UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

In the Matter of CROW BUTTE RESOURCES, INC. (Marsland Expansion Area)	Docket No. 40-8943-MLA-2 ASLBP No. 13-926-01-MLA-BD01

Hearing Exhibit

Exhibit Number: NRC014

Exhibit Title: Rebuttal Testimony of David Back, Thomas Lancaster, and Elise Striz (Sept. 5, 2018)

September 5, 2018

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NRC STAFF'S REBUTTAL TESTIMONY

Q.1 Please state your name, position, and employer, and briefly describe your role in reviewing the Crow Butte Resources (CBR) application for the Marsland Expansion Area (MEA) license amendment.

A.1a My name is David Back. I am a Hydrogeologist at Sanford Cohen and Associates, Inc. (SC&A). Exhibit NRC002 provides a statement of my professional qualifications. I provided technical support for the NRC Staff's environmental review of the MEA license amendment application. I prepared the sections of the Staff's final Environmental Assessment (EA) related to geology, hydrology, and water resources in Chapter 3 (Affected Environment), Chapter 4 (Impacts), and Chapter 5 (Cumulative Impacts).

A.1b My name is Thomas R. Lancaster. I am a Hydrogeologist in the NRC's Office of Nuclear Material Safety and Safeguards, Division of Decommissioning, Uranium Recovery, and Waste Programs, Uranium Recovery Licensing Branch. Exhibit NRC003 provides a statement of my professional qualifications. I am the safety project manager for the review of the MEA license amendment application. I was the primary safety reviewer for geology- and hydrology-related sections of the MEA license amendment application and the author of sections of the NRC Staff's Safety Evaluation Report (SER) related to those topics.

A.1c My name is Dr. Elise Striz. I am a Hydrogeologist in the NRC's Office of Nuclear Material Safety and Safeguards, Division of Decommissioning, Uranium Recovery, and Waste Programs, Uranium Recovery Licensing Branch. Exhibit NRC004 provides a statement of my professional qualifications. I was not involved in the safety or environmental reviews of the MEA license amendment application; however, I have been involved in similar reviews for other in-situ uranium recovery (ISR) facilities, including the Crow Butte license renewal. I have reviewed sections of the Marsland SER and the Marsland EA related to geology and hydrology and corresponding sections of the MEA license amendment application in conjunction with the development of this testimony.

Q.2 Are you familiar with the initial testimony and exhibits filed by the Oglala Sioux Tribe (OST) and Crow Butte Resources, Inc. (CBR) in this proceeding?

A.2 (D. Back, T. Lancaster, E. Striz) Yes. We have reviewed the testimony provided by Dr. Kreamer (Ex. OST003) and Mr. Wireman (Ex. OST004) on behalf of the OST, as well as CBR's initial testimony (Ex. CBR001). We have also reviewed any relevant supporting information cited by the OST and CBR, including the exhibits filed with their initial testimony.

Q.3 On page 2 of his testimony (Ex. OST004), Mr. Wireman asserts that the MEA Technical Report (TR) contains no information on sources of recharge to the Basal Chadron Sandstone aquifer, and he suggests that CBR should conduct hydrogeologic mapping to locate and characterize the suggested discharge areas of that aquifer. How do you respond?

A.3 (D. Back, T. Lancaster, E. Striz) Mr. Wireman is mistaken regarding both claims. Section 3.3.2.1 of the EA (Ex. NRC006 at 3-27 to 3-29) and Section 2.7.2.3 of the TR (Ex. CBR006 at 2-86) discuss sources of recharge and discharge areas for the Basal Chadron Sandstone aquifer. The EA states that groundwater within the Basal Chadron

Sandstone aquifer flows from recharge areas south of Dawes County northward through the MEA (Ex. NRC006 at 3-27).

Based on a review of the potentiometric surface of the Basal Chadron Sandstone aquifer at the MEA (shown in Ex. CBR008-R at 113-116 (Figures 2.9-6a to 2.9-6d)), CBR determined that the potentiometric elevation of the recharge zone within the Basal Chadron Sandstone must be located above a minimum elevation of 3,715 feet above mean sea level (amsl) (Ex. CBR006 at 2-86). Figure 3-8 of the EA (Ex. NRC006 at 3-29) provides CBR's conceptualization of the regional potentiometric surface (Ex. CBR021), which shows the recharge zone for the Basal Chadron Sandstone aquifer to the west or southwest of the MEA where the potentiometric surface is expected to reach elevations above 3,715 feet amsl (Ex. CBR-006 at 2-86).

The EA states that groundwater flow in the Basal Chadron Sandstone aquifer at the MEA is currently to the northwest toward the existing Crow Butte license area (Ex.NRC006 at 3-27 to 3-28), and that the aquifer discharges where erosion has exposed the sandstone unit on the land surface north of Crawford, Nebraska. One such Basal Chadron Sandstone outcrop has been identified about 20 miles northwest of Crawford (Ex. NRC006 at 3-27). The recharge and discharge areas are sufficiently distant from the MEA that they will not impact the behavior of the Basal Chadron Sandstone aquifer at the MEA. Accordingly, no additional information, including "hydrogeologic mapping," is necessary.

Q.4 On page 2 of his testimony, Mr. Wireman questions the EA's statement (Ex. NRC006 at 3-27 [PDF 66]) that groundwater flow in the Basal Chadron Sandstone aquifer is not affected by the Pine Ridge Escarpment. He claims (Ex. OST004 at 3) that this cannot be the case because the Pine Ridge Escarpment was uplifted prior to the deposition of the Basal Chadron Sandstone. How do you respond?

A.4 (D. Back, T. Lancaster, E. Striz) As explained in Section 3.3.1 of the EA, the Pine Ridge Escarpment forms a surface water divide between the Niobrara River and White River watersheds (Ex. NRC006 at 3-18). As discussed in Section 3.3.2.1 of the EA, the Pine Ridge Escarpment is also a groundwater divide for the unconfined surficial aquifers (the Arikaree and Brule Formations) (Ex. NRC006 at 3-27). Figure 3-7 in the EA, which shows groundwater flow directions in the surficial aquifers, is based on an interpretation of 1995 potentiometric surface data by the Nebraska Department of Natural Resources (NDNR). Figure 3-7 shows all flow within the surficial aquifers south of the Pine Ridge Escarpment converging on the Niobrara River. As stated in the EA, more recent modeling by NDNR confirmed that the majority of the water flowing in the river is derived from groundwater (Ex. NRC006 at 3-27).

