressure in the injection zone during injection does not cause migration of injection fluids into an underground source of drinking water. From an operations standpoint, procedures must be in place for leaking well casings or well valves (see UIC Class III Application). Mechanical integrity testing is conducted following installation of all wells and subsequently tested every 5 years after a well begins operation. In addition, all wells that have had rig work completed with the drill string entering the well casing will be tested for mechanical integrity before being returned to service. Water quality sampling is conducted bi-weekly at all monitoring well locations, which would indicate an excursion (i.e., presence of mining solutions). Contingency plans in the event of well failure are also discussed in the UIC Class III Application, which may either include identifying and patching the leaking well casing or abandoning the well if the leak cannot be repaired.

Demonstration that hydraulic control is being maintained will be provided by exterior monitoring wells surrounding each wellfield. Planned procedures for monitoring the capture of injected mining solutions are discussed in detail in the UIC Class III Permit Application. These procedures include routine water level measurements in the production zone and overlying water-bearing zones and water quality sampling at monitoring wells every 2 weeks. Any changes in water levels or water quality within the production zone will be evaluated after sample collection to ensure that the system is operating properly and successfully. The proposed procedures will also allow for flow rate adjustments to ensure capture of mining fluids. ISL mining at the TCEA will be a recirculation system with a close mass balance resulting from the over-production (or bleed) rates. Within the wellfield and its vicinity, there will be local changes in head and flow direction. However, beyond the TCEA permit boundary, the magnitude of regional groundwater flow will not be meaningfully affected and will resume to regional flow conditions within a few hundred feet outside the permit boundary. The procedures proposed in the UIC Class III Permit Application are considered an adequate trigger for hydraulic adjustments to the production system in response to increases in pumping by private wells screened in Basal Chadron Sandstone.

The Basal Chadron Sandstone hydrologic properties must be known to formulate the best injection/extraction well arrays and for appropriate containment. Based on the pumping rate, test duration and formation characteristics, the Radius of Influence (ROI) (i.e., the area over which drawdown occurs) can also be determined for a given test. Tables 11 and 12 present relevant hydrologic information based on an aquifer test performed in the TCEA in April 2008, compared with the same properties in the CSA and the NTEA. These data indicate that mean transmissivity and hydraulic conductivity at the TCEA are more than adequate to successfully development the TCEA for ISL mining activities.

4.6 Lateral and Vertical Extent of the Exempt Aquifer

The lateral extent of the area requested for aquifer exemption is shown on Figure 2. A legal description of the lateral extent is presented in Table 3. The lateral extent of the proposed aquifer exemption presented here is equivalent to the proposed NRC permit boundary.

The vertical extent of the requested exemption is the full thickness of the Basal Chadron Sandstone, which extends from the top of the Pierre Shale to the base of the Middle Chadron (Table 4; Figures 5a through 5e). This vertical extent is slightly different than the vertical extent requested and received in the 1983 Aquifer Exemption Petition for the CSA, which includes the Middle Chadron and Upper/Middle Chadron.

4.7 Local Water Supply

The White River and associated tributaries indirectly supply some drinking water to the residents of Crawford. The city system, which serves a population of 1,115 (NDHHS, 2009), is supplied by three infiltration galleries (located along the White River, Dead Man's Creek, and Soldier Creek) and two wells that produce "groundwater under the influence of surface water" (University of Nebraska Cooperative Extension HE Form 526). In 1981, average daily usage ranged from a low of 199 gallons per day (gpd) per person during the month of February to a high of 508 gallon per day (gpd)/person during the month of July. The maximum recorded daily water usage in Crawford until 1981 was nearly 1 million gallons. Based on the Crawford Municipal Water Conservation Plan (Spring 2003), the average per capita water use in 2002 (including residential and business customers, public facilities including parks, (etc.) and water lost to system leaks) was 323 gpd. Information regarding the City of Crawford water system is summarized in Table 13 (Teahon, 2007; Teahon and Grantham 2010).

In general, groundwater supplies in the vicinity of the TCEA are limited due to topography and shallow geology (University of Nebraska-Lincoln, 1986). Groundwater quality within the White River drainage generally is poor (Engberg and Spalding, 1978). Locally, groundwater is obtained at limited locations from shallow alluvial sediments. The primary groundwater supply is the Brule Formation, typically encountered at depths from approximately 30 to 200 feet, with the exception of locations where the overlying alluvium is not present. In general, the static water level for Brule Formation wells in the TCEA ranges from 30 to 80 feet bgs, depending on local topography (Figures 5a through 5e and 22). Groundwater from the underlying Basal Chadron Sandstone aquifer is not used as a domestic supply within the TCEA because of the greater depth (580 to 940 feet bgs) and inferior water quality. Gosselin et al. (1996) state that: (1) "*the sands near the bottom of the Chadron Formation yield sodium-*

sulphate water with high total dissolved solids," and (2) in proximity to "*uranium deposits in the Crawford area, groundwater from the Chadron Formation is not suitable for domestic or livestock purposes because of high radium concentrations.*"

Alternate supplies of stock water are provided by the underlying Basal Chadron Sandstone, which occurs at depths ranging from about 580 to 940 feet bgs. However, because of greater depth and inferior water quality, the Basal Chadron Sandstone is not used for a domestic supply within the TCEA, as noted in the previous paragraph. In addition, it is economically impractical to install water supply wells into the deeper Basal Chadron Sandstone in the vicinity of the TCEA, in contrast to the vicinity of the NTEA where most Basal Chadron Sandstone wells either flow at the surface or have water levels very close to surface elevation because of artesian pressure.

Based on National Groundwater Association website (NGWA, 2004), average water use for rural (domestic) wells in Nebraska is approximately 380 gallons per day (gpd). Assuming an average family size of four persons, this correlates well with data from the USGS that suggest an average per capita use on the order of 97 gallons per day (USGS, 1999). Since there is only one residence located within the proposed TCEA (NW1/4 SE1/4 Section 29, T31N, R52W), water use would be expected to average about 380 gpd (Figure 20). Since there are twenty-three occupied residences within the 2.25-mile AOR, water use would be expected to average about 8,740 gpd for the entire area.

CBR conducted an updated water user survey in 2010 to identify and locate all private water supply wells within the 2.25-mile AOR of the proposed TCEA. The water user survey determined the location, depth, casing size, depth to water, and flow rate of all wells within the area that were (or potentially could be) used as domestic, agricultural, or livestock water supply. CBR updated the water user survey in 2008, 2009, and 2010 for all groundwater wells within the AOR. Table 14 and Appendix E list the active water supply wells within the TCEA and AOR. A list of abandoned water supply wells within the TCEA and AOR is provided in Appendix F. All active and abandoned water supply wells are depicted on Figure 20.

There are a total of eighty-nine active private and public water supply wells within the TCEA and AOR. Forty-nine wells are classified as agricultural use, seventeen wells are classified as domestic use, twelve wells are domestic/agricultural use, four City of Crawford wells are classified as livestock or observation use, one well is used by the City of Crawford as a test well for a municipal system, and six City of Crawford water supply wells, with four of these six wells being part of the city's infiltration gallery (Appendix E, Figure 20). Within the TCEA, there are seven private water supply wells that are completed in the Brule Formation. There are an additional seventy-two private water supply wells and ten public water supply wells located in the AOR outside of the TCEA permit boundary. The majority of the total eighty-nine private water supply wells are completed in the Brule Formation. However, there are six groundwater wells without well construction (e.g., well depth) or water quality information (Wells 300, 322, 395, 400, 402, and 432). Well construction and water quality information for these wells are not available in the Nebraska Department of Natural Resources (NDNR) water well data retrieval database (NDNR, 2010) or known by the well owner. Wells 300 and 432 are old wells with hand pumps, and Wells 322 and 402 have windmills, which would suggest that these are shallow wells completed in the Brule Formation.

Well depth information is unknown for Well 270, which is located within the TCEA permit boundary; however, water quality data from this well is consistent with the Brule Formation (Tables 8 and 14). Similarly, well depth information is unknown for Well 364, but a field conductivity measurement collected by CBR (386 µhmos) indicates that this is a Brule Formation well. There are six private water supply wells located outside, but within one mile, of the TCEA permit boundary, that are part of the project monitoring program (Wells 269, 274, 275, 313, and 314). The completion depths and water quality information collected to date for these wells indicate that they are completed in the Brule Formation. As discussed in Section 4.2.2, Well 312 will be sampled in future monitoring instead of Well 313.

Based on available information, all water supply wells within the TCEA and AOR are completed in the relatively shallow Brule Formation, with no domestic or agricultural use of groundwater from the Basal Chadron Sandstone (Figure 20 and Table 14).

Based on population projections, future water use within the TCEA and AOR will likely be a continuation of present use (see Section 2.3). It is unlikely that any irrigation development will occur within the license area due to the limited water supplies, topography, and climate. Irrigation within the review area is anticipated to be consistent with the past (e.g., limited irrigation in the immediate vicinity of the White River). It is anticipated that the City of Crawford municipal water supply will continue to be provided by the groundwater and infiltration galleries related to the White River and associated tributaries.

The City of Crawford has a designated wellhead protection area and adopted controls pursuant to the Nebraska Wellhead Protection Area Act (Nebraska Revised Statutes § 46-1501 – 46-1509) for the purpose of protecting the public water supply system. The boundaries of the Wellhead Protection Area (WHPA) are described in the City of Crawford Ordinance 575 [May 10, 2005] (City of Crawford 2010). The area includes 960 acres in Sections 15, 16, 21 and 22 of T31N R52W, Dawes County (Table 13, Figure 20). There are two public water supply wells located within the WHPA (Wells

454 and 455). A horizontal distance of 1,000 feet is the minimum required separation of a city water supply well (used for domestic, irrigation, stock, or heat pump purposes) from potential sources of contamination (City of Crawford, 2010).

The minimum horizontal distances required for additional potential sources of contamination are provided in the Class III UIC Application.

The nearest point of the northern TCEA permit boundary to the nearest boundary of the City of Crawford's WHPA is approximately 4,000 linear feet. Therefore, all proposed assets within the TCEA boundary that could be affected by the required minimum horizontal distances are located at a distance of over 4-times the minimum allowed distances separating the city's water supply wells from potential sources of contamination. Therefore, operations at the TCEA would not be expected to impact the city's WHPA.

5. Regulatory Criteria for Aquifer Exemption Demonstration

As required in Title 122, Chapter 5, Section 004 the aquifer exemption petition must demonstrate that the portion of the Basal Chadron Sandstone aquifer for which the exemption is sought: 1) does not currently serve as a source of drinking water; and 2) cannot now and will not in the future serve as a source of drinking water. The following information supports this determination.

5.1 The Basal Chadron Sandstone is not a Source of Drinking Water (Title 122; Chapter 5, Section 004.01)

With the exception of monitoring wells installed by CBR, there are only seven active permitted water supply wells within the TCEA (Wells 270, 271, 272, 273, 277, 281, and 286) (Table 14). All seven of these water supply wells are completed within the shallow Brule Formation and are used for domestic and agricultural (i.e. livestock watering) purposes. The Brule Formation is hydraulically isolated from the underlying Basal Chadron Sandstone by up to 560 feet of low permeability claystones and siltstones (see Section 4.4.1). All active and abandoned water supply wells within the TCEA are depicted on Figure 20. Table 14 and Appendices E and F present information from the updated water user survey for the active and abandoned water supply wells within the TCEA and surrounding 2.25-mile AOR. Note that some of the wells are old windmills (e.g., Well 314) or hand pump wells (e.g., Well 300) that are no longer in use, but have not yet been formally abandoned. There are no active water supply wells completed in the Basal Chadron Sandstone within the TCEA.

Figure 20 also depicts the locations of all active and abandoned water wells outside of the TCEA, but within a 2.25-mile AOR, as identified by CBR. Information from the updated water user survey for these additional water supply wells is listed in Table 14 and Appendices E and F. No active water supply wells are currently completed in the Basal Chadron Sandstone outside of the TCEA. However, there are six groundwater wells without well construction (e.g., well depth) or water quality information (Wells 300, 322, 395, 400, 402, and 432) (see discussion in Section 4.7).

In summary, there is no domestic use of groundwater from the Basal Chadron Sandstone within the TCEA, based on available information. There are no public drinking water supplies that use groundwater from the Basal Chadron Sandstone outside of the TCEA and within the 2.25-mile AOR.

5.2 The Basal Chadron Sandstone Cannot/Will Not Serve as Future Source of Drinking Water (Title 122, Chapter 5)

The small numbers of residences within the area are supplied domestic water from wells completed in the relatively shallow Brule Formation. Based on population projections, future water use within the proposed exemption area and area surrounding the proposed exemption area will likely be a continuation of present use. It is anticipated that the City of Crawford municipal water supply will continue to be provided by the White River and associated tributaries.

In addition to the absence of wells completed in the Basal Chadron Sandstone and used for drinking water supply within the 2.25-mile AOR (Figure 20), CBR must demonstrate that the Basal Chadron Sandstone within the TCEA cannot and will not serve as a future source of drinking water based on one of the following four criteria:

- 004.02A It is mineral, hydrocarbon, or geothermal energy bearing with production capability,
- 004.02B It is situated at a depth or location which makes recovery of water for drinking water purposes economically or technologically impractical,
- 004.02C It is so contaminated that it would be economically or technologically impractical to render that water fit for human consumption, or
- 004.02D It is located above a Class III well mining area subject to subsidence or catastrophic collapse.

Of these four criteria, both 004.02A and 004.02C are applicable to aquifer exemption for the TCEA.

5.2.1 The Basal Chadron Sandstone is Mineral-Bearing with Production Capability (Title 122, Chapter 5, 004.2A)

Based on water quality data from the TCEA presented in Section 4.2.2, the Basal Chadron Sandstone contains significant levels of radionuclides (Table 8). Indicated ore resources as U_3O_8 for the TCEA are 3,750,481 pounds (lbs) with an additional inferred estimate of 1,135,452 lbs. Total reserves are estimated at 4,900,000 lbs. The ore grade as U_3O_8 ranges from 0.05 to 5 percent with an average ore grade of 0.22 percent (see Section 3.1). Therefore, all available information indicates that the Basal Chadron Sandstone is a mineral-bearing interval within the TCEA.

Results of the 2008 pump test conducted in the Basal Chadron Sandstone indicate a mean hydraulic conductivity of 7.5 feet/day (2.65 x 10^{-3} cm/sec), a mean transmissivity of 477 ft^2/day (ranging from 267 to 743 ft^2/day), and a mean permeability of approximately 2,990 md (Table 11). The mean storativity was 8.8 x 10^{-4} (ranging from 4.8 x 10^{-5} to 1.6 x 10^{-4}) (Table 11). Estimated hydraulic parameters for individual well locations for the 2008 pump test are summarized in Table 12. These data indicate that mean transmissivity and hydraulic conductivity of the Basal Chadron Sandstone are more than adequate to successfully develop the TCEA for ISL mining activities.

In summary, all available data support the determination that the Basal Chadron Sandstone is a mineral-bearing interval with production capability that is amenable to ISL operations.

5.2.2 The Basal Chadron Sandstone Groundwater Cannot Technically/Economically be Rendered Fit for Consumption (Title 122, Chapter 005.02C)

Water quality results from wells completed in the Basal Chadron Sandstone within the TCEA are summarized in Table 8. As shown, groundwater from the Basal Chadron Sandstone aquifer within the TCEA has a TDS value less than 10,000 mg/L, indicating that the unit qualifies as an underground source of drinking water as defined in Chapter 1 of Title 122 of the NDEQ regulations.

Groundwater from the Basal Chadron Sandstone aquifer can significantly exceed groundwater standards within the TCEA (Table 8). Concentrations of uranium >0.03 mg/L are common in the mineralized zone within the TCEA (Figure 2).

The Maximum Contaminant Levels (MCL)s for radium-226 and uranium are 5.0 pCi/l and 0.03 mg/L, respectively (USEPA, 2000a). Although expensive, it is technologically possible to remove both radium and uranium from groundwater. Removal of these constituents has been required of municipal water supplies since December 2003 (USEPA, 2000b). U.S. Environmental Protection Agency (USEPA) (1998) identified Point of Entry (POE) or Point of Use (POU) removal technologies that would be amenable to individuals using well water, including POU ion exchange and POU reverse osmosis. USEPA evaluated the cost of implementing treatment technologies and determined that the threshold above which treatment becomes economically impractical is about 2.5 percent of the median household income. The median 2008 household income in Dawes County was $36,051 (USCB, 2008), so the maximum cost an individual might be able to incur if they desired to treat well water to MCLs would be about $784/year. The USEPA indicated that the typical POU reverse osmosis and

POU ion exchange cost is approximately $2.26 to 2.63 per thousand gallons (USEPA, 1998). With an average household use of 138,700 gallons per year (at 380 gpd) (see Section 4.7), the approximate minimum treatment cost would be approximately $313 per year. However, this cost analysis assumes that water would be obtained through a municipality, so costs would be dispersed, subject to an economy of scale, among a large group of users and additional costs associated with the system (i.e. disposal of spent units, etc) are likewise dispersed. Additionally, individual well users are not subject to treatment regulations specified in 40 Code of Federal Regulations (CFR) Parts 9, 141 and 142.

If individuals elect to perform wellhead treatment, the cost could be much higher for installation of an individual treatment system, and is expected to include more maintenance and application costs if a complex treatment system was selected. Available treatment technologies can be customized based on a specific set of design parameters, which include a range of flow rates and pressure. Current treatment technologies are economically viable as a community-wide treatment system for a central water supply. Costs for radium and uranium treatment systems are approximately $50,000 each, as the systems are independent of one another. Media exchange per system costs approximately $25,000. Frequency of media exchange depends upon contaminant level and utilization. Disposal of effluent and materials from such treatment also would be problematic. A portable exchange system (PES) for treating a private well (with an approximate pumping rate of 10 gpm) for uranium and radium, with two treatment vessels (resin bottles), has an initial capital cost of approximately $27,000 for initial installation of the system. There is an equipment charge of approximately $10,000 to exchange a set of exhausted treatment bottles and disposal approximately every five years. Therefore, while technologies exist to treat groundwater for the removal of radium and uranium, to do so might be considered cost prohibitive on an individual basis.

6. Conclusions

As required under Title 122, injection into a USDW is prohibited unless an aquifer exemption is obtained. The aquifer exemption must demonstrate that the portion of the aquifer for which the exemption is sought: 1) does not currently serve as a source of drinking water; and 2) cannot now and will not in the future serve as a source of drinking water for one of four reasons.

The following multiple lines of evidence establish the technical and regulatory basis for the proposed aquifer exemption.

- Geologic information presented in this application demonstrate the lateral continuity of the upper and lower confining layers for the Basal Chadron Sandstone on both regional and local scales, as well as the lateral continuity and thickness distribution of the proposed mining interval.
- The aquifer proposed for exemption has been adequately characterized to be under confined conditions and is hydraulically isolated from overlying water-bearing units within the TCEA and surrounding AOR.
- A 2008 pump test within the TCEA indicates that transmissivity is relatively consistent and is higher than estimates for the current production facility and proposed NTEA, indicating that the aquifer is capable of production and is amenable to ISL operations.
- The Basal Chadron Sandstone does not currently serve as a source of drinking water in the TCEA and cannot and will not in the future serve as a source of drinking water.
- Site-specific water quality results indicate that groundwater is mineral-bearing. Additionally, the presence of sodium-sulphate and high TDS yields unfavorable water quality conditions.
- Because of the presence of high levels of uranium and radium, economic impracticability and technical complications related to removing these radionuclides render the use of the Basal Chadron Sandstone unsuitable as a source of underground drinking water in the TCEA.

Assuming the required permits are obtained to conduct ISL operations in the exempted aquifer zone, CBR is committed to restoring the aquifer to water quality conditions that are consistent with pre-mining use. ISL mining has been conducted by CBR in the CSA since 1991 using the same procedures and processes proposed for the TCEA. CBR has demonstrated the ability to safely restore wellfields in the current mining area, as exemplified by ongoing restoration processes for mine units in the CSA.

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Tables

TABLE 1
THREE CROW CONSTRUCTION, MINING, RESTORATION SCHEDULE

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES - CRAWFORD, NEBRASKA

Planned Activity	Start Date	End Date
Production and Restoration		
Facility Construction	1/1/2014	12/2/2014
Production		
Mine Unit 1	12/2/2014	11/1/2017
Mine Unit 2	6/2/2015	6/1/2018
Mine Unit 3	12/31/2015	12/31/2018
Mine Unit 4	6/6/2016	6/6/2019
Mine Unit 5	1/2/2017	1/3/2020
Mine Unit 6	6/1/2017	1/1/2020
Mine Unit 7	1/2/2018	1/1/2021
Mine Unit 8	6/1/2018	6/1/2021
Mine Unit 9	1/2/2019	6/1/2022
Groundwater Restoration		
Mine Unit 1	11/2/2017	2/19/2020
Mine Unit 2	6/4/2018	9/18/2020
Mine Unit 3	11/1/2019	4/19/2021
Mine Unit 4	6/7/2019	9/23/2021
Mine Unit 5	1/6/2020	4/22/2022
Mine Unit 6	6/2/2020	9/1/2022
Mine Unit 7	1/4/2021	4/19/2023
Mine Unit 8	6/2/2021	9/22/2023
Mine Unit 9	1/4/2022	5/31/2024
Final Site Reclamation	5/31/2024	9/8/2025

TABLE 2
GENERAL STRATIGRAPHIC CHART FOR NORTHWEST NEBRASKA

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES - CRAWFORD, NEBRASKA

Geologic Period	Series	Formation or Group	Rock Types	Thickness (feet)
Miocene		Ogallala	SS, Slt	1560*
		Arikaree	SS, Slt	1070*
Oligocene/Eocene		White River	SS, Slt, Cly	1450*
Cretaceous	Upper	Pierre	Sh	1500
		Niobrara	Chalk, Ls, Sh	300
		Carlile	Sh	200-250
		Greenhorn	Ls	30
		Graneros	Sh	250-280
		D Sand	SS	5-30
		D Shale	Sh	60
		G Sand	SS	10-45
		Huntsman	Sh	60-80
	Lower	J Sand	SS	10-30
		Skull Creek	Sh	220
		Dakota	SS, Sh	180
Jurassic	Upper	Morrison	Sh, SS	300
		Sundance	SS, Sh, Ls	300
Permian	Guadalupe	Satanka	Ls, Sh, Anhy	450
	Leonard	Upper	Ls, Anhy	150
		Lower	Sh	150
	Wolfcamp	Chase	Anhy	80
		Council Grove	Anhy, Sh	300
		Admire	Dolo, Ls	70
Pennsylvanian	Virgil	Shawnee	Ls	80
	Missouri	Kansas City	Ls, Sh	80
	Des Moines	Marmaton/ Cherokee	Ls, Sh	130
	Atoka	Upper/Lower	Ls, Sh	200
Mississippian	Lower	Lower	Ls, Sh	30
Pre-Cambrian			Granite	

* Maximum thickness based on Swinehart, et. al, 1985.

TABLE 3
DESCRIPTION OF PROPOSED AQUIFER EXEMPTION LOCATION - THREE CROW

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES - CRAWFORD, NEBRASKA

Township/Range	Section	Location	Comments
T31N R52W	28	W1/2	South of Fort Robinson State Park boundary.
T31N R52W	29		Entire section south of Fort Robinson State Park boundary.
T31N R52W	30		Entire section south of Fort Robinson State Park boundary.
T31N R52W	33	NW1/4	
T321N R53W	25	W1/4	South of Fort Robinson State Park boundary.