As shown in CBR's regional cross-sections (Ex. CBR008-R at 87-90 (Figures 2.6-21 to 2.6-24)), the Basal Chadron Sandstone is a continuous and essentially flat feature from the MEA, beneath the Pine Ridge Escarpment, to the existing Crow Butte license area. In addition, as shown in the regional cross-sections, the overlying Chadron, Brule and Arikaree formations are also continuous and relatively flat from north of the Pine Ridge Escarpment to the southern boundary of the MEA. Therefore, these formations were deposited without any apparent interruption by the Pine Ridge Escarpment.

As seen in the regional cross-sections (Ex. CBR008-R at 87-90 (Figures 2.6-21 to 2.6-24)), the Brule and Arikaree formations have been significantly eroded on the north side of the Pine Ridge Escarpment as compared with the south side. The stratigraphic evidence supports the view that these formations were deposited before this erosion occurred along the escarpment.

Finally, as discussed in A.3 above and as shown in Figure 3-8 in the EA (Ex. NRC006 at 3-29), which is based on Ex. CBR021, the groundwater flow in the Basal

Chadron Sandstone aquifer is to the northwest from the MEA towards the existing Crow Butte license area. Groundwater flow to the northwest through the Pine Ridge Escarpment in the Basal Chadron Sandstone aquifer would be unlikely if there was a groundwater flow divide in the Basal Chadron related to the Pine Ridge Escarpment.

Q.5 On page 2 of his testimony, Mr. Wireman asserts that the TR should discuss the relationship between annual recharge to the Basal Chadron Sandstone aquifer and the estimated consumptive use for the MEA. He also asserts that continuous pumping associated with mining and groundwater restoration will cause some drawdown of the Basal Chadron Sandstone aquifer miles from pumping centers. How do you respond to these statements?

A.5 (D. Back, T. Lancaster, E. Striz) The issue raised in Contention 2 is the adequacy of the description of geologic setting and site hydrology in the context of CBR's ability to demonstrate confinement of the production zone aquifer and contain fluid migration at the MEA. Contention 2 therefore relates to groundwater quality impacts, not groundwater quantity impacts (i.e., consumptive use). Each of Mr. Wireman's assertions here (regarding the relationship between recharge and consumptive use and the potential drawdown due to pumping) is solely related to consumptive use, not groundwater quality.

Q.6 On pages 2-3 of his testimony, Mr. Wireman claims that CBR must install monitoring wells in the Basal Chadron Sandstone aquifer upgradient and downgradient of the "license area," because such wells are necessary to fully evaluate downgradient impacts such as potential perturbation of the potentiometric surface and potential contamination of groundwater from restoration operations. What is your response?

A.6 (D. Back, T. Lancaster, E. Striz) Additional monitoring wells in the Basal Chadron Sandstone aquifer outside of the MEA license area are not necessary for the safe

operation of the MEA or to evaluate potential environmental impacts of MEA operations. As discussed in A.29 of our initial testimony (Ex. NRC001 at 40), and as discussed in Section 4.3.2.2 of the EA (Ex. NRC006 at 4-21), each wellfield will be surrounded by a ring of monitoring wells in the Basal Chadron Sandstone aquifer. As required by License Condition 10.1.3, those wells must be spaced no more than 400 feet apart (Ex. NRC009 at PDF 10). Additionally, as required by License Condition 11.1.5, CBR will be required to monitor these wells through biweekly testing, and, if an excursion is detected and confirmed, CBR would be required to take corrective actions (e.g., adjusting wellfield extraction and injection rates to draw fluids back into the wellfield) and conduct more frequent (weekly) sampling (Ex. NRC009 at PDF 17). As stated in A.29 of our initial testimony (Ex. NRC001 at 40) and as explained in Section 2.3.2 of the EA, License Condition 10.1.6 requires CBR to conduct ISR operations and restoration in the MEA wellfields under an inward hydraulic gradient (Ex. NRC006 at 2-8; Ex. NRC009 at PDF 11). The perimeter monitoring wells will be sufficient to identify potential excursions and to assess inward hydraulic gradient during the operation and restoration.

Mr. Wireman mentions potential perturbation of the potentiometric surface (i.e., drawdown) as an impact. As discussed in A.5 above, the issue raised in Contention 2 is the adequacy of the description of geologic setting and site hydrology in the context of CBR's ability to demonstrate confinement of the production zone aquifer and contain fluid migration at the MEA. This issue relates to groundwater quality impacts, not groundwater quantity impacts such as drawdown (i.e., consumptive use).

Q.7 On page 3 of his testimony, Mr. Wireman claims that "no data on surface water hydrology" are included in the TR or EA, and that CBR should perform baseline sampling of two ephemeral streams and investigate a spring located within the MEA. How do you respond?

A.7 (D. Back, T. Lancaster, E. Striz) As discussed in A.12 of our initial testimony (Ex. NRC001 at 14-16), Sections 3.3.1, 3.11.3, and 4.2.2 of the EA provide an extensive description of surface water hydrology, based on descriptions and supporting information in Sections 2.2.3 and 2.7.1 of the TR. In Section 3.11.3, the EA specifically explains that the MEA contains only ephemeral drainages, and that lack of water flow in those drainages has prevented collection of surface water samples (Ex. NRC006 at 3-72). In Sections 3.3.1 and 3.4.2, the EA describes Dooley Spring as ephemeral and "dry and revegetated" (Ex. NRC006 at 3-19, 3-41). Finally, the EA and the TR both state that CBR has committed to sample surface water from the ephemeral drainages if water flow becomes available (Ex. NRC006 at 6-1 to 6.2; Ex. CBR-006 at 2-123, 2-128).

Q.8 On page 3 of his testimony, Mr. Wireman claims that CBR should collect additional meteorological data for the MEA because of abnormal amounts of rain in one month during the period that site-specific data was collected. What is your response?