TABLE 4
REPRESENTATIVE STRATIGRAPHIC SECTION - THREE CROW

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES - CRAWFORD, NEBRASKA

ELEVATION (FT-AMSL)	GROUP	FORMATION & MEMBER (SCHULTZ AND STOUT, 1955)			FORMATION & MEMBER (REVISED)		REFERENCES (REVISED)
Varying - 3725	White River Group	Brule Formation	Whitney Member		Brule Formation	"Brown Siltstones"	LaGarry (1998)
						Whitney Member	
			Orella Member	Orella D		Orella Member	
				Orella C			
				Orella B			
				Orella A			
3725 - 3425		Chadron Formation	Upper Chadron	Chadron C	Chadron Formation	Big Cottonwood Creek Member	Terry (1998) Terry & LaGarry (1998)
3475 - 3425			Upper/Middle Chadron	Chadron B			
3425 - 3275			Middle Chadron			Peanut Peak Member	Terry (1998) Terry & LaGarry (1998)
3275-3100			Red Clay Horizon	Chadron A	Chamberlain Pass Formation	Upper Interior Paleosol	Terry (1998)
			Basal Chadron Sandstone			Channel Sandstone	Terry (1998)
Varying	Montana Group	Pierre Shale	Interior Paleosol		Pierre Shale	Yellow Mounds Paleosol	Retallack (1983) Terry (1998)
3100 - ~2400			Pierre Shale			Pierre Shale	Terry (1998)

NOTES:

1) Topsoil, colluvial and alluvial deposits are not shown, but are Quaternary in age and range in thickness from 0 to 30 ft-bgs.
2) FT-AMSL = feet above mean sea level
3) Elevations are representative averages for TCEA only.

TABLE 5
COMPARISON OF MEAN MONTHLY PRECIPITATION WITH NORMAL MEAN MONTHLY DISCHARGE OF THE WHITE RIVER

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES - CRAWFORD, NEBRASKA

Month	Mean Precipitation[1] inches	Mean Precipitation[1] centimeters	Mean Discharge[2] Ft^3/sec	Mean Discharge[2] $Meters^3$/sec
January	0.61	1.55	21	0.59
February	0.76	1.93	23	0.65
March	1.74	4.42	27	0.76
April	2.65	6.73	25	0.71
May	3.11	7.9	27	0.76
June	2.42	6.15	22	0.62
July	2.77	7.04	16	0.45
August	1.21	3.07	13	0.37
September	1.38	3.51	14	0.4
October	1.66	4.22	17	0.48
November	0.82	2.08	19	0.54
December	0.79	2.01	20	0.57

NOTES:

1 - Climatology of the US No. 81, 1971-2000, NOAA, 25-Nebraska.
2 - USGS 2004. Period of Record 1931-2004.
3 - Data represents the White River at Crawford, Nebraska.

TABLE 6
NORMAL MEAN MONTHLY DISCHARGE OF THE WHITE RIVER AT CRAWFORD, NEBRASKA (1999-2007)

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES - CRAWFORD, NEBRASKA

Month	1999 (Ft^3/sec)	2000 (Ft^3/sec)	2001 (Ft^3/sec)	2002 (Ft^3/sec)	2003 (Ft^3/sec)	2004 (Ft^3/sec)	2005 (Ft^3/sec)	2006 (Ft^3/sec)	2007 (Ft^3/sec)
January	22.6	21.7	21	22.9	22.6	23	23.9	24.1	18.9
February	22.4	24.1	24.3	23.6	24	24.8	23.3	24.5	20.2
March	23.1	25.5	27	26.8	26.4	25.9	24.5	26.4	22.6
April	26.1	29.1	26.4	25.3	26.5	22.7	25.3	25.9	23.4
May	23.7	10	24.7	23.9	25.9	21.1	26.5	23.2	20.3
June	27.1	20.5	18.6	16.6	23.2	17.1	26.5	17.8	15.9
July	21.4	15.4	14.4	10.3	13.2	17.4	17.6	11	10
August	15	11.5	12.5	10.1	11.7	11.3	18.1	10	4.1
September	17	12.1	12.9	13.7	23.3	17.8	14.8	14.8	8.7
October	19.4	17.4	17.2	18.1	17.5	20.8	18.5	*	*
November	20.8	20.1	22	22.3	22.6	21.3	21	*	*
December	21.4	20.7	22.2	22.2	23.1	22.1	23.1	*	*
Average	**21.7**	**16.7**	**20.3**	**19.7**	**21.6**	**20.4**	**21.9**	**19.7**	**16.0**

Source: Nebraska Department of Natural Resources (NDNR) 2010.
*Data not available for fourth quarter 2006 and 2007.

TABLE 7
WATER LEVELS - BRULE FORMATION AND BASAL CHADRON SANDSTONE (JANUARY 2009 and 2010)

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES – CRAWFORD, NEBRASKA

Well	1/9/2009	1/30/2009	1/22/2010 & 2/8/2010
BRULE FORMATION			
BOW 2006-1	3862.90	3863.34	3863.83
BOW 2006-2	3879.01	3879.07	3878.50
BOW 2006-3	3878.25	3878.05	3877.20
BOW 2006-4	3857.78	3857.50	3861.58
BOW 2006-5	NM	NM	3842.83
BOW 2006-6	NM	NM	3904.43
BOW 2006-7	NM	NM	3913.02
Well 273 (Miller Well)	NM	NM	3819.13
BASAL CHADRON SANDSTONE			
CPW2006-2	3,721.22	3,721.01	3,717.26
COW2006-1	3,723.94	3,723.64	3,720.36
COW2006-2	3,721.11	3,720.85	3,717.13
COW2006-3	3,720.43	3,720.22	3,716.73
COW2006-4	3,720.81	3,720.46	3,717.02
COW2006-5	3,720.26	3,720.03	3,716.46
COW2006-6	3,713.43	3,712.89	3,708.23
COW2006-7	3,711.76	3,712.20	3,707.55
UBCOW2006-1	3,720.51	3,720.36	3,716.73
UBCOW2006-2	3,720.84	3,720.61	3,716.96

NOTES:

1) Groundwater elevations are in feet above mean sea level (ft-amsl).
2) Groundwater elevations for the Brule Formation and Basal Chadron Sandstone are based on depth to water measurements.
3) A single water level measurement was collected from Well 273 on 2/8/2010.
NM - not measured

TABLE 8
SUMMARY OF WATER QUALITY FOR THE TCEA AND VICINITY (2007-2009)

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES - CRAWFORD, NEBRASKA

CONSTITUENT	PRIVATE WELLS IN AOR[a] BRULE FORMATION		TCEA WELLS[b] BRULE FORMATION		TCEA WELLS[c] BASAL CHADRON SANDSTONE	
	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN
mg/L (unless stated otherwise)						
Calcium	7 - 99	54	14 - 101	50.25	8 - 24	13.0
Magnesium	1 - 9	4.2	1 - 14	4.96	2 - 7	3.7
Sodium	16 - 75	28.6	14 - 83	35	333 - 474	399
Potassium	6 - 20	11.7	6 - 12	9.1	6 - 9	9.6
Bicarbonate	170 - 313	227	194 - 478	246	353 - 418	396
Sulfate	4 -75	19	9 - 25	16.4	225 - 361	271.4
Chloride	1 - 42	10	4 - 23	8.54	166 - 274	186
Specific Conductance (• mhos)	246 - 633	436	239 - 735	410	1690 - 2190	1867
Total Dissolved Solids (TDS)	215 - 448	313	221 - 499	302	980 - 1300	1098
pH (std. units)	7.38 - 8.4	7.82	7.49 - 8.74	7.98	7.82 - 8.75	8.23
Anions (meq/l)	3.0 - 6.24	4.75	3.67 - 8.78	4.78	16.3 - 20.6	17.7
Cations (meq/l)	3.37 - 6.46	5.07	3.43 - 8.06	4.68	16 - 21.8	18.6
Uranium	0.008 - 0.0272	0.0161	0.0032 - 0.0264	0.0134	0.0004 - 0.0385	0.0087
Dissolved Ra-226[d] (pCi/l)	0.006 - 0.5	0.28	0.065 - 0.41	0.126	0.23 - 181	18.1
Suspended Ra-226[d] (pCi/l)	--	--	0.04 - 0.20	0.087	--	--

[a] 9 private water supply wells (2007 – 2009)

[b] 7 CBR TCEA Brule monitor wells (includes Well 274 [Miller Well[) (2008 – 2009) [Note Suspended Ra-226 analyses were for 3 sampling events in 2009 for wells BOW 2006-5, BOW 2006-6 and BOW 2006-7]

[c] 10 CBR TCEA Basal Chadron monitor wells (2008 – 2009)

[d] Values less than detection limits reduced by one-half in order to provide a conservative estimate.

mg/l = milligrams/liter
meq/l = milliequivalents per liter
pCi/l = picocuries per liter
µmhos/cm = micromhos per centimeter

TABLE 9
WATER QUALITY SUMMARY - BRULE FORMATION AND BASAL CHADRON SANDSTONE MONITORING WELLS (NOVEMBER 2008-JANUARY 2009)

PETITION FOR AQUIFER EXEMPTION - THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES

Location ID:		COW 2006-1		COW 2006-1		COW 2006-1		COW 2006-2		COW 2006-2		COW 2006-2		COW 2006-3		COW 2006-3		COW 2006-3		COW 2006-4		COW 2006-4		COW 2006-4	
Date Collected:		12/2/2008		12/16/2008		1/5/2009		12/2/2008		12/16/2008		1/5/2009		12/3/2008		12/17/2008		1/5/2009		12/1/2008		12/15/2008		1/6/2009	
Formation:		CHADRON		CHADRON		CHADRON		CHADRON		CHADRON		CHADRON		CHADRON		CHADRON		CHADRON		CHADRON		CHADRON		CHADRON	
MAJOR IONS	**Units**	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL
ALKALINITY, TOTAL AS CaCO3	mg/L	343	1	346	1	349	1	310	1	311	1	317	1	328	1	333	1	334	1	348	1	350	1	350	1
CARBONATE AS CO3	mg/L	13	1	10	1	12	1	12	1	10	1	11	1	<1.0	1	9	1	11	1	10	1	9	1	10	1
BICARBONATE AS HCO3	mg/L	392	1	403	1	402	1	353	1	358	1	363	1	401	1	389	1	386	1	405	1	409	1	406	1
CALCIUM	mg/L	9	1	10	1	9	1	12	1	11	1	10	1	12	1	12	1	12	1	10	1	10	1	9	1
CHLORIDE	mg/L	182	1	176	1	169	1	274	1	264	1	237	1	172	1	168	1	166	1	172	1	173	1	174	1
FLUORIDE	mg/L	1.2	0.1	1.1	0.1	1.2	0.1	1.2	0.1	1.2	0.1	1.2	0.1	1.2	0.1	1.3	0.1	1.3	0.1	1.2	0.1	1.2	0.1	1.2	0.1
MAGNESIUM	mg/L	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1	3	1
NITROGEN, AMMONIA AS N	mg/L	0.44	0.05	0.45	0.05	0.46	0.05	0.49	0.05	0.52	0.05	0.52	0.05	0.46	0.05	0.48	0.05	0.48	0.05	0.45	0.05	0.5	0.05	0.48	0.05
NITROGEN, NITRATE+NITRITE AS N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
POTASSIUM	mg/L	8	1	7	1	7	1	11	1	12	1	10	1	8	1	8	1	8	1	7	1	6	1	7	1
SILICA	mg/L	16.2	0.2	15.4	0.2	14.5	0.2	16.5	0.2	14.7	0.2	14.3	0.2	14.7	0.2	14	0.2	14.2	0.2	14.5	0.2	14.3	0.2	14.2	
SODIUM	mg/L	414	2	423	2	403	2	474	2	474	2	448	2	413	2	423	2	405	2	394	2	398	2	390	2
SULFATE	mg/L	242	1	244	1	242	1	289	1	289	1	291	1	286	1	285	1	283	1	227	1	225	1	228	1
PHYSICAL PROPERTIES																									
CONDUCTIVITY	umhos/cm	1800	1	1810	1	1800	1	2130	1	2140	1	2000	1	1840	1	1870	1	1800	1	1750	1	1780	1	1700	1
pH	s.u.	8.38	0.01	8.24	0.01	8.3	0.01	8.52	0.01	8.35	0.01	8.4	0.01	8.26	0.01	8.16	0.01	8.2	0.01	8.29	0.01	8.13	0.01	8.2	0.01
SOLIDS,TOTAL DISSOLVED TDS@180C	mg/L	1040	10	1040	10	1060	10	1220	10	1230	10	1200	10	1080	10	1110	10	1100	10	1040	10	1050	10	1040	10
METALS, DISSOLVED																									
ALUMINUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
ARSENIC	mg/L	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	0.001	0.001	0.001	0.001
BARIUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
BORON	mg/L	1	0.1	1.1	0.1	1.1	0.1	1	0.1	1.1	0.1	1.1	0.1	1	0.1	1.2	0.1	1.1	0.1	1.1	0.1	1.1	0.1	1	0.1
CADMIUM	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
CHROMIUM	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
COPPER	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
IRON	mg/L	0.04	0.03	0.04	0.03	0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	0.03	0.03	0.04	0.03	0.04	0.03	0.08	0.03	<0.03	0.03	<0.03	0.03
LEAD	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
MANGANESE	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	<0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
MERCURY	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
MOLYBDENUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
NICKEL	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
SELENIUM	mg/L	0.003	0.001	0.002	0.001	<0.001	0.001	0.002	0.001	0.002	0.001	<0.001	0.001	0.003	0.001	0.002	0.001	<0.001	0.001	0.002	0.001	<0.001	0.001	<0.001	0.001
URANIUM	mg/L	0.0014	0.0003	0.0016	0.0003	0.0014	0.0003	0.0294	0.0003	0.0339	0.0003	0.0294	0.0003	0.0042	0.0003	0.0046	0.0003	0.004	0.0003	0.0013	0.0003	0.0012	0.0003	0.0012	0.0003
VANADIUM	mg/L	<0.1	0.1	<0.1	0.1	<0.01	0.1	<0.01	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
ZINC	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.01	0.01	<0.01	0.01	<0.01	0.01	0.01	0.01	<0.01	0.01	<0.01	0.01	0.07	0.01	0.01	0.01	<0.01	0.01
DATA QUALITY																									
A/C BALANCE (± 5)	%	4.94		6.38		4.38		4.13		4.76		3.44		4.49		5.69		3.85		4.15		4.65		3.26	
ANIONS	meq/L	17.1		17		16.9		20		19.7		19.2		17.5		17.4		17.3		16.6		16.6		16.7	
CATIONS	meq/L	18.9		19.3		18.4		21.8		21.7		20.5		19.1		19.5		18.7		18.1		18.3		17.9	
SOLIDS, TOTAL DISSOLVED CALC.	mg/L	1090		1090		1040		1270		1260		1210		1110		1120		1100		1040		1040		1040	
TDS BALANCE (0.80-1.20)	dec. %	0.95		0.95		1.02		0.96		0.98		0.99		0.97		0.99		1		1		1.01		1	

TABLE 9

WATER QUALITY SUMMARY - BRULE FORMATION AND BASAL CHADRON SANDSTONE MONITORING WELLS (NOVEMBER 2008-JANUARY 2009)

PETITION FOR AQUIFER EXEMPTION - THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES

Location ID: / Date Collected: / Formation:		COW 2006-5 1/16/2009 CHADRON		COW 2006-5 1/30/2009 CHADRON		COW 2006-5 2/13/2009 CHADRON		COW 2006-6 1/16/2009 CHADRON		COW 2006-6 1/30/2009 CHADRON		COW 2006-6 2/13/2009 CHADRON	
MAJOR IONS	**Units**	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL
ALKALINITY, TOTAL AS CaCO3	mg/L	337	1	339	1	339	1	348	1	350	1	354	1
CARBONATE AS CO3	mg/L	<1.0	1	3	1	<1.0	1	13	1	12	1	9	1
BICARBONATE AS HCO3	mg/L	411	1	408	1	414	1	398	1	402	1	413	1
CALCIUM	mg/L	8	1	8	1	9	1	11	1	11	1	12	1
CHLORIDE	mg/L	181	1	179	1	181	1	215	1	213	1	202	1
FLUORIDE	mg/L	1.2	0.1	1.2	0.1	1.2	0.1	1.2	0.1	1.3	0.1	1.2	0.1
MAGNESIUM	mg/L	2	1	2	1	2	1	3	1	3	1	4	1
NITROGEN, AMMONIA AS N	mg/L	0.52	0.05	0.52	0.05	0.48	0.05	0.57	0.05	0.57	0.05	0.51	0.05
NITROGEN, NITRATE+NITRITE AS N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
POTASSIUM	mg/L	7	1	7	1	6. 0	1	13	1	10	1	9	1
SILICA	mg/L	12	0.2	11.5	0.2	12	0.2	11.4	0.2	11	0.2	11.8	0.2
SODIUM	mg/L	372	2	383	2	373	1	428	2	417	2	432	1
SULFATE	mg/L	276	1	274	1	274	1	354	1	361	1	348	1
PHYSICAL PROPERTIES													
CONDUCTIVITY	umhos/cm	1830	1	1890	1	1900	1	2130	1	2180	1	2190	1
pH	s.u.	8.25	0.01	8.42	0.01	8.22	0.01	8.75	0.01	8.73	0.01	8.5	0.01
SOLIDS,TOTAL DISSOLVED TDS@180C	mg/L	1080	10	1100	10	1100	10	1280	10	1300	10	1240	10
METALS, DISSOLVED													
ALUMINUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	<0.1	0.1
ARSENIC	mg/L	<0.001	0.001	<0.001	0.001	0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	0.001
BARIUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
BORON	mg/L	1	0.1	0.9	0.1	1	0.1	1.1	0.1	1	0.1	1.2	0.1
CADMIUM	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
CHROMIUM	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
COPPER	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
IRON	mg/L	<0.03	0.03	<0.03	0.03	<0.03	0.03	0.11	0.03	<0.03	0.03	<0.03	0.03
LEAD	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
MANGANESE	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	<0.01	0.01	<0.01	0.01	0.01	0.01
MERCURY	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
MOLYBDENUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
NICKEL	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
SELENIUM	mg/L	0.003	0.001	0.002	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001
URANIUM	mg/L	0.0013	0.0003	0.0012	0.0003	0.0011	0.0003	0.001	0.0003	0.0006	0.0003	0.0004	0.0003
VANADIUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.01	0.1
ZINC	mg/L	<0.01	0.01	<0.01	0.01	0.13	0.01	0.04	0.01	0.01	0.01	0.01	0.01
DATA QUALITY													
A/C BALANCE (± 5)	%	-1.76		-0.33		-1.74		-1.62		-3.51		-0.35	
ANIONS	meq/L	17.6		17.6		17.7		20.4		20.6		20.1	
CATIONS	meq/L	17		17.5		17.1		19.8		19.2		20	
SOLIDS, TOTAL DISSOLVED CALC.	mg/L	1070		1070		1070		1250		1240		1240	
TDS BALANCE (0.80-1.20)	dec. %	1.01		1.03		1.03		1.02		1.05		1	

Location ID: / Date Collected: / Formation:		COW 2006-7 1/16/2009 CHADRON		COW 2006-7 1/30/2009 CHADRON		COW 2006-7 2/13/2009 CHADRON		CPW 2006-2 11/24/2008 CHADRON		CPW 2006-2 12/8/2008 CHADRON		CPW 2006-2 12/22/2008 CHADRON	
MAJOR IONS	**Units**	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL
ALKALINITY, TOTAL AS CaCO3	mg/L	329	1	334	1	330	1	343	1	350	1	348	1
CARBONATE AS CO3	mg/L	<1.0	1	<1.0	1	<1.0	1	<1.0	1	19	1	7	1
BICARBONATE AS HCO3	mg/L	401	1	408	1	403	1	418	1	389	1	410	1
CALCIUM	mg/L	18	1	16	1	17	1	9	1	9	1	10	1
CHLORIDE	mg/L	179	1	183	1	176	1	170	1	169	1	166	1
FLUORIDE	mg/L	1.2	0.1	1.2	0.1	1.2	0.1	1.2	0.1	1.2	0.1	1.2	0.1
MAGNESIUM	mg/L	5	1	4	1	5	1	3	1	3	1	3	1
NITROGEN, AMMONIA AS N	mg/L	0.36	0.05	0.36	0.05	0.32	0.05	0.5	0.05	0.5	0.05	0.48	0.05
NITROGEN, NITRATE+NITRITE AS N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	ND	0.05
POTASSIUM	mg/L	15	1	11	1	11	1	7	1	7	1	7	1
SILICA	mg/L	12.4	0.2	11.2	0.2	12.5	0.2	13.7	0.2	14.7	0.2	13.9	0.2
SODIUM	mg/L	357	2	335	2	333	1	415	2	408	2	410	2
SULFATE	mg/L	263	1	262	1	258	1	263	1	259	1	256	1
PHYSICAL PROPERTIES													
CONDUCTIVITY	umhos/cm	1780	1	1840	1	1840	1	1780	1	1820	1	1770	1
pH	s.u.	8	0.01	8.17	0.01	8.01	0.01	8.17	0.01	8.3	0.01	8.25	0.01
SOLIDS,TOTAL DISSOLVED TDS@180C	mg/L	1050	10	1090	10	1070	10	1040	10	1040	10	1070	10
METALS, DISSOLVED													
ALUMINUM	mg/L	<0.1	0.1	<0.1	0.1	ND	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
ARSENIC	mg/L	0.002	0.001	0.002	0.001	0.003	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
BARIUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
BORON	mg/L	0.9	0.1	0.9	0.1	0.9	0.1	1.1	0.1	1.2	0.1	1.1	0.1
CADMIUM	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
CHROMIUM	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
COPPER	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
IRON	mg/L	<0.03	0.03	0.06	0.03	0.12	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03
LEAD	mg/L	<0.001	0.001	<0.001	0.001	ND	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
MANGANESE	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
MERCURY	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0001	0.001	<0.001	0.001
MOLYBDENUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
NICKEL	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
SELENIUM	mg/L	0.002	0.001	0.002	0.001	0.002	0.001	0.003	0.001	0.002	0.001	<0.001	0.001
URANIUM	mg/L	0.0053	0.0003	0.0056	0.0003	0.0052	0.0003	0.0385	0.0003	0.038	0.0003	0.0335	0.0003
VANADIUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
ZINC	mg/L	0.02	0.01	0.03	0.01	0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
DATA QUALITY													
A/C BALANCE (± 5)	%	0.153		-4		-3.05		4.71		3.86		4.67	
ANIONS	meq/L	17.2		17.4		17		17.2		17.2		17	
CATIONS	meq/L	17.2		16		16		18.9		18.6		18.7	
SOLIDS, TOTAL DISSOLVED CALC.	mg/L	1050		1030		1020		1090		1080		1080	
TDS BALANCE (0.80-1.20)	dec. %	1		1.06		1.05		0.95		0.96		0.99	

TABLE 9
WATER QUALITY SUMMARY - BRULE FORMATION AND BASAL CHADRON SANDSTONE MONITORING WELLS (NOVEMBER 2008-JANUARY 2009)

PETITION FOR AQUIFER EXEMPTION - THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES

Location ID:		UBCOW 2006-1		UBCOW 2006-1		UBCOW 2006-1		UBCOW 2006-2		UBCOW 2006-2		UBCOW 2006-2	
Date Collected:		11/24/2008		12/8/2008		12/22/2008		12/1/2008		12/15/2008		1/6/2009	
Formation:		CHADRON		CHADRON		CHADRON		CHADRON		CHADRON		CHADRON	
MAJOR IONS	**Units**	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL
ALKALINITY, TOTAL AS CaCO3	mg/L	332	1	340	1	339	1	314	1	315	1	314	1
CARBONATE AS CO3	mg/L	<1.0	1	13	1	<1.0	1	8	1	<1.0	1	5	1
BICARBONATE AS HCO3	mg/L	405	1	387	1	413	1	367	1	383	1	374	1
CALCIUM	mg/L	19	1	19	1	19	1	23	1	24	1	23	1
CHLORIDE	mg/L	174	1	169	1	168	1	175	1	175	1	174	1
FLUORIDE	mg/L	1.2	0.1.0	1.1	0.1	1.2	0.1	1.1	0.1	1.1	0.1	1.1	0.1
MAGNESIUM	mg/L	5	1	6	1	5	1	7	1	7	1	7	1
NITROGEN, AMMONIA AS N	mg/L	0.3	0.05	0.31	0.05	0.29	0.05	0.28	0.05	0.3	0.05	0.3	0.05
NITROGEN, NITRATE+NITRITE AS N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
POTASSIUM	mg/L	14	1	13	1	13	1	13	1	13	1	13	1
SILICA	mg/L	14.8	0.2	15.5	0.2	14.9	0.2	15.9	0.2	15.3	0.2	15.4	
SODIUM	mg/L	379	2	367	2	372	2	382	2	384	2	380	2
SULFATE	mg/L	236	1	227	1	227	1	292	1	291	1	290	1
PHYSICAL PROPERTIES													
CONDUCTIVITY	umhos/cm	1690	1	1720	1	1740	1	1820	1	1870	1	1800	1
pH	s.u.	7.82	0.01	8.02	0.01	8.02	0.01	8.09	0.01	7.89	0.01	8,0	0.01
SOLIDS,TOTAL DISSOLVED TDS@180C	mg/L	988	10	980	10	1010	10	1110	10	1110	10	1100	10
METALS, DISSOLVED													
ALUMINUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
ARSENIC	mg/L	0.007	0.001	0.007	0.001	0.007	0.001	0.007	0.001	0.008	0.001	0.007	0.001
BARIUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
BORON	mg/L	1	0.1	1.1	0.1	1	0.1	1	0.1	1	0.1	0.9	0.1
CADMIUM	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
CHROMIUM	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
COPPER	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	>0.01	0.01
IRON	mg/L	<0.03	0.03	<0.03	0.03	<0.03	0.03	0.03	0.03	<0.03	0.03	<0.03	0.03
LEAD	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
MANGANESE	mg/L	0.01	0.01	0.01	0.01	0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
MERCURY	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
MOLYBDENUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.01	0.1	<0.1	0.1
NICKEL	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
SELENIUM	mg/L	0.003	0.001	0.002	0.001	<0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	0.001
URANIUM	mg/L	0.0026	0.0003	0.0025	0.0003	0.0021	0.0003	0.0034	0.0003	0.0032	0.0003	0.0033	0.0003
VANADIUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
ZINC	mg/L	<0.01	0.01	<0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	<0.01	0.01
DATA QUALITY													
A/C BALANCE (± 5)	%	5		3.94		4.66		3.75		3.84		3.4	
ANIONS	meq/L	16.5		16.4		16.3		17.4		17.4		17.3	
CATIONS	meq/L	18.3		17.7		17.9		18.7		18.8		18.5	
SOLIDS, TOTAL DISSOLVED CALC.	mg/L	1050		1020		1030		1100		1100		1100	
TDS BALANCE (0.80-1.20)	dec. %	0.94		0.96		0.98		1.01		1.01		1	

Location ID:		BOW 2006-1		BOW 2006-1		BOW 2006-1		BOW 2006-2		BOW 2006-2	
Date Collected:		11/24/2008		12/8/2008		12/22/2008		12/1/2008		12/15/2008	
Formation:		BRULE		BRULE		BRULE		BRULE		BRULE	
MAJOR IONS	**Units**	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL
ALKALINITY, TOTAL AS CaCO3	mg/L	159	1	162	1	160	1	162	1	162	1
CARBONATE AS CO3	mg/L	<1.0	1	<1.0	1	<1.0	1	<1.0	1	<1.0	1
BICARBONATE AS HCO3	mg/L	194	1	197	1	196	1	197	1	197	1
CALCIUM	mg/L	62	1	65	1	63	1	48	1	53	1
CHLORIDE	mg/L	8	1	8	1	8	1	8	1	8	1
FLUORIDE	mg/L	0.4	0.1	0.4	0.1	0.4	0.1	0.4	0.1	0.4	0.1
MAGNESIUM	mg/L	4	1	4	1	4	1	4	1	4	1
NITROGEN, AMMONIA AS N	mg/L	<0.05	0.05	<0.05	0.05	ND	0.05	<0.05	0.05	<0.05	0.05
NITROGEN, NITRATE+NITRITE AS N	mg/L	3.84	0.05	4.14	0.05	3.9	0.05	2.43	0.05	2.4	0.05
POTASSIUM	mg/L	10	1	10	1	10	1	8	1	9	1
SILICA	mg/L	73.2	0.2	69	0.2	65.4	0.2	78.1	0.2	69.4	0.2
SODIUM	mg/L	17	2	17	2	16	2	23	2	27	2
SULFATE	mg/L	19	1	18	1	18	1	17	1	17	1
PHYSICAL PROPERTIES											
CONDUCTIVITY	umhos/cm	348	1	294	1	400	1	308	1	258	1
pH	s.u.	7.49	0.01	7.82	0.01	7.71	0.01	7.81	0.01	7.66	0.01
SOLIDS,TOTAL DISSOLVED TDS@180C	mg/L	279	10	237	10	284	10	286	10	288	10
METALS, DISSOLVED											
ALUMINUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
ARSENIC	mg/L	0.002	0.001	0.003	0.001	0.003	0.001	0.006	0.001	0.007	0.001
BARIUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.1	0.1	0.1	0.1
BORON	mg/L	<0.1	0.1	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
CADMIUM	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
CHROMIUM	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
COPPER	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
IRON	mg/L	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03
LEAD	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
MANGANESE	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.04	0.01	0.05	0.01
MERCURY	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
MOLYBDENUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
NICKEL	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.005	0.05	<0.5	0.05
SELENIUM	mg/L	0.005	0.001	0.004	0.001	0.005	0.001	0.005	0.001	0.006	0.001
URANIUM	mg/L	0.0176	0.0003	0.0172	0.0003	0.0146	0.0003	0.0136	0.0003	0.0128	0.0003
VANADIUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.10	0.1	<0.1	0.1
ZINC	mg/L	0.02	0.01	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01
DATA QUALITY											
A/C BALANCE (± 5)	%	3.93		4.96		4.47		-0.702		4.8	
ANIONS	meq/L	4.09		4.14		4.1		3.98		4.01	
CATIONS	meq/L	4.42		4.57		4.49		3.93		4.41	
SOLIDS, TOTAL DISSOLVED CALC.	mg/L	325		325		317		314		314	
TDS BALANCE (0.80-1.20)	dec. %	0.86		0.73		0.9		0.91		0.92	

TABLE 9
WATER QUALITY SUMMARY - BRULE FORMATION AND BASAL CHADRON SANDSTONE MONITORING WELLS (NOVEMBER 2008-JANUARY 2009)

PETITION FOR AQUIFER EXEMPTION - THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES

Location ID:		BOW 2006-2		BOW 2006-3		BOW 2006-3		BOW 2006-3		BOW 2006-4		BOW 2006-4		BOW 2006-4		BOW 2006-5		BOW 2006-5		BOW 2006-5		BOW 2006-6		BOW 2006-6	
Date Collected:		1/13/2009		12/1/2008		12/17/2008		1/13/2009		1/16/2009		1/30/2009		2/13/2009		11/20/2009		12/4/2009		12/18/2009		11/20/2009		12/4/2009	
Formation:		BRULE		BRULE		BRULE		BRULE		BRULE		BRULE		BRULE		BRULE		BRULE		BRULE		BRULE		BRULE	
MAJOR IONS	**Units**	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL
ALKALINITY, TOTAL AS CaCO3	mg/L	159	1	159	1	159	1	160	1	162	1	170	1	172	1	392	5	381	5	383	5	172	5	171	5
CARBONATE AS CO3	mg/L	<1.0	1	<1.0	1	<1.0	1	<1.0	1	<1.0	1	<1.0	1	<1.0	1	<5.0	5	<5.0	5	<5.0	5	<5.0	5	<5.0	5
BICARBONATE AS HCO3	mg/L	194	1	194	1	194	1	195	1	198	1	207	1	210	1	478	5	464	5	467	5	210	5	209	5
CALCIUM	mg/L	51	1	26	1	27	1	25	1	14	1	14	1	17	1	100	1	101	1	97	1	46	1	40	1
CHLORIDE	mg/L	8	1	4	1	5	1	4	1	23	1	11	1	11	1	14	1	13	1	13	1	4	1	4	1
FLUORIDE	mg/L	0.4	0.1	0.6	0.1	0.6	0.1	0.6	0.1	0.6	0.1	0.6	0.1	0.6	0.1	0.1	0.1	1.2	0.1	1.3	0.1	0.4	0.1	0.4	0.1
MAGNESIUM	mg/L	4	1	2	1	2	1	2	1	1	1	1	1	2	1	14	1	14	1	14	1	7	1	5	1
NITROGEN, AMMONIA AS N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
NITROGEN, NITRATE+NITRITE AS N	mg/L	2.33	0.05	2.57	0.05	2.59	0.05	2.49	0.05	2.16	0.05	2.18	0.05	2.23	0.05	<0.1	0.1	2.1	0.1	0.1	0.1	1.8	0.1	2.5	0.1
POTASSIUM	mg/L	8	1	10	1	11	1	10	1	10	1	8	1	9	1	12	1	12	1	12	1	6	1	7	1
SILICA	mg/L	56.3	0.2	81	0.2	73.2	0.2	59.9	0.2	69.9	0.2	62.7	0.2	64.5	0.2	53.1	0.2	52.5	0.2	55.6	0.2	2.8	0.2	61.6	0.2
SODIUM	mg/L	26	2	56	2	56	2	59	2	83	2	68	2	67	1	34	1	35	1	31	1	14	1	25	1
SULFATE	mg/L	18	1	16	1	16	1	17	1	25	1	20	1	23	1	24	1	25	1	23	1	10	1	11	1
PHYSICAL PROPERTIES																									
CONDUCTIVITY	umhos/cm	391	1	286	1	239	1	375	1	466	1	445	1	311	1	730	1	735	1	728	1	348	1	347	1
pH	s.u.	7.81	0.01	8.18	0.01	7.95	0.01	8.04	0.01	8.7	0.01	8.74	0.01	8.35	0.01	8.14	0.01	7.78	0.01	7.86	0.01	8.12	0.01	7.94	0.01
SOLIDS,TOTAL DISSOLVED TDS@180C	mg/L	264	10	280	10	282	10	254	10	312	10	327	10	304	10	499	10	470	10	442	10	242	10	253	10
METALS, DISSOLVED																									
ALUMINUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
ARSENIC	mg/L	0.007	0.001	0.014	0.001	0.013	0.001	0.015	0.001	0.009	0.001	0.009	0.001	0.01	0.001	0.006	0.001	0.005	0.001	0.006	0.001	0.004	0.001	0.006	0.001
BARIUM	mg/L	0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.2	0.1	0.2	0.1	0.2	0.1	0.2	0.1	0.2	0.1
BORON	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
CADMIUM	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
CHROMIUM	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
COPPER	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.1	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.01	0.01
IRON	mg/L	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03
LEAD	mg/L	<0.001	0.001	N<0.001	0.001	<0.001	0.001	<0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.002	0.001	<0.001	0.001	0.003	0.001	0.001	0.001	0.002	0.001
MANGANESE	mg/L	0.03	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.07	0.01	0.06	0.01	0.08	0.01	<0.01	0.01	<0.01	0.01
MERCURY	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
MOLYBDENUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
NICKEL	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
SELENIUM	mg/L	0.007	0.001	0.003	0.001	0.003	0.001	<0.001	0.001	0.005	0.001	0.003	0.001	0.003	0.001	<0.001	0.001	<0.001	0.001	0.001	0.001	0.003	0.001	0.002	0.001
URANIUM	mg/L	0.014	0.0003	0.0111	0.0003	0.0103	0.0003	0.0032	0.0003	0.0098	0.0003	0.0102	0.0003	0.0099	0.0003	0.0227	0.0003	0.0242	0.0003	0.0264	0.0003	0.0083	0.0003	0.0086	0.0003
VANADIUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	0.004	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
ZINC	mg/L	0.02	0.01	<0.01	0.01	0.01	0.01	<0.01	0.01	0.23	0.01	0.28	0.01	0.44	0.01	1.14	0.01	1.07	0.01	1.22	0.01	0.62	0.01	0.7	0.01
DATA QUALITY																									
A/C BALANCE (± 5)	%	3.6		3.75		4.27		3.71		0.918		-3.71		-3.34		-4.89		-3.86		-5.62		-1.91		-2.88	
ANIONS	meq/L	3.95		3.83		3.86		3.88		4.59		4.32		4.4		8.78		8.71		8.58		3.76		3.95	
CATIONS	meq/L	4.25		4.13		4.21		4.18		4.68		4.01		4.12		7.96		8.06		7.67		3.62		3.73	
SOLIDS, TOTAL DISSOLVED CALC.	mg/L	292		323		316		300		352		236		323		5.02		506		493		1.9		285	
TDS BALANCE (0.80-1.20)	dec. %	0.9		0.87		0.89		0.85		0.89		1.39		0.94		0.99		0.93		0.9		1.27		0.89	

TABLE 9
WATER QUALITY SUMMARY - BRULE FORMATION AND BASAL CHADRON SANDSTONE MONITORING WELLS (NOVEMBER 2008-JANUARY 2009)

PETITION FOR AQUIFER EXEMPTION - THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES

Location ID:		BOW 2006-6		BOW 2006-7		BOW 2006-7		BOW 2006-7		Miller Well (273)		Miller Well (273)		Miller Well (273)	
Date Collected:		12/18/2009		11/20/2009		12/4/2009		12/18/2009		11/20/2009		12/4/2009		12/18/2009	
Formation:		BRULE		BRULE		BRULE		BRULE		BRULE		BRULE		BRULE	
MAJOR IONS	**Units**	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL	RESULTS	RL
ALKALINITY, TOTAL AS CaCO3	mg/L	173	5	162	5	163	5	168	5	246	5	241	5	243	5
CARBONATE AS CO3	mg/L	<5.0	5	<5.0	5	<5.0	5	<5.0	5	<5.0	5	<5.0	5	<5.0	5
BICARBONATE AS HCO3	mg/L	211	5	197	5	199	5	205	5	301	5	294	5	296	5
CALCIUM	mg/L	46	1	30	1	33	1	33	1	71	1	72	1	72	1
CHLORIDE	mg/L	4	1	4	1	16	1	9	1	6	1	6	1	6	1
FLUORIDE	mg/L	0.4	0.1	0.6	0.1	0.6	0.1	0.6	0.1	0.6	0.1	0.6	0.1	0.6	0.1
MAGNESIUM	mg/L	6	1	3	1	3	1	3	1	6	1	5	1	6	1
NITROGEN, AMMONIA AS N	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
NITROGEN, NITRATE+NITRITE AS N	mg/L	1.8	0.1	1.2	0.1	1.2	0.1	1.2	0.1	2.2	0.1	1.1	0.1	2.5	0.1
POTASSIUM	mg/L	6	1	8	1	8	1	8	1	8	1	9	1	9	1
SILICA	mg/L	64.7	0.2	68.4	0.2	66.5	0.2	72.7	0.2	64.1	0.2	61.7	0.2	65.4	0.2
SODIUM	mg/L	16	1	35	1	42	1	33	1	19	1	21	1	19	1
SULFATE	mg/L	9	1	15	1	11	1	11	1	10	1	10	1	10	1
PHYSICAL PROPERTIES															
CONDUCTIVITY	umhos/cm	345	1	338	1	375	1	351	1	471	1	477	1	475	1
pH	s.u.	7.96	0.01	8.13	0.01	8	0.01	7.96	0.01	8.12	0.01	7.75	0.01	7.68	0.01
SOLIDS,TOTAL DISSOLVED TDS@180C	mg/L	221	10	266	10	276	10	229	10	320	10	319	10	312	10
METALS, DISSOLVED															
ALUMINUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
ARSENIC	mg/L	0.005	0.001	0.007	0.001	0.004	0.001	0.005	0.001	0.003	0.001	0.003	0.001	0.003	0.001
BARIUM	mg/L	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	<0.1	0.1	0.1	0.1
BORON	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
CADMIUM	mg/L	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005	<0.005	0.005
CHROMIUM	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
COPPER	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
IRON	mg/L	0.04	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03	<0.03	0.03
LEAD	mg/L	0.003	0.001	<0.001	0.001	0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
MANGANESE	mg/L	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01
MERCURY	mg/L	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001	<0.001	0.001
MOLYBDENUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
NICKEL	mg/L	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05	<0.05	0.05
SELENIUM	mg/L	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001	0.002	0.001	0.003	0.001
URANIUM	mg/L	0.0097	0.0003	0.01	0.0003	0.0103	0.0003	0.0122	0.0003	0.0137	0.0003	0.015	0.0003	0.0168	0.0003
VANADIUM	mg/L	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1	<0.1	0.1
ZINC	mg/L	0.64	0.01	0.29	0.01	0.36	0.01	0.3	0.01	<0.01	0.01	0.01	0.01	<0.01	0.01
DATA QUALITY															
A/C BALANCE (± 5)	%	-3.84		-3.34		-1.35		-5.53		-4.48		-1.18		-3.32	
ANIONS	meq/L	3.92		3.67		4.05		3.96		5.5		5.3		5.43	
CATIONS	meq/L	3.63		3.43		3.94		3.55		5.02		5.17		5.08	
SOLIDS, TOTAL DISSOLVED CALC.	mg/L	281		192		301		295		359		351		360	
TDS BALANCE (0.80-1.20)	dec. %	0.79		1.39		0.92		0.78		0.89		0.91		0.87	

NOTES:
1) Detections are bolded.
mg/L - milligrams per liter
umhos/cm - micromhos per centimeter
s.u. - standard units
meq/L - milliequivalents per liter
dec. % - decimal percent

TABLE 10
SUMMARY OF 2008 THREE CROW PUMP TEST WELL INFORMATION

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES - CRAWFORD, NEBRASKA

Well	Distance to Pumping Well	Northing (ft)	Easting (ft)	Township & Range	Section
Basal Chadron Sandstone Pumping Well					
CPW 2006-2	0.00	492,983.11	1,068,178.21	30	T31N R52W
Basal Chadron Sandstone Observation Wells					
COW 2006-1	4,601	494,341.24	1,063,782.51	25	T31N R53W
COW 2006-2	2,138	494,512.66	1,066,684.93	30	T31N R52W
COW 2006-3	1,155	494,006.65	1,068,713.99	30	T31N R52W
COW 2006-4	2,718	490,369.75	1,068,924.73	29	T31N R52W
COW 2006-5	3,877	490,191.11	1,070,868.10	29	T31N R52W
UBCOW 2006-1	45	492,976.82	1,068,222.59	30	T31N R52W
UBCOW 2006-2	2,711	490,371.92	1,068,906.48	29	T31N R52W
Brule Formation Observation Wells					
BOW 2006-1	39	493,015.54	1,068,155.97	30	T31N R52W
BOW 2006-2	2,444.00	491,217.68	1,066,488.62	30	T31N R52W
BOW 2006-3	2,789	490,288.86	1,068,899.77	29	T31N R52W

TABLE 10
SUMMARY OF 2008 THREE CROW PUMP TEST WELL INFORMATION

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES - CRAWFORD, NEBRASKA

Well	TOC Elev. (ft-amsl)	Surface Elevation (ft-amsl)	Casing Stickup (ft)	Depth Drilled (ft bgs)	Casing Depth (ft bgs)	Top Screen (ft bgs)
Basal Chadron Sandstone Pumping Well						
CPW 2006-2	3,914.73	3,913.63	1.10	900	790	791
Basal Chadron Sandstone Observation Wells						
COW 2006-1	3,906.95	3,905.80	1.15	840	759	764
COW 2006-2	3,933.71	3,932.71	1.00	880	779	781
COW 2006-3	3,903.68	3,902.78	0.90	840	729	731
COW 2006-4	3,955.82	3,954.67	1.15	910	789	783
COW 2006-5	3,892.71	3,982.26	0.45	920	849	851
UBCOW 2006-1	3,915.06	3,913.96	1.10	760	649	654
UBCOW 2006-2	3,955.55	3,954.03	1.52	770	659	665
Brule Formation Observation Wells						
BOW 2006-1	3,915.50	3,914.75	0.75	170	39	45
BOW 2006-2	3,938.64	3,937.65	0.99	180	69	75
BOW 2006-3	3,957.36	3,956.23	1.13	200	45	45

TABLE 10
SUMMARY OF 2008 THREE CROW PUMP TEST WELL INFORMATION

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES - CRAWFORD, NEBRASKA

Well	Bottom Screen (ft bgs)	Screen Length (ft)	Casing O.D. (in.)	04/21/08 Static Water Elevation (ft AMSL)
Basal Chadron Sandstone Pumping Well				
CPW 2006-2	871	80	4.95	3722.26
Basal Chadron Sandstone Observation Wells				
COW 2006-1	829	65	4.95	3724.93
COW 2006-2	851	70	4.95	3721.50
COW 2006-3	811	80	4.95	3718.77
COW 2006-4	878	95	4.95	3722.61
COW 2006-5	901	50	4.95	3721.64
UBCOW 2006-1	744	90	4.95	3721.88
UBCOW 2006-2	770	105	4.95	3721.75
Brule Formation Observation Wells				
BOW 2006-1	50	5	4.95	3862.91
BOW 2006-2	180	105	4.95	3878.85
BOW 2006-3	190	145	4.95	3879.16

TABLE 11
SUMMARY OF THREE CROW PUMP TEST RESULTS vs. CSA vs. NORTH TREND

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES - CRAWFORD, NEBRASKA

	Tests #1-#4 Existing Class III Permit Area (mean)	Test #6 North Trend 2006 (mean)	Test #7 Three Crow 2008 (mean)
Transmissivity (ft^2/day)	363	60	477
Formation Thickness (feet)	39.0	26	64
Hyd. Cond. (ft/day)	9.3	2.3	7.5
Storativity	9.7E-05	5.3E-05	8.8E-04

TABLE 12
SUMMARY OF 2008 THREE CROW PUMP TEST RESULTS

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES - CRAWFORD, NEBRASKA

Well	Distance from Pumping Well (feet)	Analytical Results	Theis Drawdown	Theis Recovery	Cooper & Jacob 'u' assumption satisfied (<0.01)	Averages
CPW 2006-2	Pumping Well	Transmissivity (ft^2/day)	NA	3.35E+02	NA	3.35E+02
		Hyd. Cond. (ft/day)	NA	5.24E+00	NA	5.24E+00
		Storativity	--	--	--	--
COW 2006-1	4,601	Transmissivity (ft^2/day)	6.38E+02	8.48E+02	NA	7.43E+02
		Hyd. Cond. (ft/day)	9.97E+00	1.32E+01	NA	1.16E+01
		Storativity	1.64E-04	--	--	1.64E-04
COW 2006-2	2,138	Transmissivity (ft^2/day)	3.67E+02	4.73E+02	NA	4.20E+02
		Hyd. Cond. (ft/day)	5.74E+00	7.39E+00	NA	6.57E+00
		Storativity	9.65E-05	--	--	9.65E-05
COW 2006-3*	1,155	Transmissivity (ft^2/day)	2.16E+02	3.22E+02	2.61E+02	2.67E+02
		Hyd. Cond. (ft/day)	3.38E+00	5.04E+00	4.08E+00	4.16E+00
		Storativity	4.83E-05	--	4.14E-05	4.49E-05
COW 2006-4	2,718	Transmissivity (ft^2/day)	3.51E+02	5.31E+02	NA	4.41E+02
		Hyd. Cond. (ft/day)	5.48E+00	8.29E+00	NA	6.89E+00
		Storativity	6.68E-05	--	--	6.68E-05
COW 2006-5	3,877	Transmissivity (ft^2/day)	4.42E+02	5.83E+02	NA	5.12E+02
		Hyd. Cond. (ft/day)	6.90E+00	9.11E+00	NA	8.01E+00
		Storativity	6.83E-05	--	--	6.83E-05
					Avg. Transmissivity (ft^2/day)	4.77E+02
					Avg. Hyd. Cond. (ft/day)	7.45E+00
					Avg. Storativity	8.81E-05

* - The 'u' assumpition limitation (<0.01) inherent to the Cooper & Jacob method was satisfied for monitor well COW 2006-3 only.