A.8 (D. Back, T. Lancaster, E. Striz) Additional data are not necessary. The issue raised in Contention 2 is the adequacy of the description of the geologic setting and site hydrology in the context of CBR's ability to demonstrate confinement of the production zone aquifer and to contain migration of ISR production fluids. The fact that rainfall was higher than normal during one month of site-specific meteorological data collection is not relevant to that issue. However, for purposes of its environmental review of the MEA, the Staff used the regional and site-specific meteorological information provided in the application (Ex. CBR006 at 2-28 to 2-38; Ex. CBR008-R at 14-45 (Figs. 2.5-1 to 2.5-32); Ex. CBR009 at 29-49 (Tables 2.5-1 to 2.5-14)) to gain a general understanding of climatic conditions and to provide a basis for describing the climatic conditions at the MEA site in the EA (Ex. NRC006 at 3-48 to 3-49). Also, in Appendices K-1 and K-2 of the MEA application, CBR describes modeling studies conducted to assess potential erosion and

flooding at the MEA (Exs. CBR019 and CBR020). In these studies, CBR used precipitation data from the National Oceanic and Atmospheric Administration (NOAA) and the National Climate Data Center (NCDC) as inputs to its erosion model and rainfall-runoff model (Ex. CBR019 at 2 (PDF 6)).

Q.9 On page 3 of his testimony, Mr. Wireman claims that the structural setting at the MEA is more complex than what CBR describes. He also states that there is disagreement between CBR and previous researchers on the existence of the Pine Ridge and Niobrara River faults, and that there is no discussion of potential effects of these geologic structures on groundwater flow in the Arikaree and White River Groups. What is your response?

A.9 (D. Back, T. Lancaster, E. Striz) Mr. Wireman first asserts that the structural setting at the MEA is more complex than described by CBR, and that numerous significant structural features occur in northwestern Nebraska (Ex. OST004 at 3). As discussed in A.9 of our initial testimony (Ex. NRC001 at 10), both the EA and the TR describe significant structural features and provide a map showing their locations (Ex. NRC006 at 3-6 to 3-7; Ex. CBR006 at 2-55 to 2-59; Ex. CBR008-R at 47, 81, and 82). In A.9 and A.19 of our initial testimony (Ex. NRC001 at 10-12, 24-26), we discuss the extensive site characterization data that CBR provided, including the cross-sections and structure contour maps based on CBR's subsurface investigation borehole data. Nothing in Mr. Wireman's general, unsupported assertions indicates any error in the Staff's or CBR's discussions of structural geology.

CBR provides a detailed discussion of its interpretations and conclusions related to the existence of the reported Pine Ridge and Niobrara River faults in Section 2.6.1.3 of the TR (Ex. CBR006 at 2-56 to 2-59). In A.25 of our initial testimony (Ex. NRC001 at 34), we explain that the Staff independently evaluated the evidence of reported faults and CBR's interpretations of subsurface data related to those faults. As we explain in

A.23 of our initial testimony (Ex. NRC001 at 32), the Staff's review, which is documented in Section 3.2.2.2 of the EA and Section 2.3.3.2.2 of the SER, was based on available literature and information provided by CBR, including CBR's regional and site-specific cross-sections and structure contour maps. In A.25 of our initial testimony we also discuss why CBR's regional and site-specific data from subsurface exploration at and near the MEA site are more relevant and persuasive than the interpretations by some previous researchers (Ex. NRC001 at 34-35).

As explained in A.23 of our initial testimony (Ex. NRC001 at 32), based on our review of these reported faults, we concluded that there is no evidence of vertical offsets indicative of faults at the MEA. We also discussed in the EA the reasons why, even if these faults did exist, they would not lead to significant adverse environmental impacts (Ex. NRC006 at 3-14). Finally, in A.21 and A.26 of our initial testimony (Ex. NRC001 at 28-31, 36) we explained that CBR has demonstrated vertical hydrologic confinement of the Basal Chadron Sandstone aquifer at the MEA through several lines of evidence. These lines of evidence include the following: (1) hydrologic characteristics of the upper and lower confining units; (2) aquifer pumping test results; (3) the potentiometric surface of the Basal Chadron Sandstone aquifer, (4) differences in potentiometric surfaces between the Basal Chadron Sandstone aquifer and the overlying Brule aquifer; (5) water quality differences between the Basal Chadron Sandstone aquifer and the overlying Brule aquifer; and (6) isotopic age differences between water in the Brule and Basal Chadron Sandstone (Ex. NRC001 at 36). This evidence refutes any implication or assertion that faults, whether known or unknown, are a preferential pathway for ISR production fluids to migrate outside the MEA license area.

Q.10 On page 4 of his testimony, Mr. Wireman asserts that lithologic and hydraulic data for the Arikaree aquifer indicate "significant heterogeneity," that the heterogeneity is increased by structural deformation of rocks comprising the aquifer, and that

aquifer testing, monitoring, and flow modeling of the Arikaree must consider the heterogeneity. How do you respond?

A.10 (D. Back, T. Lancaster, E. Striz) Any heterogeneity in the surficial aquifer is not germane to the confinement of the Basal Chadron Sandstone Aquifer. In A.21 and A.26 of our initial testimony (Ex. NRC001 at 28-31, 36) we explained that CBR has demonstrated vertical hydrologic confinement of the Basal Chadron Sandstone aquifer at the MEA through several lines of evidence. Furthermore, as discussed in A.15 below, aquifer testing at ISR sites is performed to determine properties and assess confinement of the proposed production zone aquifer. Therefore, there is no need to conduct aquifer testing on the surficial Arikaree aquifer. Finally, as discussed in A.28 of our initial testimony (Ex. NRC001 at 39), monitoring wells for vertical excursions are placed in the first overlying aquifer (the Brule aquifer). There is no need, therefore, to place monitoring wells in the Arikaree aquifer, which is above the Brule.

Q.11 On page 4, of his testimony, Mr. Wireman states that based on water level data, the Arikaree and Brule aquifers comprise a single aquifer system, and, therefore, that any contaminated groundwater migrating into the Brule could be pumped from Arikaree water wells. How do you respond?