Discharge Rate: 44.7 [U.S. gal/min]

Aquifer Thickness: 64 [ft]

TABLE 13
SUMMARY OF TOWN OF CRAWFORD WATER SYSTEM

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES - CRAWFORD, NEBRASKA

Description	Capacity
Raw Water Storage Capacity	500,000 gallons
Treated Water Capacity	
West Tank	1,000,000 gallons
East Tank	750,000 gallons
Average Daily Use (2006)	419,181 gallons
Maximum Daily Use	1,000,000 gallons
Supply Wells	
South Well #1 (100 feet deep); Reg: G-93533 NW1/4 SW1/4 Sec. 15, T31N, R52W	104 gpm
West Well #2 (100 feet deep); Reg: G-93532 NW1/4 SW1/4 Sec. 15, T31N, R52W	54 gpm
Infiltration Gallery	
Wet Well; 27 feet; Reg: G-93531 SE1/4 SW1/4 Sec. 8 T31N R52W	900 gpm
Dewatering Wells; 20 to 26 feet deep SE1/4 SW1/4 Sec. 8 T31N R52W Reg Nos: 93528, 93529, 93530	33 gpm (each)
Wellhead Protection Area	
960 acres Sec. 15, 16, 21 and 22, T31N R52W	--

TABLE 14
ACTIVE AND ABANDONED WATER SUPPLY WELLS IN THE TCEA AND 2.25-MILE AREA OF REVIEW

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES - CRAWFORD, NEBRASKA

Well #	Estimated Depth	Formation	Well Use	Well Status	Within TCEA
ACTIVE WELLS					
9	110	Brule Fm	Agricultural	Active	No
10	80	Brule Fm	Agricultural	Active	No
44	90	Brule Fm	Domestic	Active	No
45	90	Brule Fm	Domestic	Active	No
46	130	Brule Fm	Domestic	Active	No
47	50	Brule Fm	Domestic	Active	No
53	80	Brule Fm	Domestic	Active	No
54	80	Brule Fm	Agricultural	Active	No
70	125	Brule Fm	Agricultural	Active	No
71	100	Brule Fm	Agricultural	Active	No
73	120	Brule Fm	Other Use[b]	Active	No
139	80	Brule Fm	Domestic/Agricultural	Active	No
142	200	Brule Fm	Domestic/Agricultural	Active	No
143	100	Brule Fm	Domestic	Active	No
146	200	Brule Fm	Agricultural	Active	No
147	100	Brule Fm	Agricultural	Active	No
148	200	Brule Fm	Agricultural	Active	No
260	260	Brule Fm	Domestic	Active	No
261	300	Brule Fm	Agricultural	Active	No
265	32	Brule Fm	Domestic	Active	No
266	15 – 20	Brule Fm	Agricultural	Active	No
267	15 – 20	Brule Fm	Agricultural	Active	No
268	15 – 20	Brule Fm	Agricultural	Active	No
269	65	Brule Fm	Domestic	Active	No
270	a	Brule Fm	Domestic/Agricultural	Active	**Yes**
271	100 – 120	Brule Fm	Domestic/Agricultural	Active	**Yes**
272	60	Brule Fm	Domestic/Agricultural	Active	**Yes**
273	140	Brule Fm	Agricultural	Active	**Yes**
274	160	Brule Fm	Domestic	Active	No
275	200	Brule Fm	Domestic	Active	No
276	300	Brule Fm	Domestic	Active	No
277	60	Brule Fm	Domestic	Active	**Yes**
278	25 – 30	Brule Fm	Domestic/Agricultural	Active	No
279	260	Brule Fm	Agricultural	Active	No
280	160	Brule Fm	Agricultural	Active	No
281	100	Brule Fm	Agricultural	Active	**Yes**
282	200	Brule Fm	Agricultural	Active	No
283	200	Brule Fm	Agricultural	Active	No
284	90	Brule Fm	Agricultural	Active	No
286	90	Brule Fm	Agricultural	Active	**Yes**
287	50	Brule Fm	Agricultural	Active	No
300	a	a	Agricultural	Active	No
310	50	Brule Fm	Agricultural	Active	No
311	200	Brule Fm	Agricultural	Active	No

TABLE 14
ACTIVE AND ABANDONED WATER SUPPLY WELLS IN THE TCEA AND 2.25-MILE AREA OF REVIEW

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES - CRAWFORD, NEBRASKA

Well #	Estimated Depth	Formation	Well Use	Well Status	Within TCEA
312	150	Brule Fm	Agricultural	Active	No
313	150	Brule Fm	Agricultural	Active	No
314	150	Brule Fm	Agricultural	Active	No
322	a	a	Agricultural	Active	No
332	120	Brule Fm	Agricultural	Active	No
333	100	Brule Fm	Agricultural	Active	No
334	100	Brule Fm	Domestic	Active	No
335	160	Brule Fm	Agricultural	Active	No
337	90	Brule Fm	Domestic/Agricultural	Active	No
338	60	Brule Fm	Agricultural	Active	No
339	30	Brule Fm	Domestic/Agricultural	Active	No
360	190	Brule Fm	Agricultural	Active	No
361	250	Brule Fm	Agricultural	Active	No
364	a	Brule Fm	Domestic/Agricultural	Active	No
367	80	Brule Fm	Agricultural	Active	No
368	170	Brule Fm	Domestic/Agricultural	Active	No
369	120	Brule Fm	Agricultural	Active	No
371	140	Brule Fm	Agricultural	Active	No
372	80	Brule Fm	Agricultural	Active	No
373	140	Brule Fm	Agricultural	Active	No
374	200	Brule Fm	Domestic/Agricultural	Active	No
381	40 -50	Brule Fm	Agricultural	Active	No
386	160	Brule Fm	Agricultural	Active	No
390	80	Brule Fm	Domestic	Active	No
395	a	a	Domestic	Active	No
398	95	Brule Fm	Domestic	Active	No
400	a	a	Agricultural	Active	No
402	a	a	Agricultural	Active	No
412	133	Brule Fm	Agricultural	Active	No
421	60	Brule Fm	Agricultural	Active	No
432	a	a	Agricultural	Active	No
434	125	Brule Fm	Domestic/Agricultural	Active	No
446	200	Brule Fm	Agricultural	Active	No
447	60	Brule Fm	Agricultural	Active	No
448	200	Brule Fm	Agricultural	Active	No
450	260	Brule Fm	Livestock/Observation	Active	No
451	200	Brule Fm	Livestock/Observation	Active	No
452	200	Brule Fm	Livestock/Observation	Active	No
453	200	Brule Fm	Livestock/Observation	Active	No
454	103	Brule Fm	Public Water Supply	Active	No
455	102	Brule Fm	Public Water Supply	Active	No
456	21	Brule Fm	Public Water Supply	Active	No
457	20	Brule Fm	Public Water Supply	Active	No
458	28	Brule Fm	Public Water Supply	Active	No
459	27	Brule Fm	Public Water Supply	Active	No

TABLE 14
ACTIVE AND ABANDONED WATER SUPPLY WELLS IN THE TCEA AND 2.25-MILE AREA OF REVIEW

PETITION FOR AQUIFER EXEMPTION – THREE CROW EXPANSION AREA
CROW BUTTE RESOURCES - CRAWFORD, NEBRASKA

Well #	Estimated Depth	Formation	Well Use	Well Status	Within TCEA
ABANDONED WELLS					
3	100	Brule Fm	Agricultural	Abandoned	No
0279A	75	Brule Fm	Agricultural	Abandoned	No
AW0285	a	a	Agricultural	Abandoned	No
291	a	a	a	Abandoned	No
292	a	a	a	Abandoned	No
293	a	a	a	Abandoned	No
294	a	a	a	Abandoned	No
295	a	a	a	Abandoned	No
296	a	a	a	Abandoned	No
297	80	Brule Fm	a	Abandoned	**Yes**
299	80	Brule Fm	a	Abandoned	No
318	75	Brule Fm	a	Abandoned	No
325	80	Brule Fm	Domestic	Abandoned	No
365	a	a	Agricultural	Abandoned	No
376	a	a	Agricultural	Abandoned	No
388	a	a	Domestic	Abandoned	No
391	a	a	a	Abandoned	No
392	80	Brule Fm	Agricultural	Abandoned	No
410	90 – 100	Brule Fm	a	Abandoned	**Yes**
411	a	a	a	Abandoned	**Yes**
413	a	a	a	Abandoned	**Yes**
414	a	a	a	Abandoned	No
AW0415	200	Brule Fm	a	Abandoned	No
419	a	a	a	Abandoned	No
420	65	Brule Fm	a	Abandoned	No
0279AW	75	Brule Fm	a	Abandoned	No
G-022460A	100	Brule Fm	Agricultural	Abandoned	No
G-022460B	100	Brule Fm	Agricultural	Abandoned	No
200450	110	Brule Fm	Agricultural	Abandoned	No
200443	100	Brule Fm	Agricultural	Abandoned	No

NOTES:

1) Wells designated as completed in the Brule Formation, in many cases, are also completed in the overlying alluvium.
[a] Unknown
[b] Well used by City of Crawford as a test well for a municipal system

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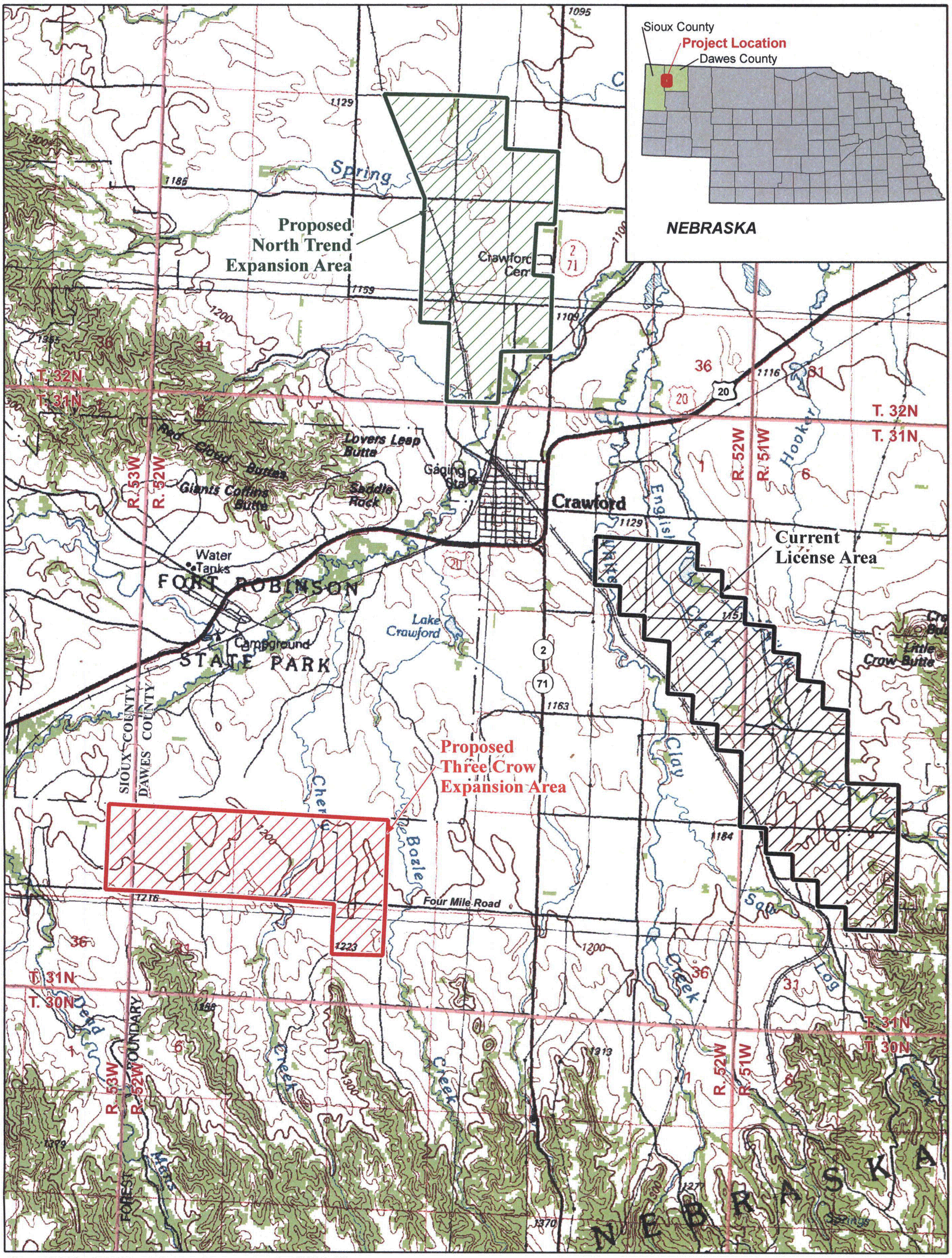
Figures



Source: USGS 1:100,000 scale topographic map - Crawford (1984), NE

LEGEND

- Proposed Three Crow Expansion Area
- Proposed North Trend Expansion Area
- Current License Area

N

W — E

0 4,000 8,000

Scale in Feet

CROW BUTTE RESOURCES, INC.

FIGURE 1
LOCATION MAP, THREE CROW EXPANSION AREA, NORTH TREND EXPANSION AREA AND ORIGINAL CROW BUTTE PROJECT AREA

PROJECT: CO001396.00003 MAPPED BY: JC CHECKED BY: MS

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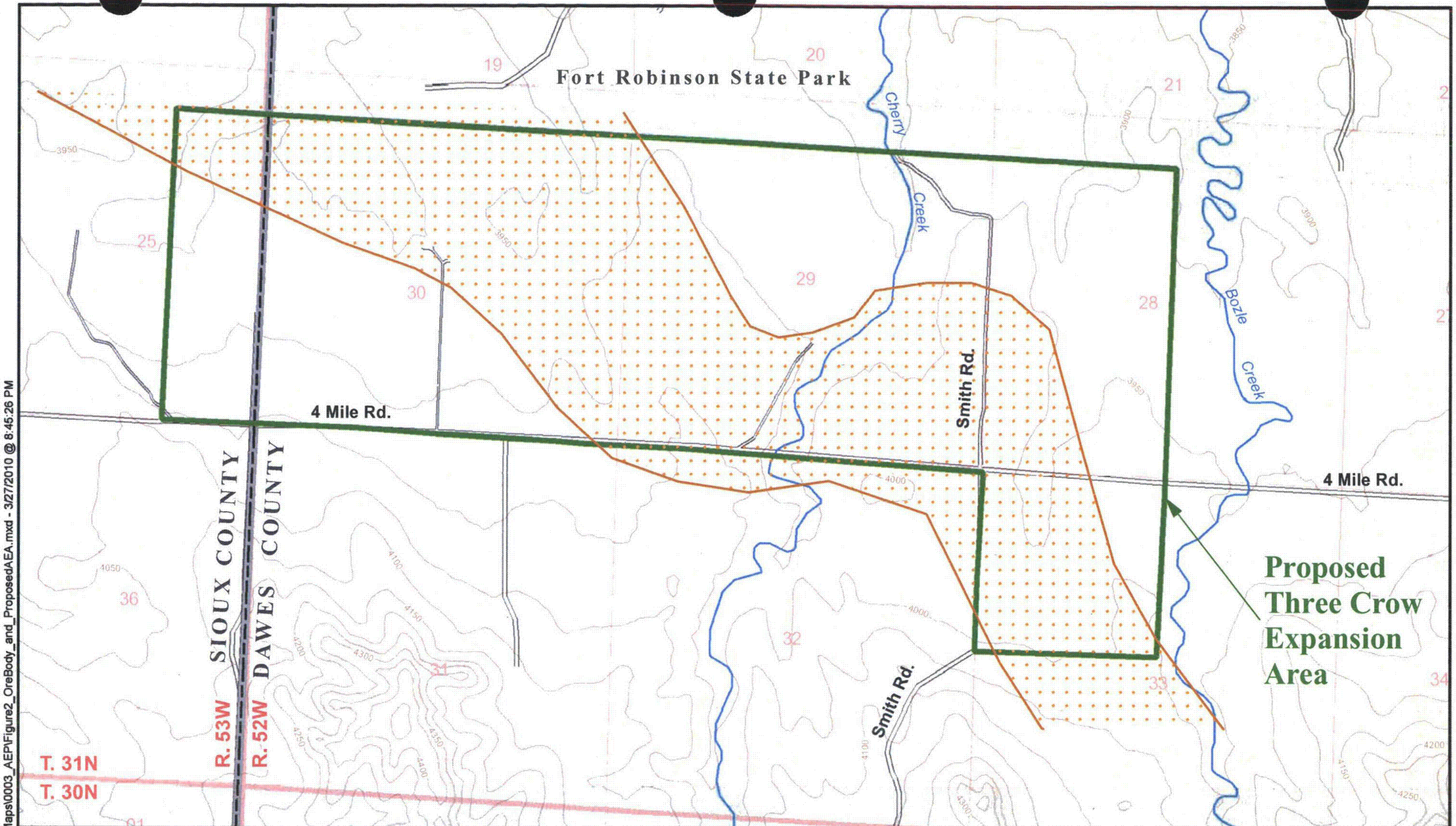

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LEGEND

- General Ore Trend
- Proposed Aquifer Exemption Boundary
- River/Creek
- County Boundary
- Elevation Contour (10-Ft Interval)
- Road

0 1,000 2,000
Scale in Feet

PROJECTION:
NAD 1927, STATE PLANE
NEBRASKA NORTH FIPS 2601

ALL ELEVATIONS ARE IN FT-AMSL

N
W E

CROW BUTTE RESOURCES, INC.

FIGURE 2
THREE CROW EXPANSION AREA ORE BODY AND PROPOSED AQUIFER EXEMPTION AREA

PROJECT: CO001396.00003 | MAPPED BY: JC | CHECKED BY: MS

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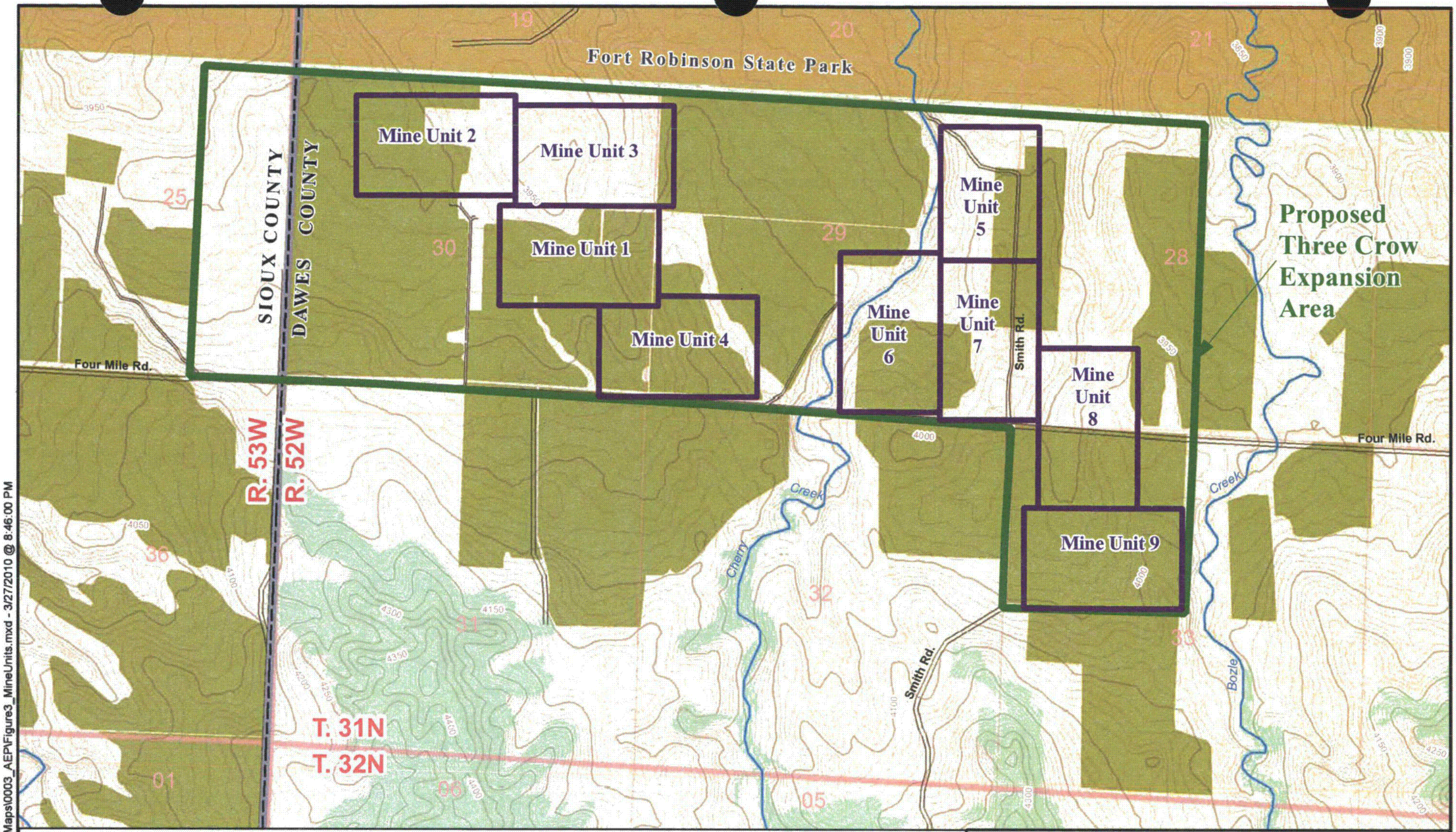

LEGEND

- Mine Unit Boundary
- Proposed Three Crow Expansion Area
- Fort Robinson State Park
- River/Creek
- County Boundary
- Elevation Contour (10-Ft Interval)
- Road

Land Use

- Cropland
- Forested Land
- Rangeland
- Recreational Land

0 1,000 2,000
Scale in Feet

PROJECTION:
NAD 1927, STATE PLANE
NEBRASKA NORTH FIPS 2601

N
W E

CROW BUTTE RESOURCES, INC.