A.11 (D. Back, T. Lancaster, E. Striz) As explained in A.21 of our initial testimony (Ex. NRC001 at 28-31), there are multiple bases for concluding that the Basal Chadron Sandstone aquifer has a high degree of confinement that will prevent migration of ISR production fluids into overlying aquifers. In particular, the strong downward gradient at the MEA would preclude migration of ISR production fluids upward into the Brule or Arikaree aquifers (Ex. NRC001 at 30-31, 40). Also, as discussed in A.23 of our initial testimony (Ex. NRC001 at 32-33), there is no evidence of vertical offsets indicating faults at the MEA that would allow such migration (and the downward gradient would preclude such movement even if faults were present). Therefore, although the Staff and CBR

both concluded that the Arikaree and Brule aquifers function as a single hydrogeological unit (Ex. NRC008 at 50), Mr. Wireman's concern is unfounded.

Q.12 On page 3 of his testimony, Mr. Wireman asserts that CBR has not yet selected "baseline restoration wells" and has not provided background concentrations from those wells. How do you respond?

A.12 (D. Back, T. Lancaster, E. Striz) The issue raised in Contention 2 is the adequacy of the description of geologic setting and site hydrology in the context of CBR's ability to demonstrate confinement of the production zone aquifer and contain fluid migration at the MEA. Baseline restoration wells are used to establish background water quality for restoration, per license condition 11.1.3 (Ex. NRC0009 at PDF 16). The installation and testing of these wells, which cannot occur until after the site is licensed and each wellfield is constructed, is not relevant to CBR's demonstration of confinement or the ability to contain fluid migration. For purposes of assessing potential impacts, CBR provided a sufficient number of wells (Ex. CBR008-R at 96 (Fig. 2.7-6)), and water quality data from those wells (Ex. CBR009 at 136-141), to establish pre-operational water quality of the Basal Chadron Sandstone aquifer.

Q.13 On page 5 of his testimony, Mr. Wireman claims that statements in the TR and EA regarding applicable restoration monitoring requirements and compliance standards are confusing. How do you respond?

A.13 (D. Back, T. Lancaster, E. Striz) Again, the issue raised in Contention 2 is the adequacy of the description of the geologic setting and site hydrology in the context of CBR's ability to demonstrate confinement of the production zone aquifer and to contain migration of ISR production fluids. The applicable standards for groundwater restoration are not relevant to this issue.

The EA (Ex. NRC006 at 4-24), the SER (Ex. NRC008 at 147), and License Condition 10.1.5 (Ex. NRC009 at PDF 11) clearly state that groundwater quality at the

MEA must be restored to the standards in 10 CFR Part 40, Appendix A, Criterion 5B(5). Criterion 5B(5) states that the concentration of a hazardous constituent must not exceed (1) the approved background concentration; (2) the maximum concentration limit (MCL) listed in Table 5C of Part 40, Appendix A (if the constituent is listed and if the MCL is greater than the background concentration); or (3) an alternate concentration limit (ACL) approved by the Commission. The factors that the Commission considers in establishing an ACL are listed in Criterion 5B(6). As required by License Condition 10.1.5, if CBR requests an ACL at the MEA, CBR would have to submit a license amendment request addressing the factors in Criterion 5B(6) and, in addition, show that it has made practicable efforts to restore the specified hazardous constituents to their background concentrations or (if applicable) MCLs, whichever is greater (Ex. NRC009 at PDF 11).

Q.14 On page 6 of his testimony, Mr. Wireman claims that the TR does not include information on the geologic formations that CBR proposes to use as deep disposal wells (DDWs), including their status as underground sources of drinking water and water quality data. Could you please respond?

A.14 (D. Back, T. Lancaster, E. Striz) Mr. Wireman is incorrect. The EA and the MEA application (both the TR and Environmental Report (ER)) identify the relevant formations as the Morrison and Sundance Formations (Ex. NRC006 at 3-30; Ex. CBR006 at 4-11 and 7-20; Ex. CBR005-R at 3-99). The TR states that the estimated total dissolved solids (TDS) in these formations exceeds 10,000 mg/L (Ex. CBR006 at 4-11, 7-20). As stated in the ER, CBR has applied to the NDEQ for permit to install and operate Class I non-hazardous waste injection wells in the MEA license area (Ex CBR005-R at 3-99). CBR also stated in the ER that these formations "have been demonstrated to be located below the lowermost underground source of drinking water" and that they "exhibit water quality that is not considered under state and federal regulations to be underground

sources of drinking water due to measured TDS concentrations" (Ex. CBR005-R at 3-99). In addition, as stated in the EA, SER, ER, and TR, these formations are separated from the Basal Chadron Sandstone aquifer by several thousand feet of low-permeability units, including at least 750 feet of Pierre Shale, a regional aquitard with hydraulic conductivity on the order of 10^{-10} cm/sec (Ex. NRC006 at 3-29 to 3-30, 3-32, 5-19; Ex. NRC008 at 52-53; Ex. CBR005-R at 7-24; Ex. CBR006 at 2-52 to 2-53 and 7-20).

Finally, we note that the licensing and regulation of DDWs is not within NRC's jurisdiction. As discussed above, to construct and operate DDWs at the MEA, CBR must obtain a separate Class I UIC permit from NDEQ.

Q.15 Dr. Kreamer's opinion (Ex. OST003) focuses almost exclusively on the 2011 aquifer pumping test (Test #8) conducted at the MEA site. Please explain the role of aquifer pumping tests in the Staff's review of ISR facilities in general, and summarize the relevant results of the MEA aquifer pumping test.

A.15 (D. Back, T. Lancaster, E. Striz) In general, an aquifer pumping test is one component of the site characterization used to develop the hydrological conceptual model for an ISR facility. Section 2.7 of NUREG-1569 states that aquifer pumping tests may be used to investigate vertical confinement of the production zone aquifer and to determine hydraulic properties of aquifers, particularly the production zone aquifer (Ex. NRC010 at 2-22, 2-24). As discussed in A.15 of our initial testimony (Ex. NRC001 at 20), properties of the production zone aquifer such as transmissivity, hydraulic gradient, and hydraulic conductivity are important for selection of injection and extraction rates and the ability to maintain an inward hydraulic gradient. Transmissivity is also important to ensure that there will be adequate flow through the aquifer to accomplish restoration. In addition to these two objectives, aquifer pumping tests are also used, along with other site characterization activities, to assess the degree of connectivity within the production zone aquifer, and to assess the presence or absence of hydraulic boundaries.

As stated in Section 3.3.2.3 of the EA (Ex. NRC006 at 3-31) and Section 2.7.2.2 of the TR (Ex. CBR006 at 2-82), CBR's regional aquifer pumping test was designed to address several objectives. These included (1) demonstrating hydraulic communication (connection) within the Basal Chadron Sandstone aquifer (production zone); (2) assessing the hydrological characteristics of the Basal Chadron Sandstone aquifer; (3) evaluating the presence or absence of hydraulic boundaries in the Basal Chadron Sandstone aquifer within the test area; and (4) demonstrating sufficient vertical confinement between the Basal Chadron Sandstone and the overlying aquifer (Brule) (Ex. CBR006 at 2-82).

With regard to demonstrating hydraulic communication, CBR reported drawdown during the MEA aquifer pumping test in observation wells over 8,000 feet from the pumping well. When considered together with other site characterization data, the long distances over which pressure responses were observed in response to pumping during the regional aquifer test supports the conclusion that the Basal Chadron Sandstone is hydraulically connected over the MEA. Hydraulic communication will be verified during subsequent aquifer pumping tests that will be conducted for each wellfield, as required by License Condition 11.3.4 (Ex. NRC009 at PDF 21). The individual wellfield pumping test results, along with additional information submitted as part of the MEA wellfield packages (as required by license condition 11.3.4), will verify the hydraulic connection in the Basal Chadron Sandstone aquifer in each wellfield.

With regard to hydraulic properties of the Basal Chadron Sandstone aquifer, CBR calculated transmissivity, hydraulic conductivity, and storativity at the pumping well and each observation well in the Basal Chadron Sandstone aquifer (Ex. CBR009 at 73 (Table 2.7-3), Ex. CBR016 at PDF 30 (Table 8)). CBR reported transmissivities ranging from 230 to 2469 ft^2/day for the MEA pumping test, with a mean value of 1012 ft^2/day (Ex. CBR009 at 73, 74 (Tables 2.7-3 and 2.7-4); Ex. CBR016 at PDF 30 (Table 8)).

CBR also reported that the mean transmissivities for the Basal Chadron Sandstone aquifer at CBR's existing ISR facility range from 363 to 826 ft^2/day (Ex. CBR016 at PDF 22 (Table 2); Ex. CBR009 at 74 (Table 2.7-4)). In addition, the Cooper-Jacob distance drawdown results provided in Figure 18 of the MEA aquifer pumping test report (Ex. CBR016 at PDF 49) show pumping effects over long distances, which support a finding that inward gradients could be maintained for the MEA as required by License Condition 10.1.6 (Ex. NRC009 at PDF 11).

With regard to confinement, as discussed in A.21 of our initial testimony (Ex. NRC001 at 28-31), the results of the MEA aquifer pumping test provide one of several lines of evidence supporting the conclusion that there is a high degree of confinement between the Basal Chadron Sandstone aquifer and the overlying Brule aquifer at the MEA. In A.21 of our initial testimony (Ex. NRC001 at 30), we explained that confinement is indicated by the lack of water level changes observed in the overlying Brule aquifer observation wells during the MEA aquifer pumping test. In addition, two other observations from the MEA aquifer pumping tests indicate confinement. First, the pressure effects from pumping at a relatively low flow rate (27 gpm) were observed at long distances over short time periods. Second, the calculated storativity values range from 1.7×10^{-3} to 8.32×10^{-5} and average 2.56×10^{-4}. According to Todd (1980), storativity values for a confined aquifer range between 5×10^{-5} and 5×10^{-3} (Ex. NRC015 at PDF 3-4).

Q.16 On page 2 of his testimony, Dr. Kreamer claims that CBR's report for the MEA aquifer pumping test (Ex. CBR016) is deficient because CBR did not provide the data and results from a first failed test. What is your response?

A.16 (D. Back, T. Lancaster, E. Striz) As stated in the MEA aquifer pumping test (Ex. CBR016 at 6), CBR performed an initial aquifer pumping test at the MEA in 2010, but ended the test after only 19 hours because a poor hydraulic connection between the

pumping well and the aquifer led to excessive well inefficiency (Ex. CBR023 at 1). In 2011, CBR conducted the 103-hour (4.29 day) aquifer pumping test that is discussed in the MEA aquifer pumping test report (Ex. CBR006 at 2-82). The 2011 test was sufficient for the NRC's safety and environmental reviews.

Dr. Kreamer suggests that the data collected from the first test, if analyzed, could provide additional insight as to the hydrogeological conditions beneath the MEA site. We disagree with Dr. Kreamer that the data from the incomplete first test would provide any materially different, useful information.

In the MEA aquifer pumping test report, CBR indicated that it rectified the pumping well issue from the first test by installing a new well (CPW-1A) 67 feet west-southwest of former pumping well (Ex. CBR016 at PDF 29 (Table 7)). In addition, CBR refined the design of the test by proposing that different wells (Monitor-6 and Monitor-7) be designated as the furthest wells to formally estimate the radius of influence. However, although CBR indicated that Monitor-2 and Monitor-8 were no longer part of the formal monitoring network, these wells were still monitored and analyzed as described in the original aquifer pumping test plan (Ex. CBR016 at PDF 23 (Table 3, note 1)).

Overall, the changes made for the second test—using a different pumping well 67 feet away from the original one, and redesignating the furthest wells for purposes of formally calculating the radius of influence—are immaterial to overall results and interpretation of the data. With the exception of the pumping well, both tests used the same observation wells except that former pumping well (i.e., CPW-1) was used as an observation well in the second test. The first test ran for only 19 hours, while the second test ran for 103 hours (4.29 days). If the original pumping well from the first test (CPW-1A) had been suitably hydraulically connected to the aquifer, the pumping drawdown response curves for both tests would, for all practical purposes, have been

the same for the first 19 hours (i.e., the measured drawdown versus time would have been essentially the same for both tests during the first 19 hours). CBR recognized that the pumping well in the first test was not hydraulically connected to the aquifer, and, therefore, that the data would not be suitable for a meaningful quantitative analysis of the transmissivity, storativity and boundary conditions. For these reasons, we do not believe that the results of the first test would yield any materially different, useful information.