FIGURE 3
THREE CROW EXPANSION AREA
PROPOSED MINE UNITS

PROJECT: CO001396.00003 MAPPED BY: JC CHECKED BY: JEC

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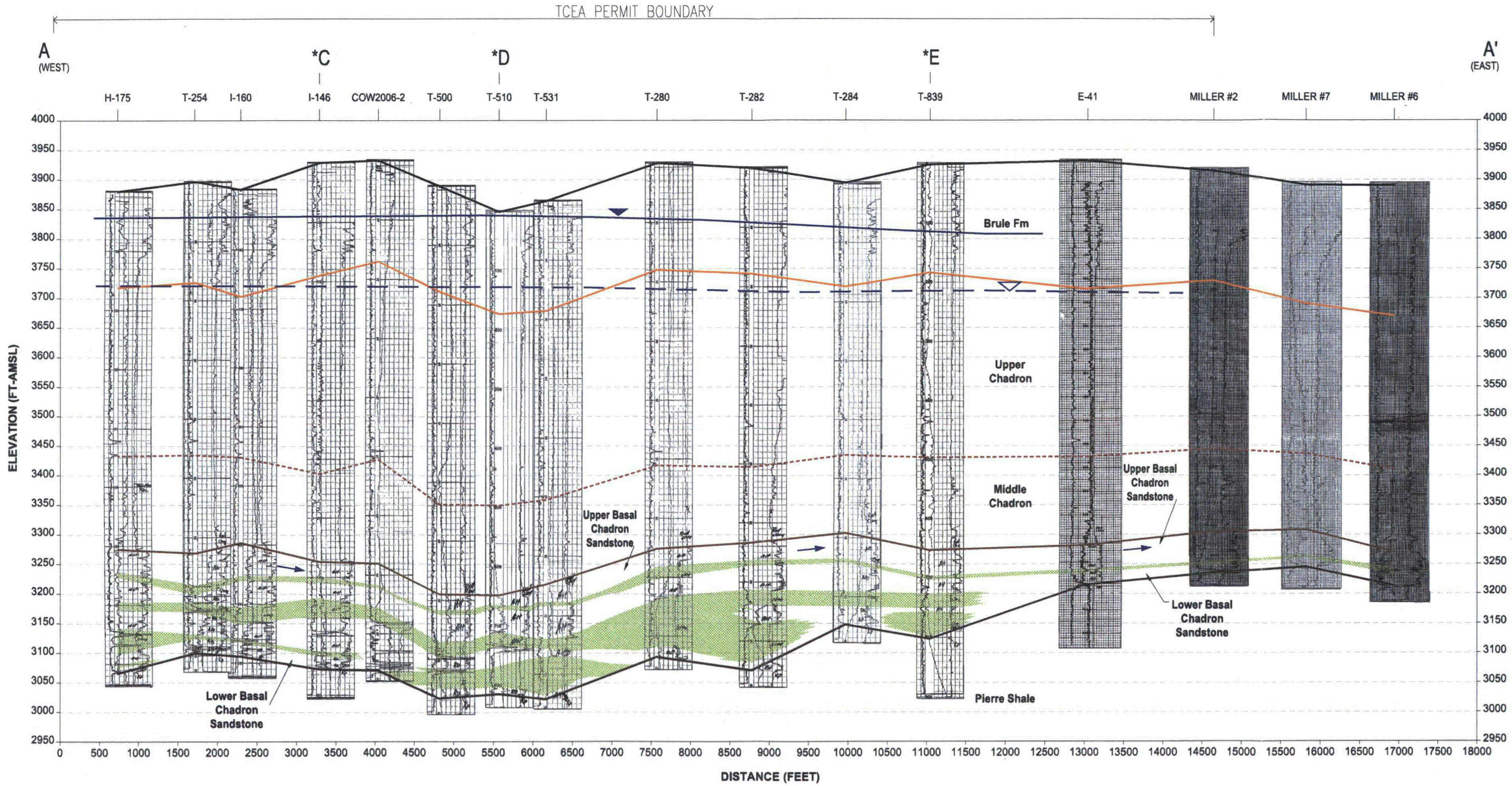
THIS PAGE IS AN OVERSIZED DRAWING OR FIGURE,

THAT CAN BE VIEWED AT THE RECORD TITLED:

**"FIGURE 4
THREE CROW
CROSS-SECTION LOCATION
MAP"**

**WITHIN THIS PACKAGE...OR
BY SEARCHING USING THE
DOCUMENT/REPORT NO.**

D-01



Notes:

1) Geologic units that underlie the Pierre Shale are not shown.

2) For locations where the Upper/Middle Chadron Fm was not observed in e-logs, the contact between the Upper Chadron Fm and the Middle Chadron Fm was extrapolated based on known occurrence, and is shown as dashed lines.

* Letter indicates location of intersecting cross-section lines shown on Figure 4.

Legend:

- Topographic Surface
- Top of Upper Chadron
- Top of Middle Chadron
- Top of Basal Chadron Sandstone
- Interbedded Clay
- Top of Pierre Shale
- Water Table (Brule Fm) - 1/22/10 & 2/08/10
- Potentiometric Surface (Basal Chadron Sandstone) - 1/22/10
- Groundwater Flow Direction

0 100' 200' VERTICAL GRAPHIC SCALE

0 750' 1,500' HORIZONTAL GRAPHIC SCALE

CROW BUTTE RESOURCES, INC.

FIGURE 5a
THREE CROW STRUCTURAL CROSS-SECTION: A-A'

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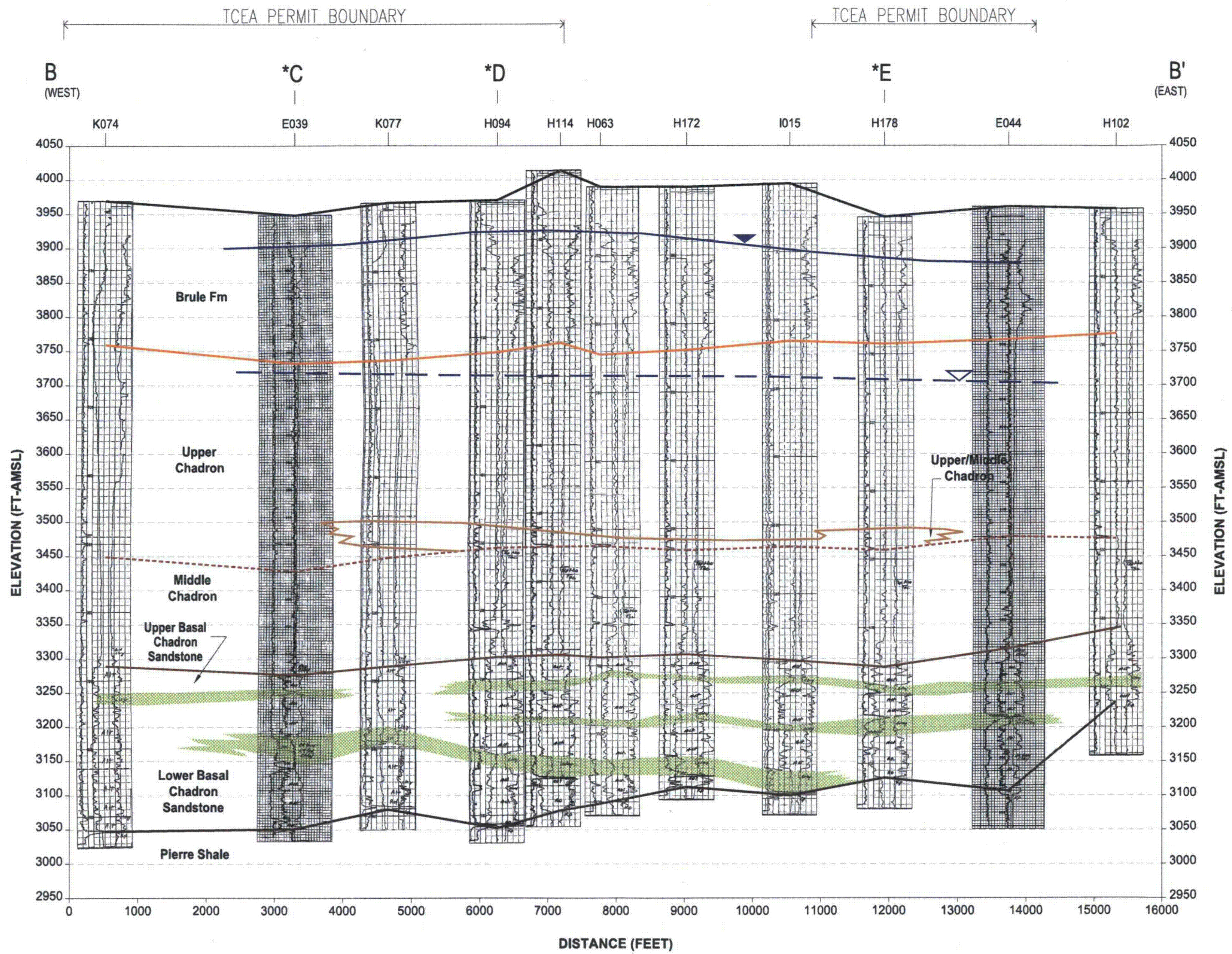

Notes:

1) Geologic units that underlie the Pierre Shale are not shown.

2) For locations where the Upper/Middle Chadron Fm was not observed in e-logs, the contact between the Upper Chadron Fm and the Middle Chadron Fm was extrapolated based on known occurrence, and is shown as dashed lines.

* Letter indicates location of intersecting cross-section lines shown on Figure 4.

Legend:

- Topographic Surface
- Top of Upper Chadron
- Top of Upper/Middle Chadron
- Top of Middle Chadron
- Top of Basal Chadron Sandstone
- Interbedded Clay
- Top of Pierre Shale
- Water Table (Brule Fm) - 1/22/10
- Potentiometric Surface (Basal Chadron Sandstone) - 1/22/10 & 2/08/10
- Groundwater Flow Direction

0 100' 200'
VERTICAL GRAPHIC SCALE

0 1,000' 2,000'
HORIZONTAL GRAPHIC SCALE

CROW BUTTE RESOURCES, INC.

FIGURE 5b
THREE CROW STRUCTURAL CROSS-SECTION: B-B'

PROJECT: CO001396 | MAPPED BY: JC | CHECKED BY: MS

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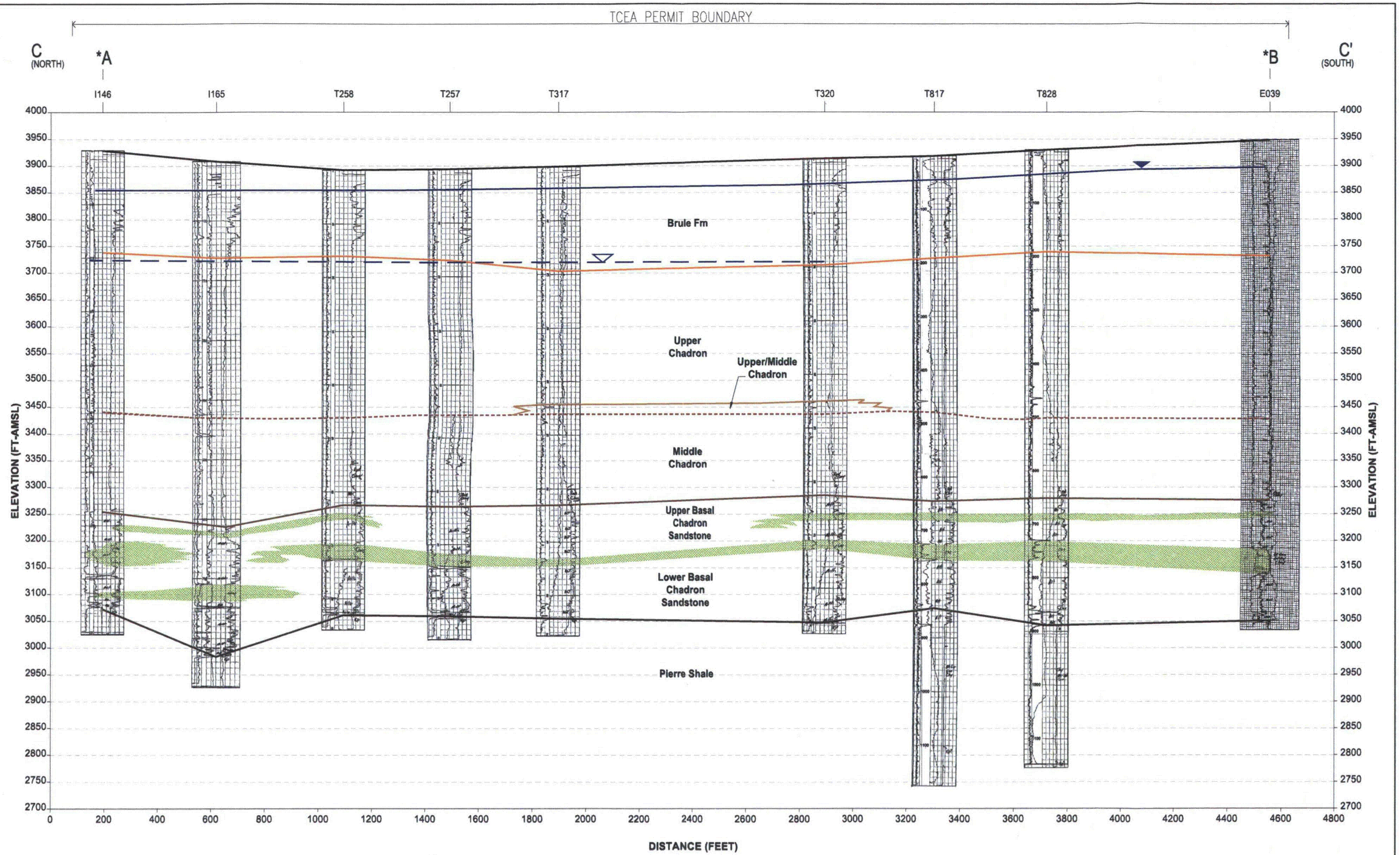

Notes:

1) Geologic units that underlie the Pierre Shale are not shown.

2) For locations where the Upper/Middle Chadron Fm was not observed in e-logs, the contact between the Upper Chadron Fm and the Middle Chadron Fm was extrapolated based on known occurrence, and is shown as dashed lines.

* Letter indicates location of intersecting cross-section lines shown on Figure 4.

Legend:

- Topographic Surface
- Top of Upper Chadron
- Top of Upper/Middle Chadron
- Top of Middle Chadron
- Top of Basal Chadron Sandstone
- Interbedded Clay
- Top of Pierre Shale
- Water Table (Brule Fm) - 1/22/10
- Potentiometric Surface (Basal Chadron Sandstone) - 1/22/10 & 2/08/10

0 100' 200' VERTICAL GRAPHIC SCALE

0 200' 400' HORIZONTAL GRAPHIC SCALE

CROW BUTTE RESOURCES, INC.

FIGURE 5c

THREE CROW STRUCTURAL CROSS-SECTION: C-C'

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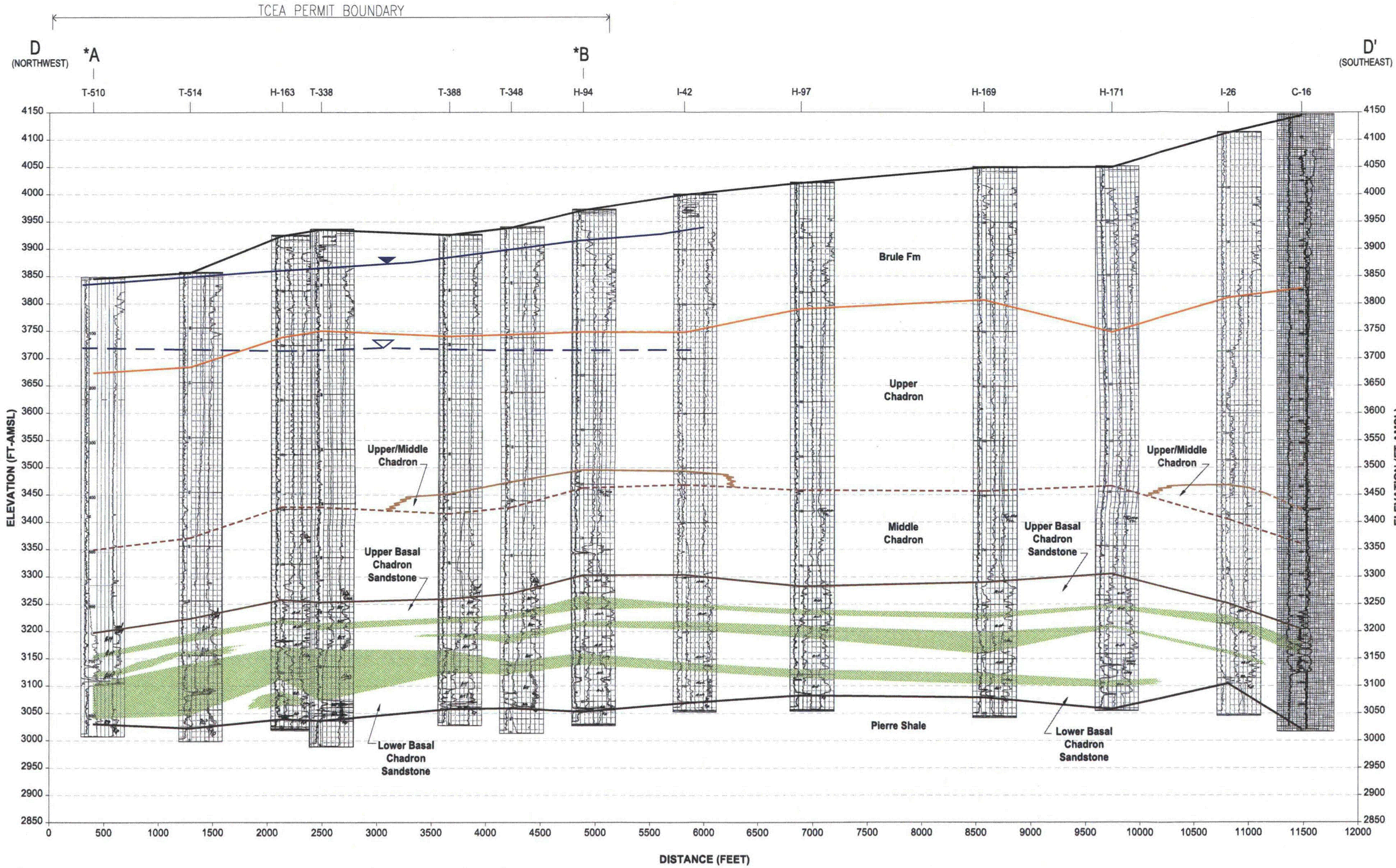

Notes:

1) Geologic units that underlie the Pierre Shale are not shown.

2) For locations where the Upper/Middle Chadron Fm was not observed in e-logs, the contact between the Upper Chadron Fm and the Middle Chadron Fm was extrapolated based on known occurrence, and is shown as dashed lines.

* Letter indicates location of intersecting cross-section lines shown on Figure 4.

Legend:

- Topographic Surface
- Top of Upper Chadron
- Top of Upper/Middle Chadron
- Top of Middle Chadron
- Top of Basal Chadron Sandstone
- Interbedded Clay
- Top of Pierre Shale
- Water Table (Brule Fm) - 1/22/10 & 2/08/10
- Potentiometric Surface (Basal Chadron Sandstone) - 1/22/10
- Groundwater Flow Direction

0 100' 200'
VERTICAL GRAPHIC SCALE

0 500' 1,000'
HORIZONTAL GRAPHIC SCALE

CROW BUTTE RESOURCES, INC.

FIGURE 5d
THREE CROW STRUCTURAL CROSS-SECTION: D-D'

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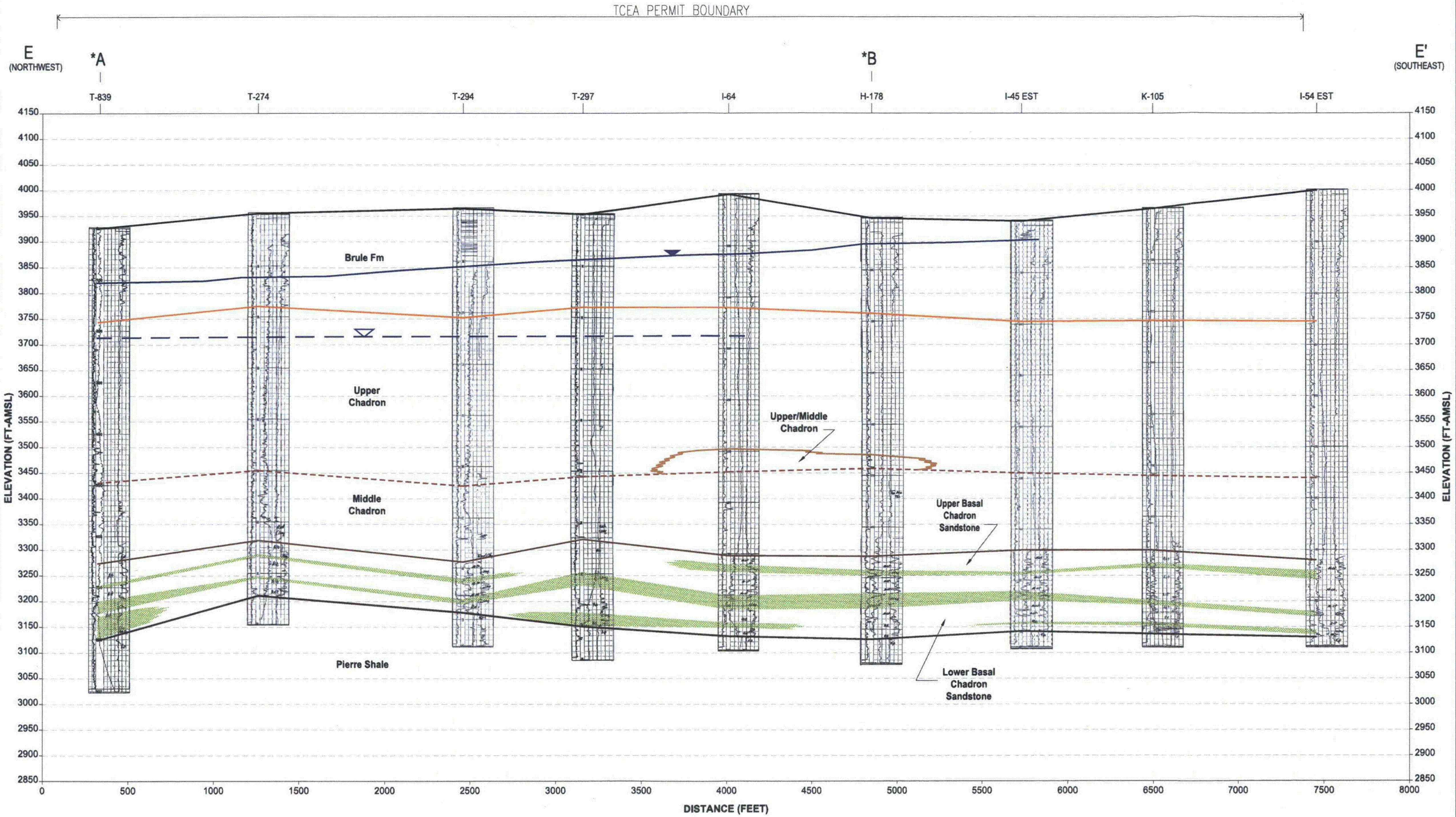

Notes:

1) Geologic units that underlie the Pierre Shale are not shown.

2) For locations where the Upper/Middle Chadron Fm was not observed in e-logs, the contact between the Upper Chadron Fm and the Middle Chadron Fm was extrapolated based on known occurrence, and is shown as dashed lines.

* Letter indicates location of intersecting cross-section lines shown on Figure 4.

Legend:

- Topographic Surface
- Top of Upper Chadron
- Top of Upper/Middle Chadron
- Top of Middle Chadron
- Top of Basal Chadron Sandstone
- Interbedded Clay
- Top of Pierre Shale
- Water Table (Brule Fm) - 1/22/10
- Potentiometric Surface (Basal Chadron Sandstone) - 1/22/10 & 2/08/10

0 100' 200'
VERTICAL GRAPHIC SCALE

0 500' 1,000'
HORIZONTAL GRAPHIC SCALE

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FIGURE 5e
THREE CROW STRUCTURAL CROSS-SECTION: E-E'

PROJECT: CO001396 | MAPPED BY: JC | CHECKED BY: MS

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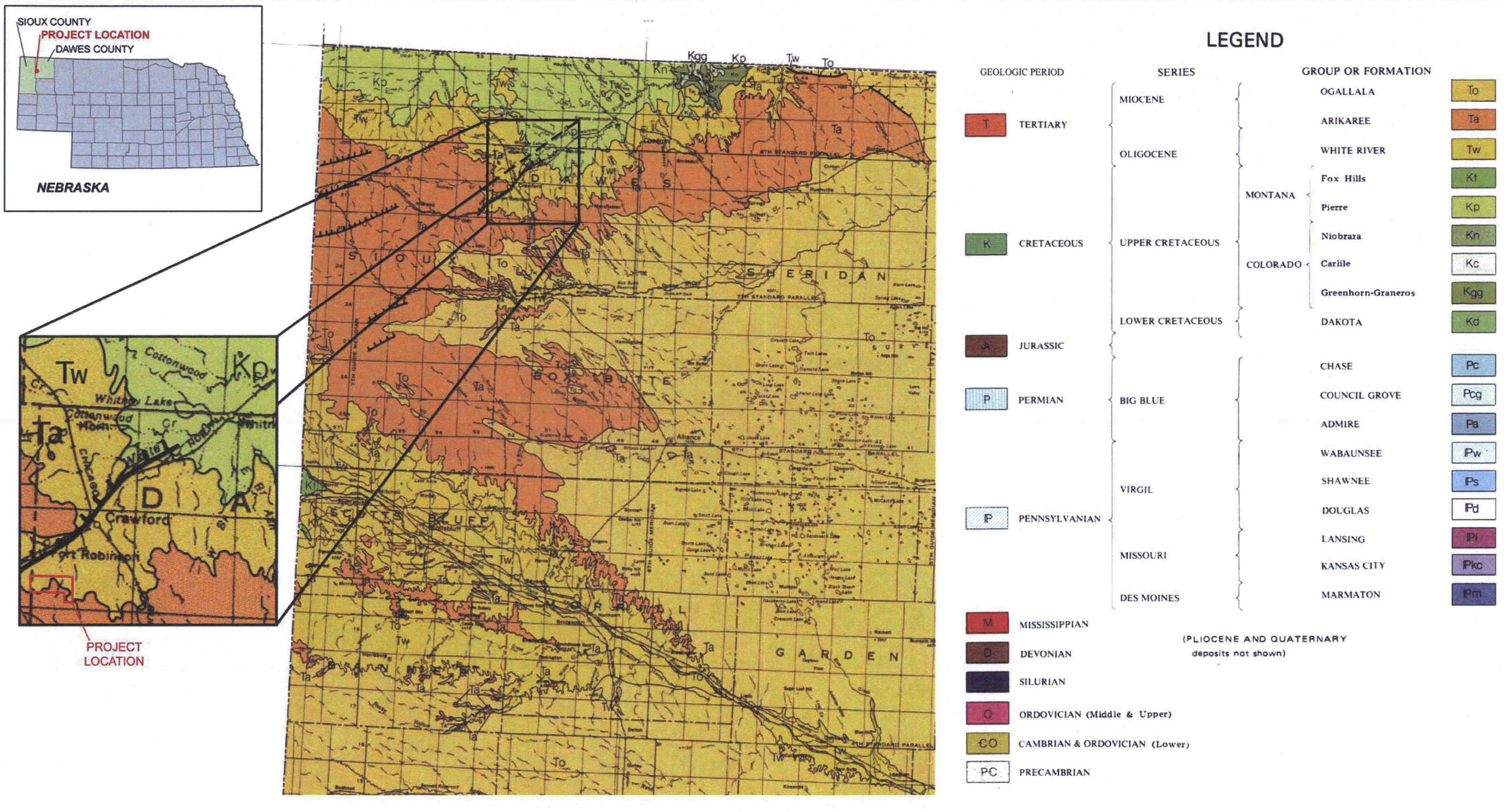
PATH: K:\CBR_Projects\CO001396_ThreeCrow\1_ACAD\e-transmit\XS_EE.dwg LAYOUT: AE SAVED DATE/TIME: 3/24/2010 5:03 PM



Source: Nebraska Geological Survey

CROW BUTTE RESOURCES, INC.

FIGURE 6
BEDROCK GEOLOGY OF THE THREE CROW EXPANSION AREA

PROJECT: CO001396.00001 MAPPED BY: JC CHECKED BY: MS

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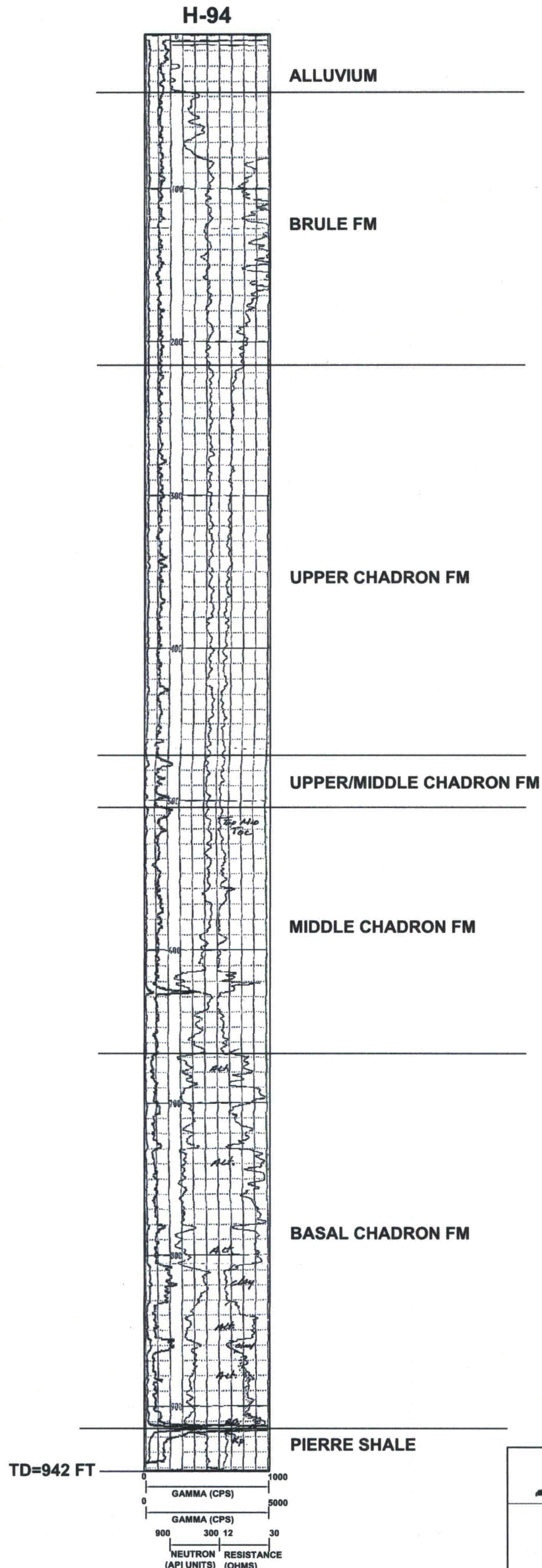

NOTE:

1). E-LOGS NEWER THAN 1990 USE SP RATHER THAN NUETRON LOGGING.

CROW BUTTE RESOURCES, INC.

FIGURE 7
THREE CROW EXPANSION AREA
TYPE LOG (H-94)

PROJECT: CO001396 | MAPPED BY: JC | CHECKED BY: MS

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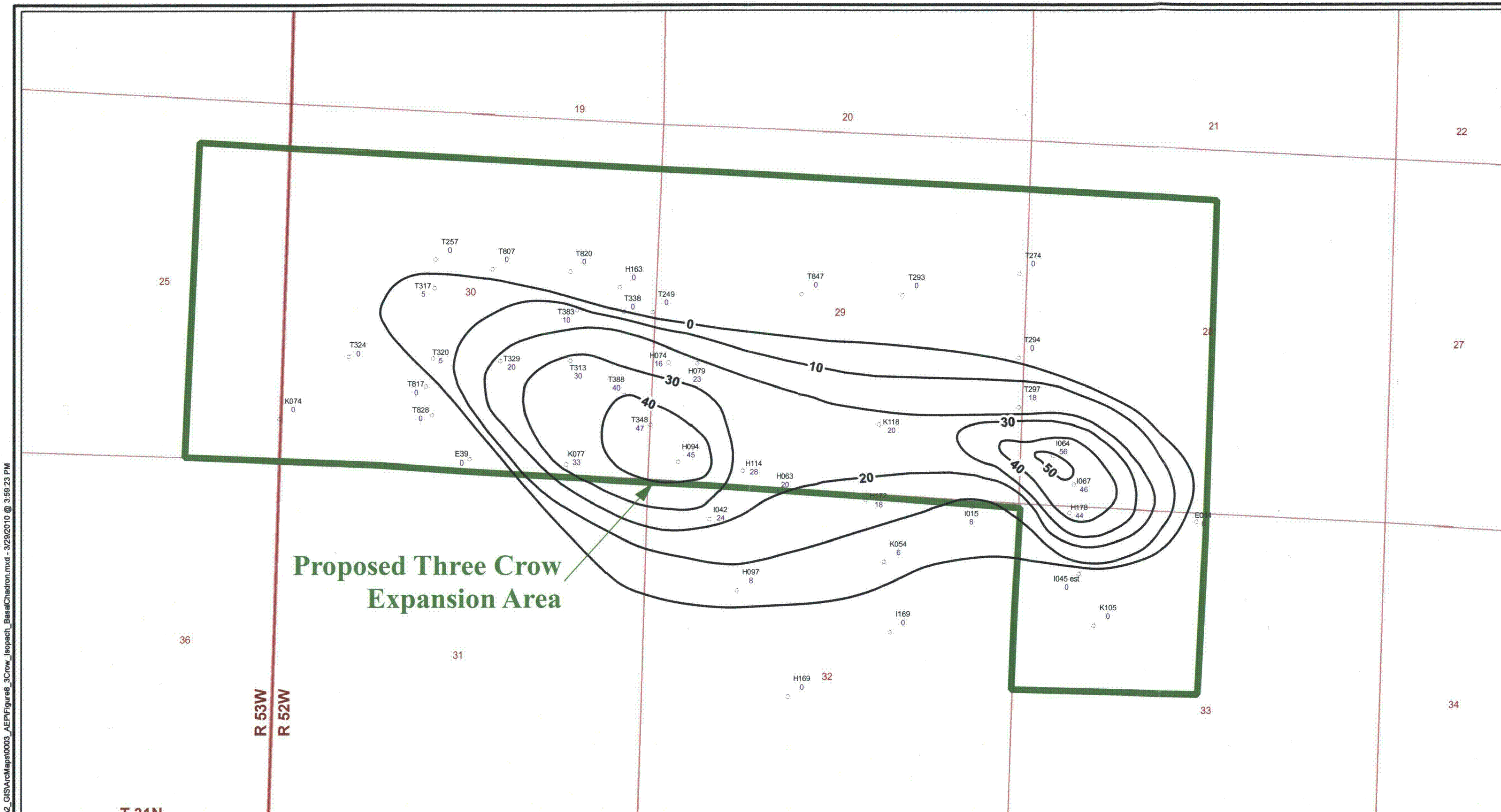
PATH: K:\CBR_Projects\CO001396_ThreeCrow\1_ACAD\e-transmit\TypeLog.dwg LAYOUT: AEP_Fig7 SAVED DATE/TIME: 3/29/2010 11:33 AM



LEGEND

- Exploration Borehole
- Isopach Contour (Feet)
- Proposed Three Crow Expansion Area

T828 — Borehole/Well ID
238 — Unit Thickness (Feet)

0 1,000 2,000
Scale in Feet

PROJECTION:
NAD 1927, STATE PLANE
NEBRASKA NORTH FIPS 2601

N W E

CROW BUTTE RESOURCES, INC.

FIGURE 8
THREE CROW ISOPACH MAP - UPPER/MIDDLE CHADRON

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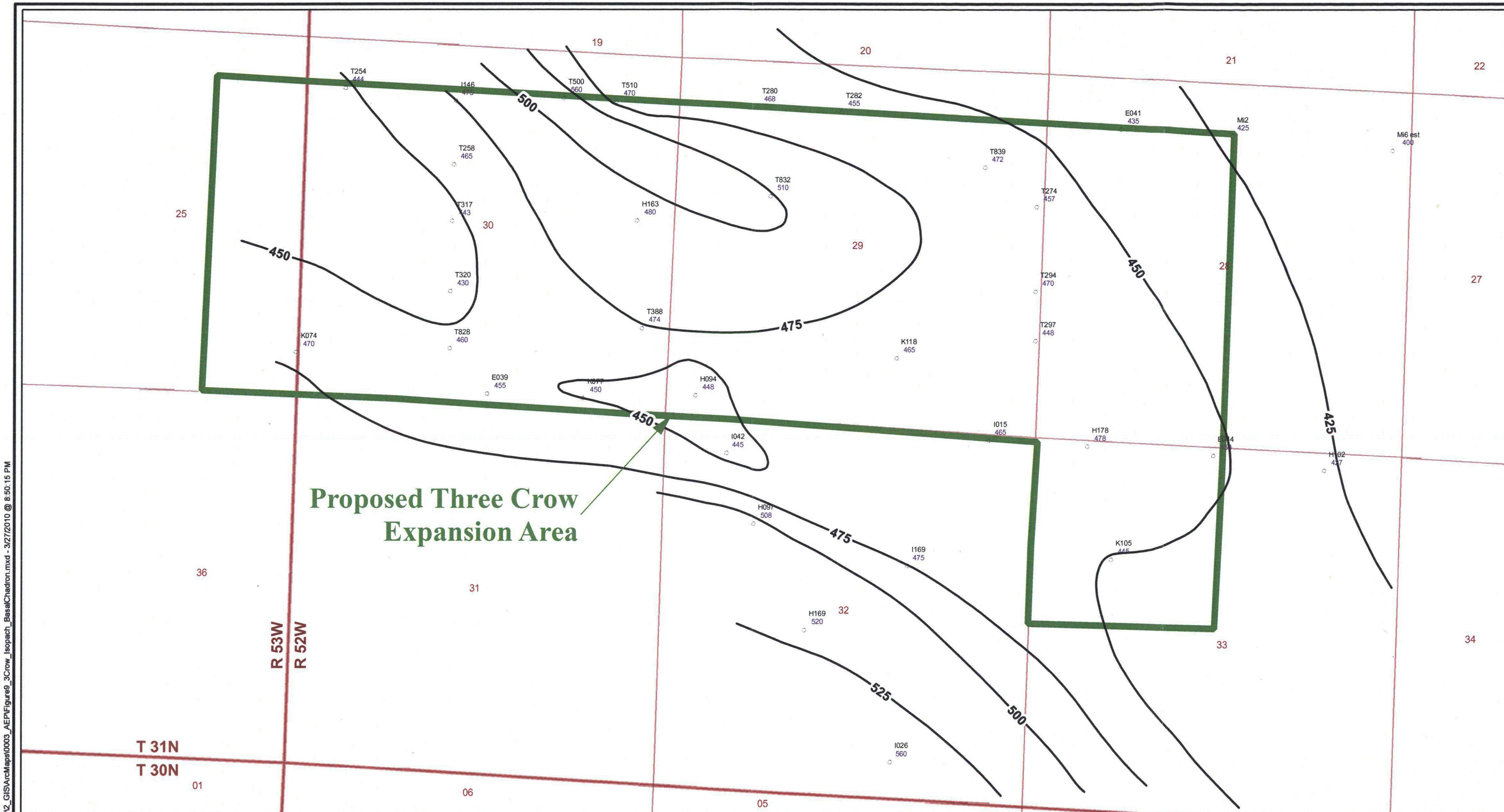
K:\CBR_Projects\CO001396_ThreeCrow2_GIS\ArcMaps\0003_AEP\Figure8_3Crow_Isopach_BasalChadron.mxd - 3/29/2010 @ 3:59:23 PM



K:\CBR_Projects\CO001396_ThreeCrow\2_GIS\ArcMaps\0003_AEP\Figure9_3Crow_Isopach_BasalChadron.mxd - 3/27/2010 @ 8:50:15 PM

LEGEND

- ◦ Exploration Borehole
- Thickness Contour (Upper Confining Zone)
- Proposed Three Crow Expansion Area

T828 ← Borehole/Well ID
238 ← Unit Thickness (Feet)

Note: 1) The upper confining zone represents the interval between the base of the Brule Formation and the top of the underlying Basal Chadron Sandstone.

0 — 1,000 — 2,000
Scale in Feet

PROJECTION: NAD 1927, STATE PLANE NEBRASKA NORTH FIPS 2601

N / W / E

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FIGURE 9
THREE CROW ISOPACH MAP - UPPER CONFINING ZONE

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LEGEND

- Exploration Borehole
- Isopach Contour (Feet)
- Proposed Three Crow Expansion Area

T828 ← Borehole/Well ID
238 ← Unit Thickness (Feet)

0 1,000 2,000
Scale in Feet

PROJECTION:
NAD 1927, STATE PLANE
NEBRASKA NORTH FIPS 2601

N
W E

CROW BUTTE RESOURCES, INC.

FIGURE 10
THREE CROW ISOPACH MAP -
UPPER AND LOWER BASAL CHADRON SANDSTONE

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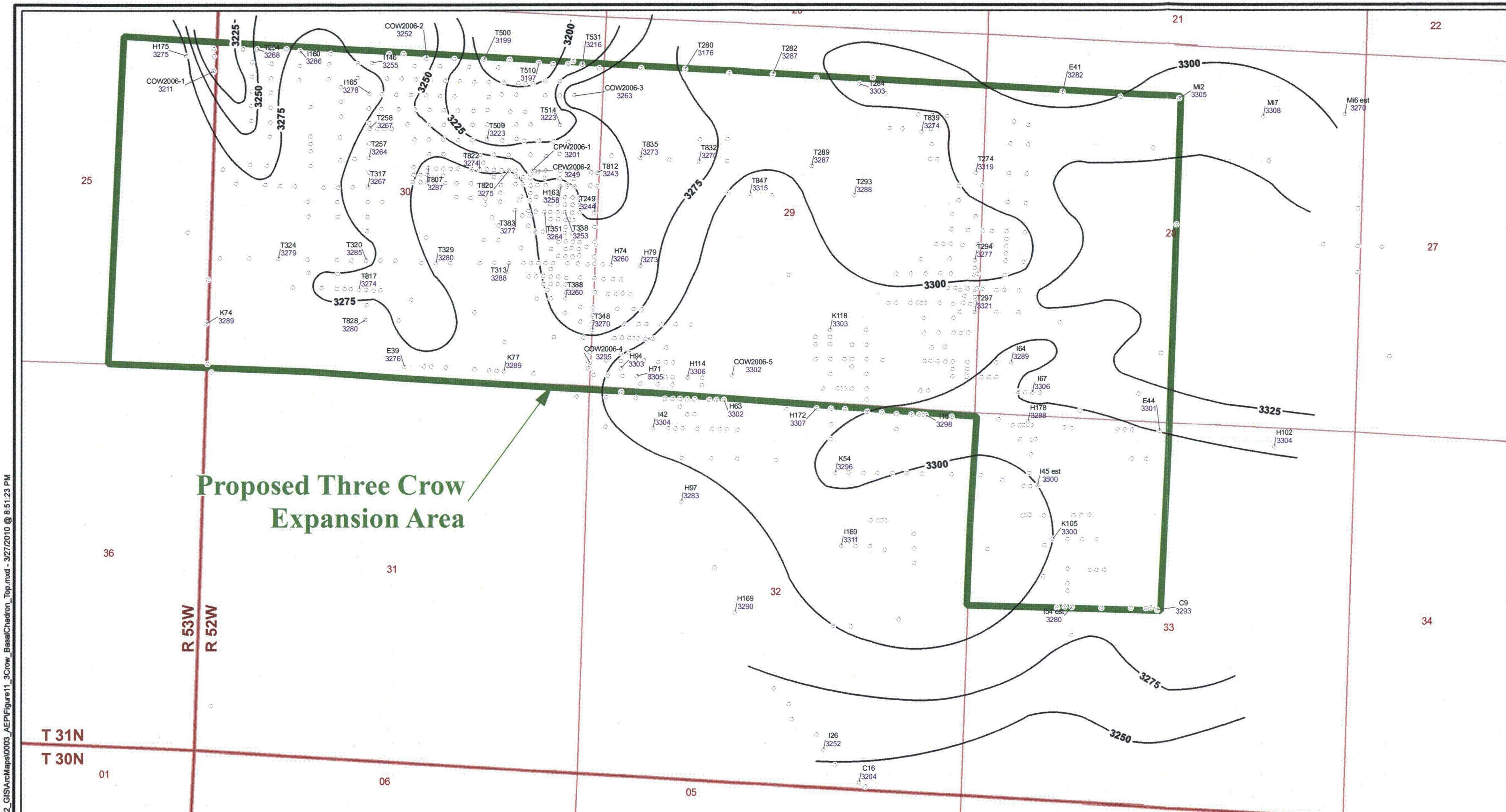

LEGEND

- ◦ Exploration Borehole
- —— Top of Basal Chadron Contour (FT-AMSL)
- ▭ Proposed Three Crow Expansion Area

T329 ↙ Borehole/Well ID

3280 ← Top of Basal Chadron (FT-AMSL)

0 1,000 2,000

Scale in Feet

PROJECTION:
NAD 1927, STATE PLANE
NEBRASKA NORTH FIPS 2601

N / W — E

CROW BUTTE RESOURCES, INC.

FIGURE 11
THREE CROW STRUCTURE CONTOUR MAP
TOP OF BASAL CHADRON SANDSTONE

PROJECT: CO001396.0003	MAPPED BY: JC	CHECKED BY: MS

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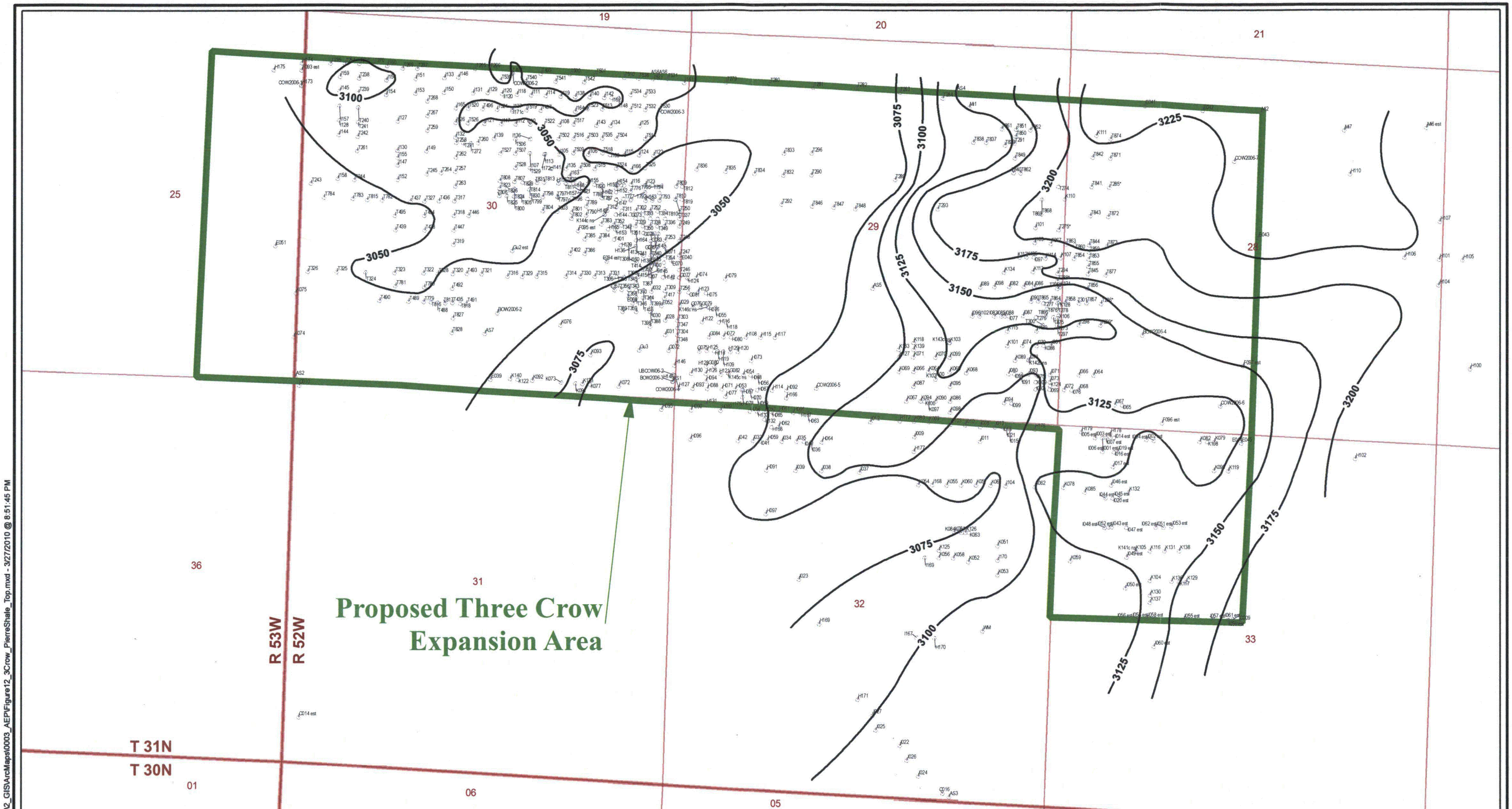

LEGEND

- Exploration Borehole
- Groundwater Potentiometric Surface (FT-AMSL)
- Proposed Three Crow Expansion Area

0 1,000 2,000
Scale in Feet

PROJECTION:
NAD 1927, STATE PLANE
NEBRASKA NORTH FIPS 2601

N W E

CROW BUTTE RESOURCES, INC.