Q.17 On pages 2 and 7 of his testimony, Dr. Kreamer claims that CBR arbitrarily analyzed selected portions of the data from the MEA aquifer pumping test. What is your response?

A.17 (D. Back, T. Lancaster, E. Striz) Dr. Kreamer's claims that only selective portions of the data were analyzed, and that the report did not present an analysis of the complete data set, are unsupported. Appendix C of the MEA aquifer pumping test report presents drawdown and recovery response curves showing all data points for all of the observation wells used in the aquifer pumping test (Ex. CBR016 at PDF 79-95 (Figures C1 to C17)).

Dr. Kreamer asserts that CBR "arbitrarily" analyzed only selected portions of the data, choosing late time data in some cases and middle time data in others. Contrary to Dr. Kreamer's assertion, the authors of the aquifer pumping test report clearly explained their rationale for matching the data to the Theis curve (Ex. CBR016 at 13):

> Type curve matching generally focused on late-time drawdown data since this data is normally considered the most reliable indicator of overall aquifer response. Type curve matching for wells CPW-1A, CPW-1, and Monitor-3 focused on middle-time data for the drawdown phase of test due to the presence of a higher permeability boundary condition apparent in the late-time data for these wells. Log-log plots of drawdown data for wells CPW-1A, CPW-1, Monitor-3, and Monitor 5 are shown in Figure 19. The drawdown data for wells CPW-1A, CPW-1, and Monitor-3 show a late-time flattening of the curve (indicative of higher permeability boundary condition), whereas the drawdown data for Monitor-5 (and all

> other distant observation wells) exhibited a more typical confined aquifer drawdown response.

Most importantly, the authors appropriately chose not to use early time data. The problems inherent with using early time data are discussed in numerous textbooks and journal articles, and are succinctly explained by Kruseman and de Ridder (Ex. CBR029 at 16):

> In applying the Theis curve-fitting method, and consequently all curve-fitting methods, one should, in general, give less weight to the early data because they may not closely represent the theoretical drawdown equation on which the type curve is based. Among other things, the theoretical equations are based on the assumptions that the well discharge remains constant and that the release of water stored in the aquifer is immediate and directly proportional to the rate of decline of the pressure head. In fact, there may be a time lag between the pressure decline and the release of stored water, and initially also the well discharge may vary as the pump is adjusting itself to the changing head. This probably causes initial disagreement between theory and actual flow. As the time of pumping extends, these effects are minimized and closer agreement may be attained.

It is a matter of professional judgment as to what portion of the curve to use after early time effects have dissipated (i.e., middle to late time).

In summary, the rationale for analyzing the aquifer pumping test data was clearly explained and consistent with recommended practice.

Q.18 On pages 2 and 6 of his testimony, Dr. Kreamer claims that analysis of excluded data can demonstrate lack of confinement in the Basal Chadron Sandstone aquifer. Do you agree?

A.18 (D. Back, T. Lancaster, E. Striz) We disagree with Dr. Kreamer. First, it is not clear what Dr. Kreamer is referring to as "excluded data." As discussed in A.17 above, all of the data for drawdown and recovery in observation wells was presented in the aquifer pumping test report.

Dr. Kreamer asserts that the Theis curves for all of the MEA observation wells show deviations consistent with leakage (i.e., a recharge boundary). We disagree with

the assertion that all wells show such deviations. As described by CBR, and confirmed by Staff review, just two (CPW-1 and Monitor-3) of the eight observation wells and the pumping well (CPW-1A) show late-time deviations in the Theis curves that could be interpreted as recharge (Ex. CBR016 at 13). Further, Dr. Kreamer appears to be suggesting that if the Theis analyses show deviations consistent with a recharge boundary, it follows that water is flowing from the overlying aquifer into the Basal Chadron Sandstone Aquifer, which would indicate a lack of confinement.

Dr. Kreamer's explanation is implausible because, as discussed in A.21 of our initial testimony (Ex. NRC001 at 28-31), there are multiple lines of evidence demonstrating a high degree of confinement, which would preclude such downward vertical flow. In addition, there are several reasons other than lack of confinement that can account for the deviations in the Theis curves at late time. CBR's explanation was that the deviation is related to an increase in transmissivity. In our view, this is plausible because an increase in transmissivity away from the pumping well could manifest as a deviation from the Theis curve at late time which resembles a recharge boundary.

Another possible explanation is that water is being released from storage in the first several feet of the aquitard immediately overlying the Basal Chadron Sandstone aquifer. In aquifers like the Basal Chadron Sandstone aquifer, which is overlain by a very thick confining unit of low hydraulic conductivity, the stresses induced by pumping during the aquifer test can propagate into the confining unit, which may compress the aquitard matrix and yield a small amount of water from storage. Although this effect can show up on a Theis curve in a way that mimics a recharge boundary, it does not represent recharge from overlying aquifers. This effect would be consistent with the MEA pumping test responses for wells MW-3 and CPW-1, which show apparent "recharge" behavior at late time. Because both wells were subjected to significant drawdown as a consequence of their proximity to the pumping well, the differential pressure across the

aquitard at each of these wells could have slightly compressed the overlying aquitard sediments to produce enough water to show this apparent “recharge” effect.

Wellbore storage effects or near-wellbore effects could also explain deviations from a Theis curve that can mimic a recharge boundary. If the Theis curve is fit to early-time drawdown data that are impacted by wellbore storage and near-wellbore effects, the late-time data will fall below the Theis curve and appear to be a recharge boundary. According to Driscoll (1986), an industry standard reference, “early data reflect the volume of water removed from the casing,” and “[b]efore the effect of casing storage on pumping test data was recognized, an interpreter might have mistaken the flattened or second part of the drawdown curve as an indication of aquifer recharge” (Ex. NRC016 (Driscoll) at PDF 8).

Additionally, as discussed in A.15 above, there are several observations from the MEA aquifer pumping test independent of the Theis curve analyses that support confinement. First, the lack of response in the Brule monitoring wells during the aquifer pumping test demonstrates no communication between the Brule and Basal Chadron Sandstone aquifers. Second, the fact that pressure responses are being observed 8,800 feet away after pumping 27 gpm over 4 days indicates the Basal Chadron Sandstone aquifer is well-confined. If storage or recharge was supplying water to the aquifer, the drawdown would not have been seen at that distance. Third, as described in A.15, the low storativity values obtained during the test further indicate a confined aquifer.

Finally, Dr. Kreamer suggests that a Cooper-Jacob semi-logarithmic time-drawdown evaluation (also known as the modified Theis method) would show a recharge boundary consistent with a lack of confinement. A Cooper-Jacob time-drawdown analysis is not necessary to identify a recharge boundary, and would not provide any additional information not already available from a Theis curve analysis,

because the Cooper-Jacob time-drawdown analysis is an approximation to the Theis analysis (Ex. CBR025 at 90-91). The Cooper-Jacob time-drawdown method was developed because it is easier to fit a straight line through the data than to fit the data to a Theis type curve, not because the Cooper-Jacob method provides any additional information. Furthermore, use of early-time data might show deviations from a Theis type curve that mimic recharge; however, for the reasons discussed in A.17 above, use of early-time data in a Theis or Cooper-Jacob time-drawdown analysis is inappropriate.

Q.19 On page 2 of his testimony, Dr. Kreamer asserts several omissions from the MEA aquifer pumping test report. He claims that CBR did not perform a Cooper-Jacob semi-logarithmic analysis as stated in the aquifer pumping test report; that CBR did not analyze data from Monitor wells 2 and 8; and that CBR did not state whether actual or average thicknesses were used to calculate transmissivity. Could you please address these claims?

A.19 (D. Back, T. Lancaster, E. Striz) First, Dr. Kreamer incorrectly asserts that CBR did not perform a Cooper-Jacob semi-logarithmic analysis as stated in the MEA aquifer pumping test report. The MEA aquifer pumping test report clearly states that CBR used "Theis (1935) drawdown and recovery methods and the Cooper-Jacob Straight-Line Distance-Drawdown method (Cooper and Jacob 1946)" to analyze the aquifer pumping test data (Ex. CBR016 at 11). The Cooper-Jacob distance-drawdown analysis for a time period of 4.29 days (the entire duration of the aquifer pumping test) is provided in Figure 18 of the MEA aquifer pumping test report (Ex. CBR016 at PDF 49). This figure plots the drawdown as a function of distance and provides the average hydraulic properties over a large area.

Dr. Kreamer is also incorrect about the analysis of wells Monitor-2 and Monitor-8. Section 7.8 of the MEA pumping test report states that although Monitor-2 and Monitor-8 were not included in the formal test monitoring network, data from these wells were still

collected and analyzed during the aquifer pumping test (Ex. CBR016 at 14). The Theis drawdown analyses for Monitor-2 and Monitor-8, respectively, are presented in Figures C2 and C8 of the aquifer pumping test report (Ex. CBR016 at PDF 80, 86). The Theis recovery analysis for those wells is presented in Figures C11 and C17, respectively (Ex. CBR016 at PDF 89, 95).

The aquifer pumping test report states that data collected from these observation wells (the most distant wells) "clearly identify drawdown in excess of 0.4 feet due to pumping," and concluded that "these data are of sufficient quality to reliably determine aquifer parameters at these locations" (Ex. CBR016 at 14). As a result, CBR was able to use the data collected from Monitor-2 and Monitor-8 to calculate aquifer properties and the radius of influence for the aquifer pumping test, which was slightly greater than 8,800 feet (Ex. CBR016 at 14).

Finally, contrary to Dr. Kreamer's implication, aquifer thickness is not needed to calculate transmissivity. As explained in A.14 of our initial testimony (Ex. NRC001 at 19-20), transmissivities are obtained directly from aquifer pumping test data. The aquifer thickness is used, in conjunction with the transmissivity, to calculate hydraulic conductivities (i.e., hydraulic conductivity is transmissivity divided by aquifer thickness). The MEA aquifer pumping test report states in several places that average transmissivities and "an average net sand thickness of 40 feet" were used to calculate hydraulic conductivities (Ex. CBR016 at 1, 13, 14, PDF 30 (Table 8)). We also note that, of these two parameters, transmissivity (which dictates the volume of groundwater flowing through the aquifer) is the one that is derived directly from the aquifer pumping test.

Q.20 On page 2 of his testimony, Dr. Kreamer states that the radius of influence of the pumping test extended significantly off site. He asserts that the test drew water from those off-site locations, and he implies that this affected the analysis

because late-time data are more influenced by off-site factors. How do you respond?

A.20 (D. Back, T. Lancaster, E. Striz) Dr. Kreamer's claim that "water was drawn from off-site" misconstrues the actual groundwater flow dynamics involved in pumping a confined aquifer like the Basal Chadron Sandstone aquifer. The changes to the potentiometric surface (i.e., drawdowns) observed in the furthest monitoring wells are a response to the decrease in pressure caused by the pumping well and are unrelated to water movement from off-site.

Dr. Kreamer does not elaborate on what off-site hydrogeological influences he is referring to, nor does he explain how they would adversely impact the pumping test conclusions. Furthermore, the late-time data observed in the aquifer response curves from the more distant observation wells did not indicate that there were any off-site influences significantly different than those observed in the middle-time data.

Q.21 Both Dr. Kreamer (Ex. OST003 at 2) and Mr. Wireman (Ex. OST004 at 4) claim in their testimony that the single aquifer pumping test conducted at the MEA site was deficient because it did not cover the entire MEA site. Therefore, they claim that the hydrogeological response of "the large majority" of the site to pumping is unknown, and that much of the BCS has not been tested to determine whether there is hydraulic connection between the BCS aquifer and the overlying Brule aquifer. How do you respond?