FIGURE 12
THREE CROW STRUCTURE CONTOUR MAP - TOP OF PIERRE SHALE

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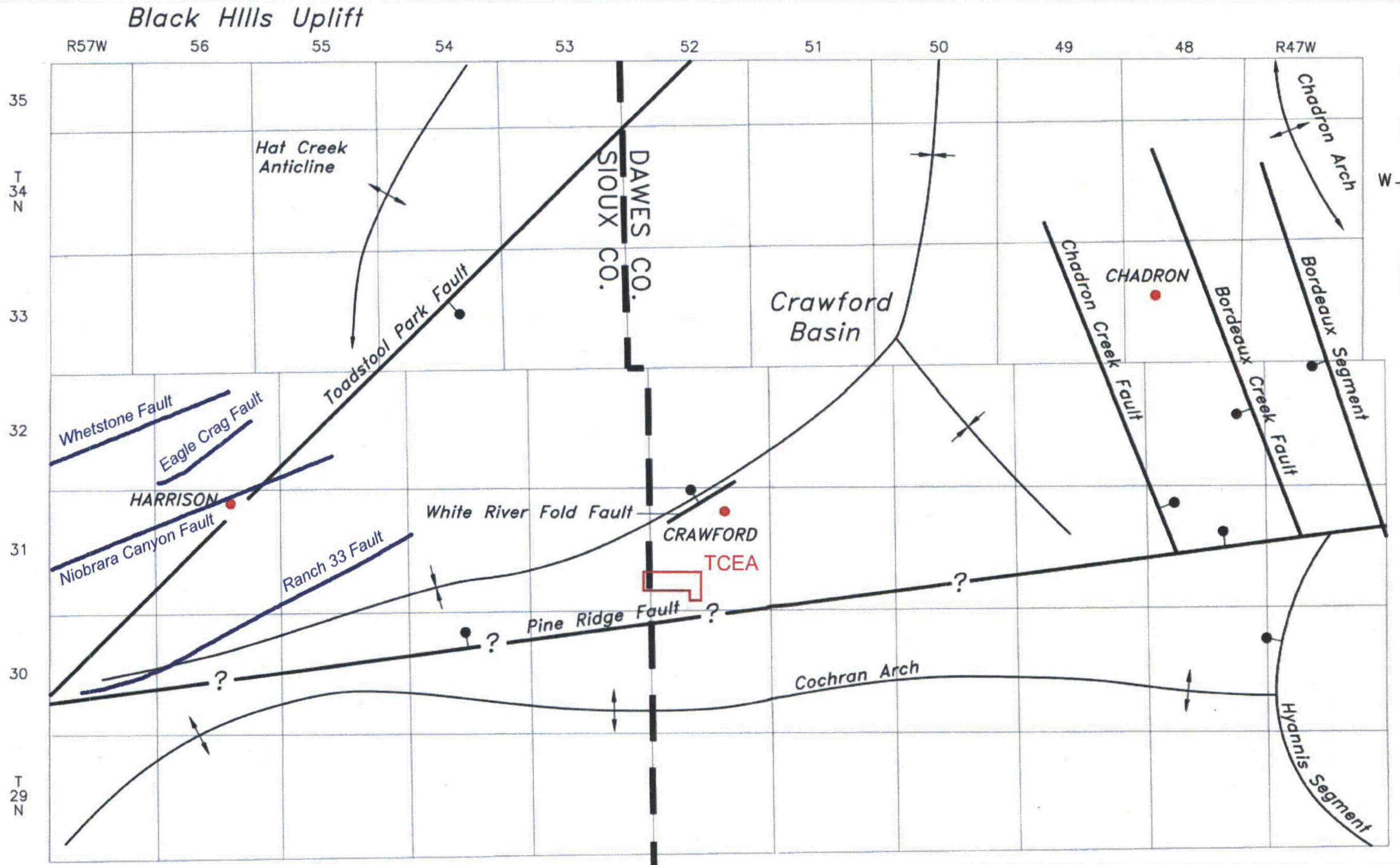
K:\CBR_Projects\CO001396_ThreeCrow\2_GIS\ArcMaps\0003_AEP\Figure12_3Crow_PierreShale_Top.mxd - 3/27/2010 @ 8:51:45 PM



LEGEND

Fault (Ball on downthrown side)

Anticline

Syncline

Proposed Three Crow Expansion Area (TCEA)

Fault interpretations by Hunt (1990)

0 5 10

SCALE IN MILES

Modified from DeGraw, 1969;
WFC-White River Fault only (Collings & Knode, 1984)

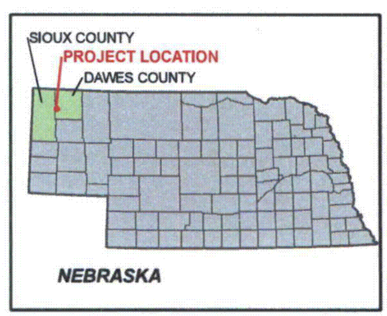


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FIGURE 13
REGIONAL STRUCTURAL FEATURES MAP
NORTHERN NEBRASKA

PROJECT: CO001396.00003 MAPPED BY: JC CHECKED BY: MS

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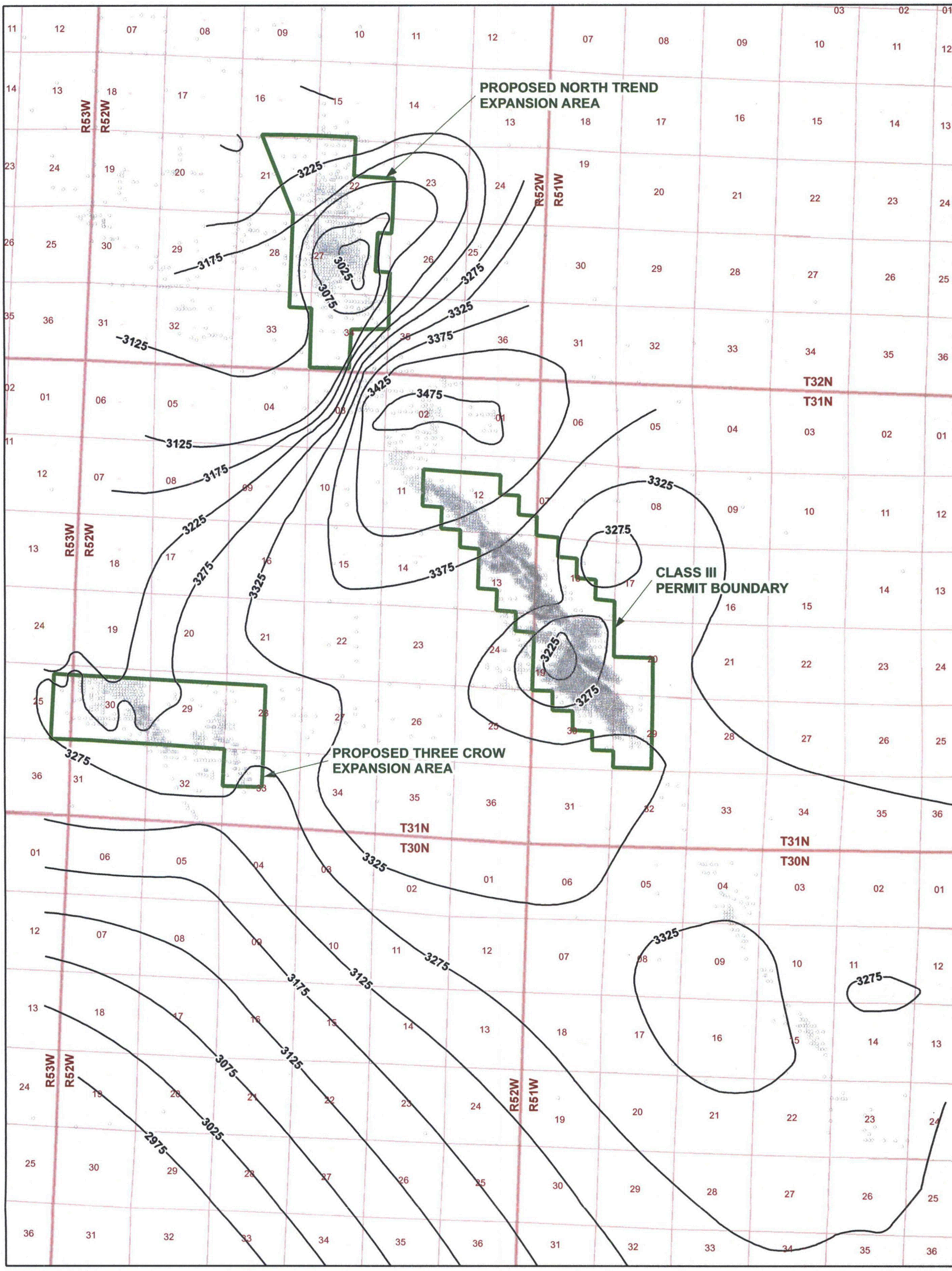

LEGEND

- Exploration Borehole
- Structural Contours (FT-AMSL)

N
W E

0 5,000 10,000

Scale in Feet

PROJECTION: NAD 1927, STATE PLANE NEBRASKA NORTH FIPS 2601

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FIGURE 14
REGIONAL STRUCTURE CONTOUR MAP - TOP OF BASAL CHADRON SANDSTONE

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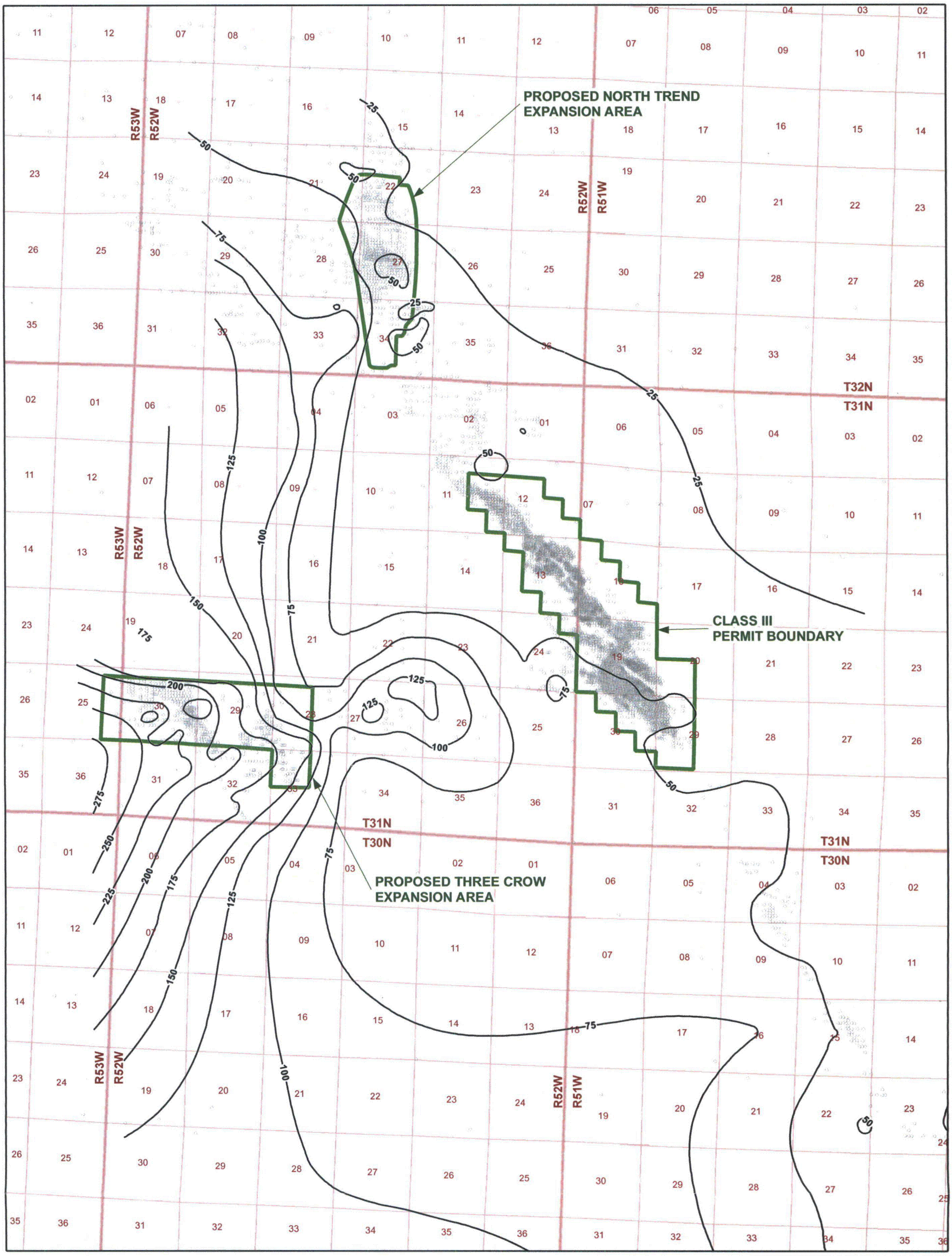
K:\CBR_Projects\CO001396_ThreeCrow2_GIS\ArcMaps\0003_AEP\Figure14_Regional_Structure_Contour_Map_Top_of_BasalChadron.mxd - 3/27/2010 @ 8:55:14 PM



LEGEND

- Unit Thickness (Feet)
- Exploration Borehole

N
W — E

0 5,000 10,000
Scale in Feet

PROJECTION: NAD 1927, STATE PLANE NEBRASKA NORTH FIPS 2601

CROW BUTTE RESOURCES, INC.

FIGURE 15
REGIONAL ISOPACH MAP -
BASAL CHADRON SANDSTONE

PROJECT: CO001396.0003	MAPPED BY: JC	CHECKED BY: MS

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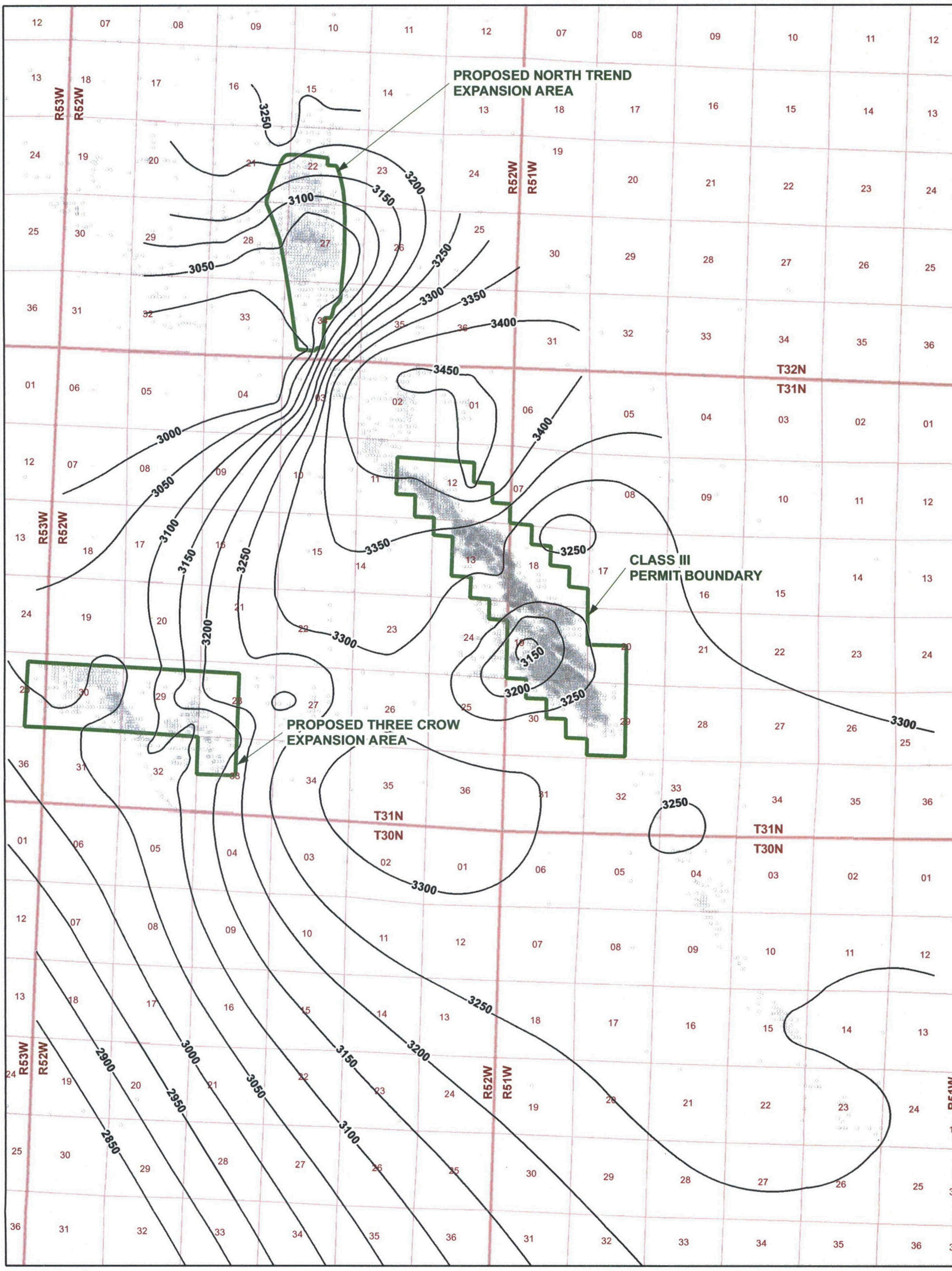

LEGEND

Elevation Contour (FT-AMSL)

Exploration Borehole

N
W E

0 5,000 10,000
Scale in Feet

PROJECTION: NAD 1927, STATE PLANE NEBRASKA NORTH FIPS 2601

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FIGURE 16
REGIONAL STRUCTURE CONTOUR MAP - TOP OF PIERRE SHALE

PROJECT: CO001396.0003 MAPPED BY: JC CHECKED BY: MS

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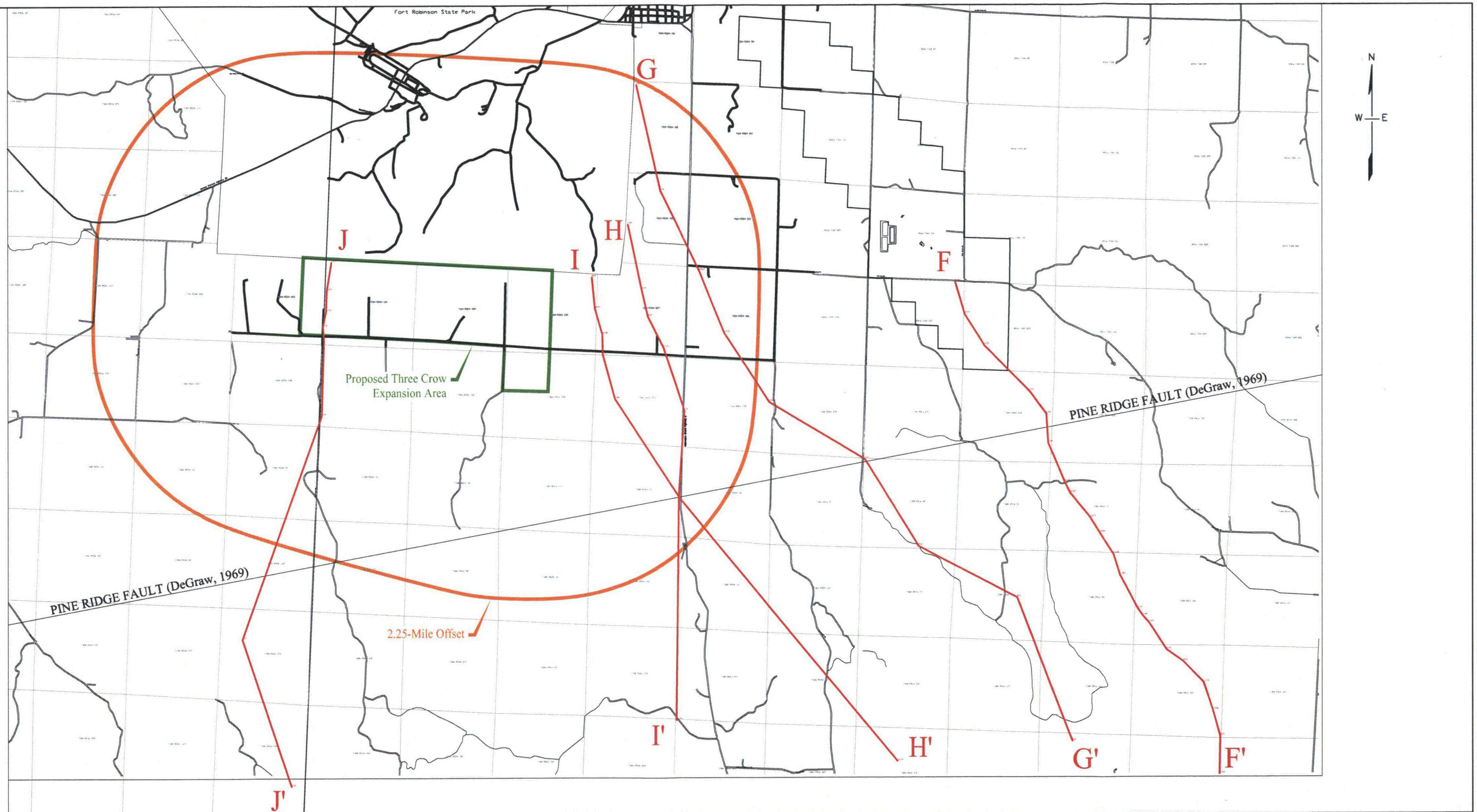

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FIGURE 17
THREE CROW SECTION LOCATION MAP

PROJECT: CO001396 MAPPED BY: JC CHECKED BY: MS

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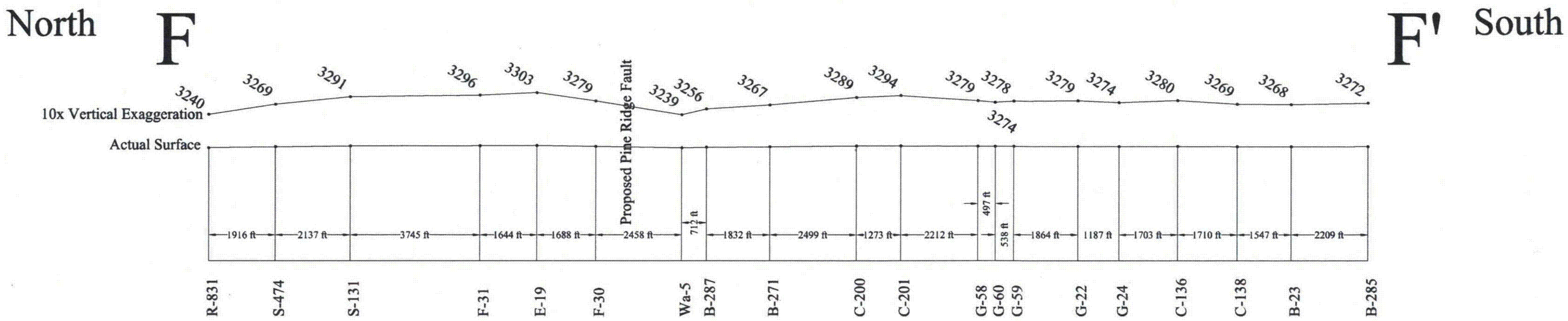
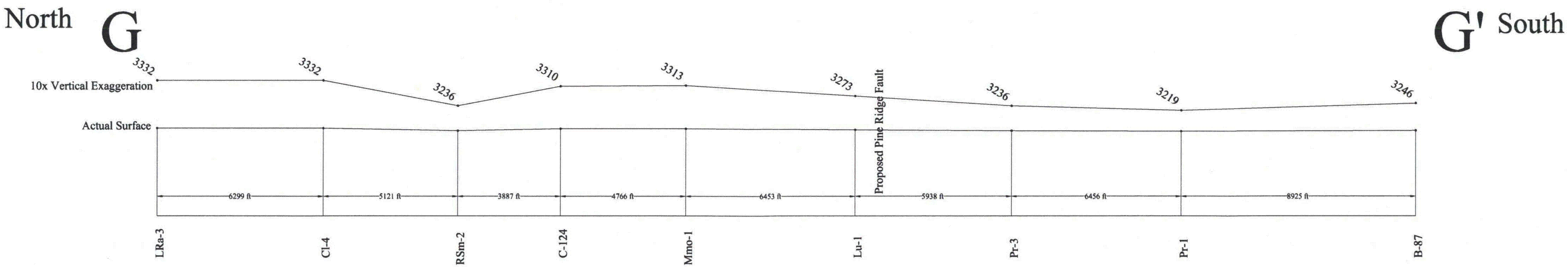
PATH: K:\CBR_Projects\...396_ThreeCrow\1_ACAD\e-transmit\Hydro-XS.dwg LAYOUT: 3 SAVED DATE/TIME: 3/27/2010 9:57 PM





2000 0 2000 4000 6000 8000 Feet

CROW BUTTE RESOURCES, INC.

FIGURE 18

THREE CROW STRUCTURAL CROSS-SECTIONS F-F' AND G-G' (TOP OF PIERRE SHALE)

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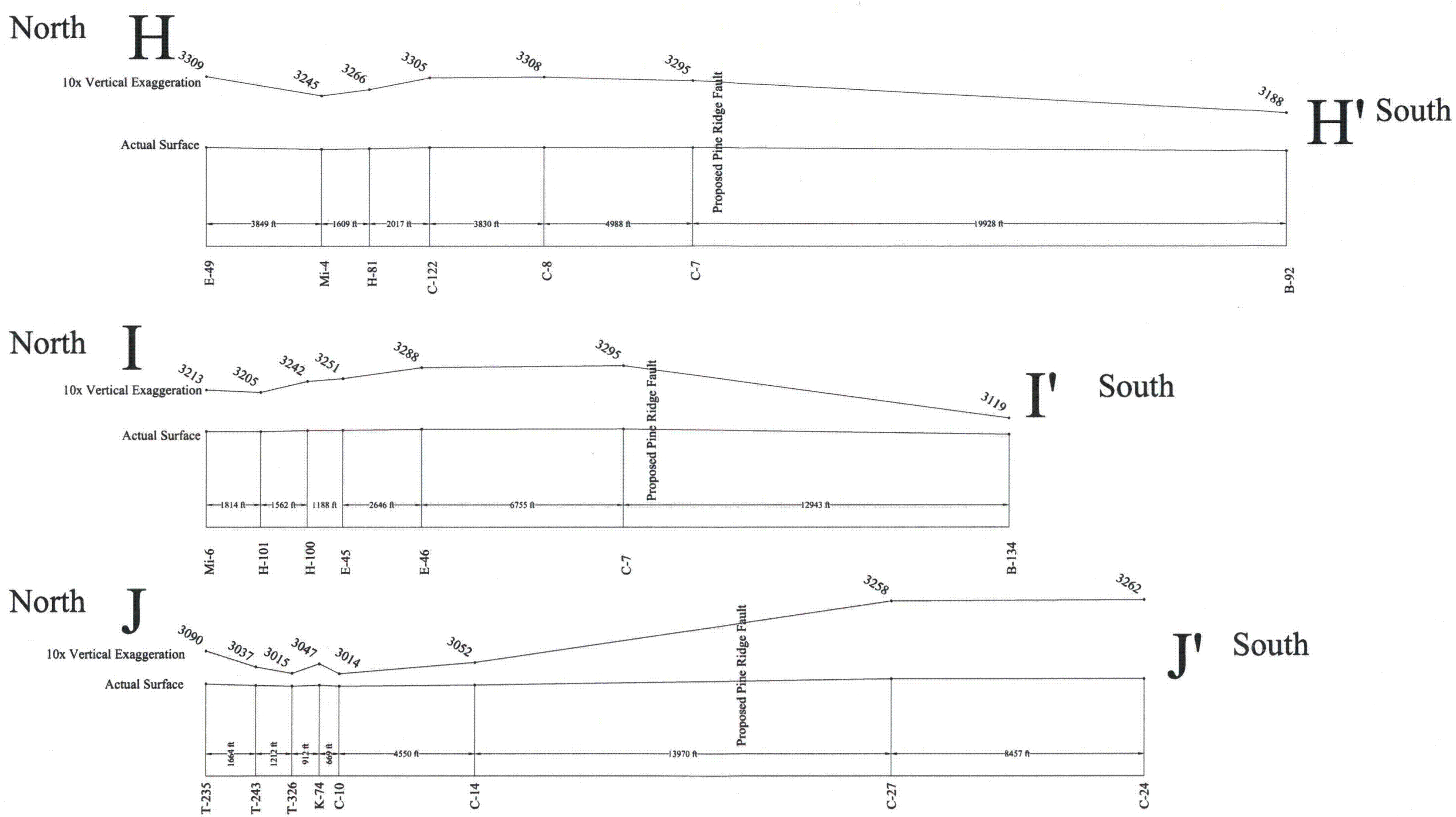
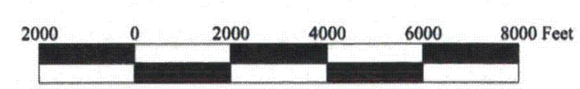
PATH: C:\working\3CROW\Hydro-XS.dwg LAYOUT: 1 SAVED DATE/TIME: 2/22/2010 12:29 PM





CROW BUTTE RESOURCES, INC.

FIGURE 19

THREE CROW STRUCTURAL CROSS-SECTIONS H-H', I-I', AND J-J' (TOP OF PIERRE SHALE)

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PATH: C:\working\3CROW\hydro-XS.dwg LAYOUT: 2 SAVED DATE/TIME: 2/22/2010 12:29 PM

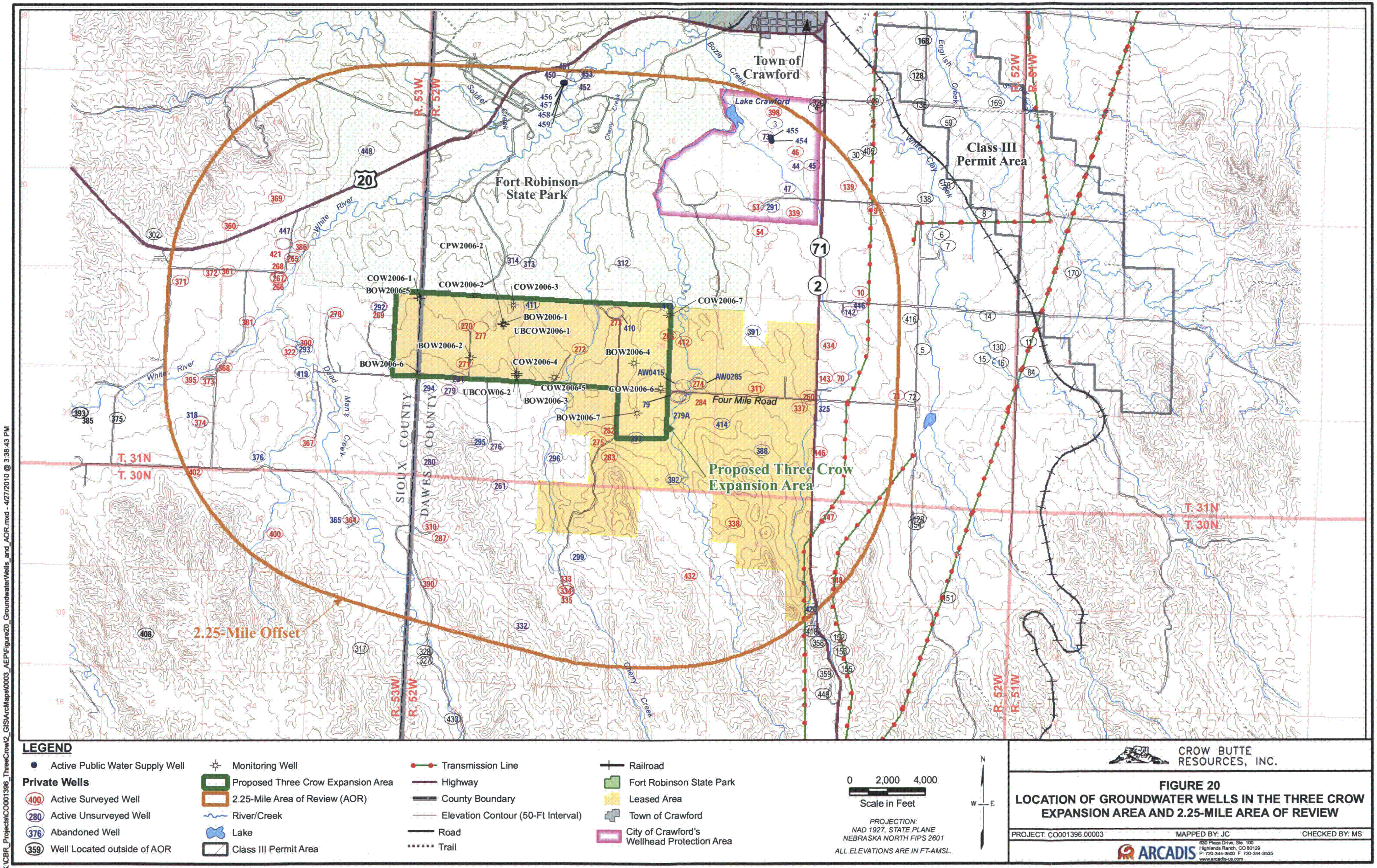
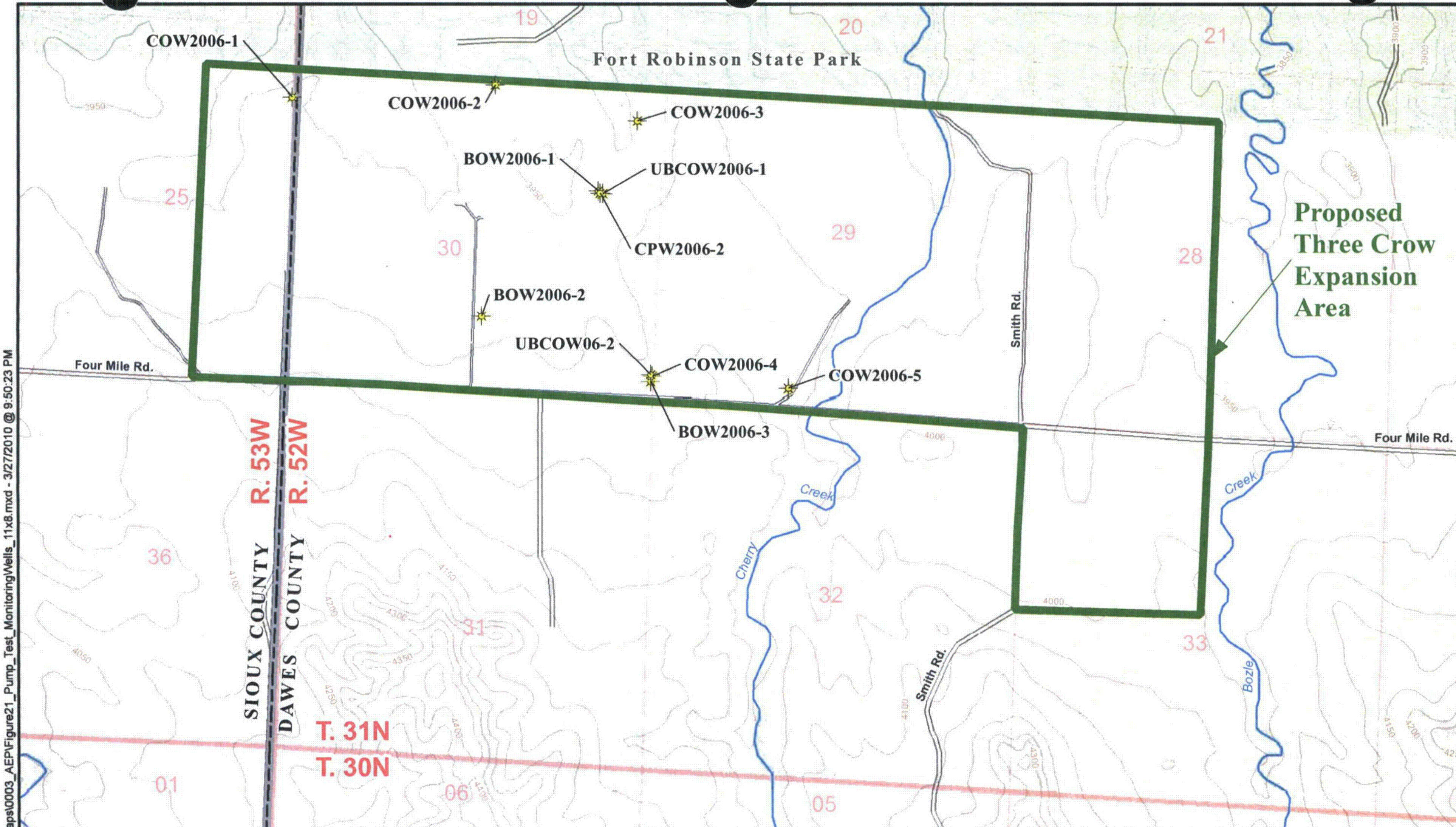


FIGURE 20
LOCATION OF GROUNDWATER WELLS IN THE THREE CROW EXPANSION AREA AND 2.25-MILE AREA OF REVIEW



LEGEND

- Monitoring Well
- Proposed Three Crow Expansion Area
- Fort Robinson State Park
- River/Creek
- County Boundary
- Elevation Contour (10-Ft Interval)
- Road

0 1,000 2,000
Scale in Feet

PROJECTION:
NAD 1927, STATE PLANE
NEBRASKA NORTH FIPS 2601

N W E

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FIGURE 21
LOCATION OF THREE CROW PUMP TEST MONITORING WELLS

PROJECT: CO001396.00003 MAPPED BY: JC CHECKED BY: MS

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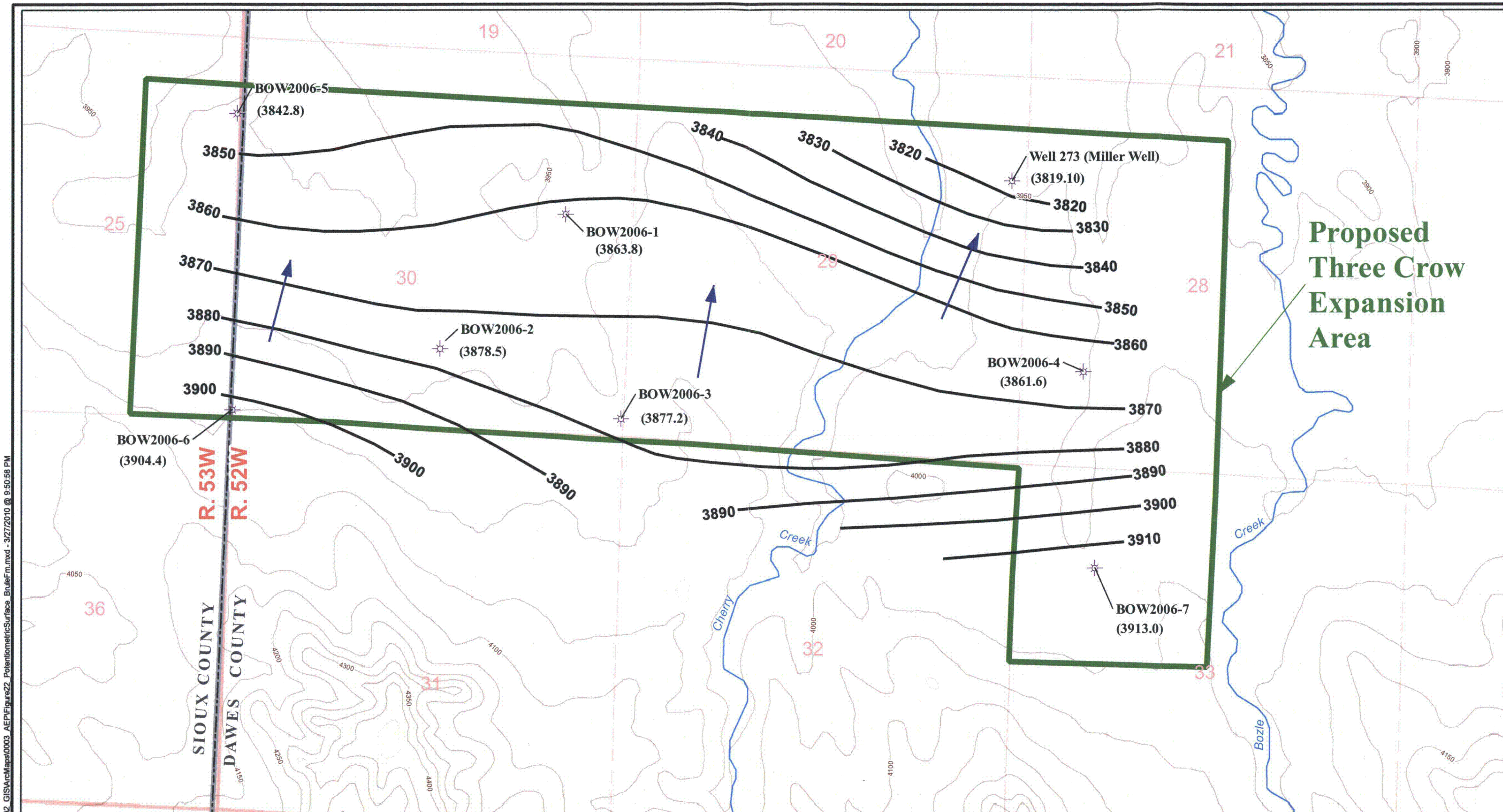

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LEGEND

- Brule Formation Monitoring Well
- Groundwater Potentiometric Surface (FT-AMSL)
- (3879) Groundwater Elevation (FT-AMSL)
- Groundwater Flow Direction
- River/Creek
- Elevation Contour (10-Ft Interval)
- County Boundary
- Proposed Three Crow Expansion Area

Notes:
1. Water levels at all well locations were collected on 1/22/2010, with the exception of Well 273 (Miller Well), which was collected on 2/8/10
2. All Elevations are in ft-amsl.

0 750 1,500
Scale in Feet

PROJECTION:
NAD 1927, STATE PLANE
NEBRASKA NORTH FIPS 2601

N W E

CROW BUTTE RESOURCES, INC.

FIGURE 22
THREE CROW EXPANSION AREA WATER LEVEL MAP - BRULE FORMATION (01/22/10 & 02/08/10)

PROJECT: CO001396.00003	MAPPED BY: JC	CHECKED BY: MS

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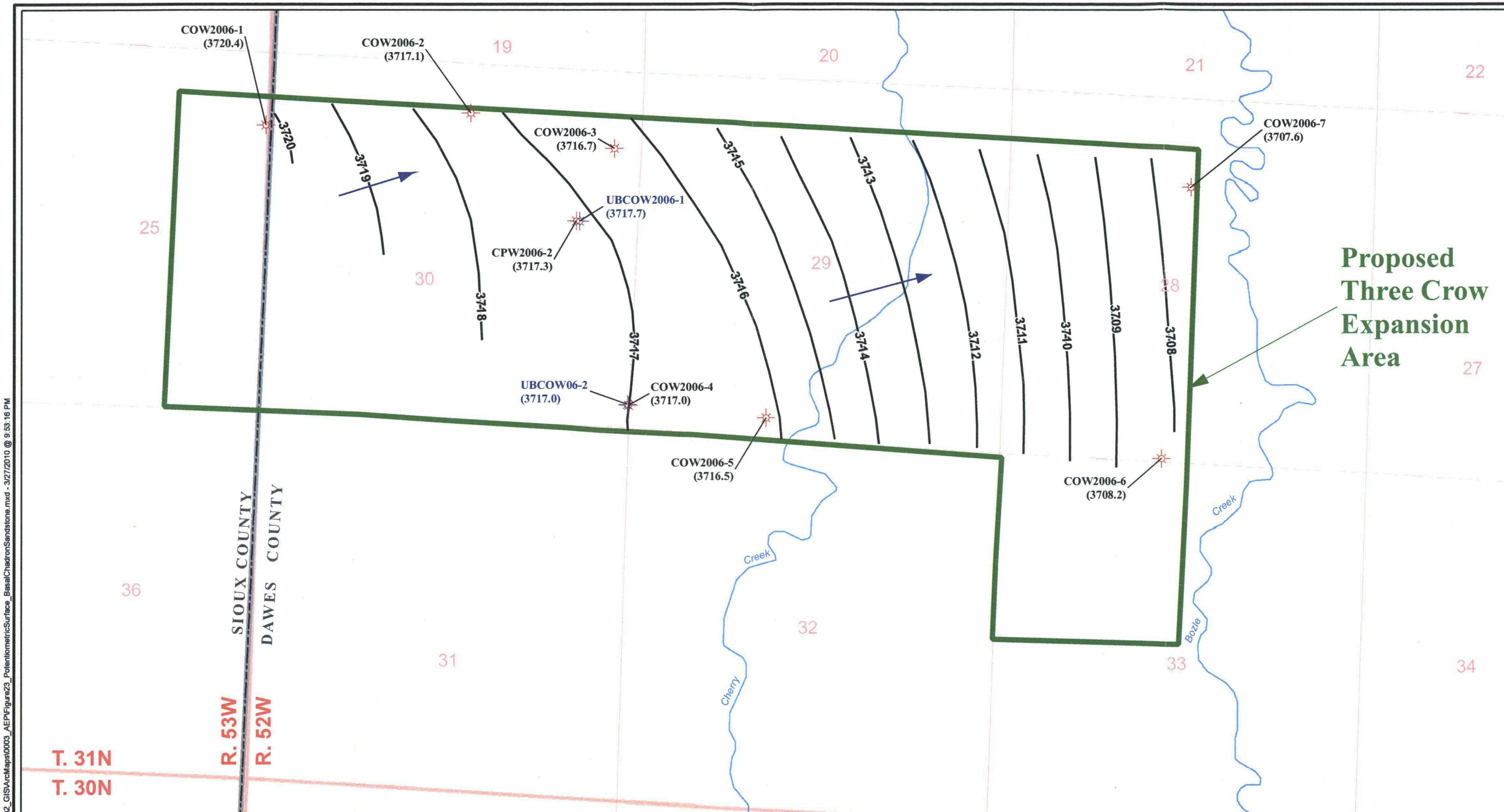

LEGEND

- Lower Basal Chadron Sandstone Monitoring Well
- Upper Basal Chadron Sandstone Monitoring Well
- (3720.5) Groundwater Elevation (FT-AMSL)
- River/Creek
- County Boundary
- Groundwater Flow Direction
- Proposed Three Crow Expansion Area

Notes:

1. Groundwater elevations are shown for wells screened in the Upper Basal Chadron Sandstone, but were not included in contouring.
2. All elevations are in ft-amsl.

0 1,000 2,000

Scale in Feet

PROJECTION:
NAD 1927, STATE PLANE
NEBRASKA NORTH FIPS 2601

N W E

CROW BUTTE RESOURCES, INC.

FIGURE 23
THREE CROW EXPANSION AREA
POTENTIOMETRIC SURFACE -
BASAL CHADRON SANDSTONE (01/22/2010)

PROJECT: CO001396.0003 MAPPED BY: JC CHECKED BY: MS

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