A.21 (D. Back, T. Lancaster, E. Striz) Based on the reported radius of influence of 8,800 feet, the aquifer pumping test covered approximately 3 miles of the approximately 7.5 mile length of the MEA site (Ex. CBR016 at PDF 32, 47 (Figure 1, Figure 16)). Furthermore, there is no need to assess the response of the entire MEA site to pumping because, as explained in A.10 of our initial testimony (Ex. NRC001 at 12), the site geology is not complicated and CBR's cross-sections demonstrate uniformity of hydrostratigraphic units

and continuity of the Basal Chadron Sandstone aquifer across the MEA. As described in A.19 of our initial testimony (Ex. NRC001 at 24-26), the hydrologic conceptual model for the MEA is supported by extensive and reliable site characterization data from CBR's comprehensive subsurface investigation of the MEA. These data include geophysical logs and observations of drill cuttings that provide data on the thickness, extent, and continuity of stratigraphic units; cross-sections covering the entire site constructed using data from 57 boreholes; isopach maps and structure contour maps, also created using borehole data; and physical and chemical properties of the overlying aquifers, upper and lower confining layers, and production zone aquifer based on drill cuttings and analysis of core samples.

In addition, the aquifer pumping test is only one of several lines of evidence demonstrating confinement of the Basal Chadron Sandstone aquifer at the MEA. In A.21 of our initial testimony (Ex. NRC001 at 28-31), we described several lines of evidence unrelated to the aquifer pumping test that support the conclusion that ISR production fluids will be adequately confined at the MEA. Finally, as discussed in A.15 above, CBR would be required by License Condition 11.3.4 (Ex. NRC009 at PDF 21) to perform an aquifer pumping test for each wellfield as part of the wellfield packages that will be submitted to further verify the conceptual model.

Q.22 On page 2 of his testimony, Dr. Kreamer asserts that, during the aquifer pumping test, it is possible that monitoring wells did not measure results from the entire thickness of the Basal Chadron Sandstone aquifer, or that those wells may have partially measured water derived from other formations. What is your response?

A.22 (D. Back, T. Lancaster, E. Striz) Dr. Kreamer states that the results from the monitoring wells may not reflect the actual conditions because the screened intervals of the monitoring wells ranged from 22 to 50 feet, while the thickness of the Basal Chadron Sandstone varies from 21 to 91 feet. Dr. Kreamer's assertion is not valid. He states,

based on Figure 2.6-9 of the TR, that the Basal Chadron Sandstone ranges in thickness from 21 to 91 feet; however, those numbers do not reflect the thicknesses at the locations of the aquifer pumping test observation wells. Comparing Figure 2.7-7 of the TR (which shows the locations of the Basal Chadron Sandstone observation wells) with Figure 2.6-9, all of the observation wells except for Monitor-5 are in areas where the thickness shown in Figure 2.6-9 is less than 50 feet (Ex. CBR008-R at 75, 97). Moreover, the completion reports provided in Appendix A of the aquifer pumping test report (Ex. CBR016 at PDF 53-64) indicate that all of the Basal Chadron Sandstone observation wells were fully screened across the Basal Chadron Sandstone aquifer.

Q.23 On pages 5-7 of his testimony, Dr. Kreamer asserts that CBR's use of the Theis and Cooper-Jacob methods for the aquifer pumping test was inappropriate because several assumptions inherent in these analytical approaches are not met at the MEA. How do you respond?

A.23 (D. Back, T. Lancaster, E. Striz) As discussed below, we disagree with Dr. Kreamer's assertions. In A.19 of our initial testimony (Ex. NRC001 at 26), we explained that the analytical methods employed by CBR are widely used and accepted methods. In particular, the Theis curve matching method is the standard approach that most practicing hydrogeologists have used to evaluate the hydraulic characteristics of ground water aquifers using aquifer pumping tests. These methods have been adopted in ASTM standards (Ex. NRC017) and, in practice, these methods have been applied to heterogeneous anisotropic aquifers. If, as Dr. Kreamer suggests, the methods are only applicable if the assumptions are strictly adhered to, the methods would never be applicable, because no hydrogeologic system could meet them. At some scale all geologic systems are heterogeneous and anisotropic, and application of these "basic equations" to these systems is done with an understanding of the assumptions inherent to their use.

The Theis and Cooper-Jacob distance drawdown methods chosen to analyze the MEA aquifer pumping test data are consistent with the objectives of the pumping test. As discussed below, it is not necessary that the assumptions in these analytical methods are strictly met, and there is no evidence in the aquifer pumping test data to suggest that the assumptions were inappropriate for the Basal Chadron Sandstone aquifer at the MEA. The MEA aquifer pumping test was a multiple day test with a large radius of influence (8,800 feet, or over 1.5 miles). This large long-term aquifer test averages the hydraulic behavior over the region of influence, which minimizes the impact of small scale anisotropy and heterogeneity.

Finally, as relevant to Contention 2, the most important information obtained from the MEA aquifer pumping test tests was the assessment of the degree of confinement of the Basal Chadron Sandstone aquifer. As discussed in A.18 above, there are several results from this test that demonstrate confinement independent of the Theis analysis. And furthermore, as discussed in A.21 of our initial testimony (Ex. NRC001 at 28-31) and reiterated in several of our rebuttal responses, there are multiple lines of evidence other than the aquifer pumping test that demonstrate confinement of the Basal Chadron Sandstone aquifer.

Driscoll (1986) discusses the simplifying assumptions to analytical solutions used to determine aquifer properties under both equilibrium and non-equilibrium conditions (Ex. NRC016 at PDF 3, 5). With respect to how well these assumptions need to be satisfied in order to obtain meaningful results Driscoll states as follows (Ex. NRC016 at PDF 3):

> These assumptions appear to limit severely the use of the two equations. In reality, however, they do not. For example, uniform hydraulic conductivity is rarely found in a real aquifer, but the average hydraulic conductivity as determined from pumping tests has proved to be reliable for predicting well performance. In confined aquifers where the well is fully penetrating and open to the formation, the assumption of no stratification is not an important limitation.

> Assumption of constant thickness is not a serious limitation because variation in aquifer thickness within the cone of depression in most situations is relatively small, especially in sedimentary rocks.

The first assumption Dr. Kreamer questions is that the aquifer is homogeneous and isotropic. Homogeneity and isotropy correspond to the assumptions of uniform hydraulic conductivity and lack of stratification stated in Driscoll (see above). The subsurface characterization (e.g., examination of cores, geophysical logging) of the Basal Chadron Sandstone at the MEA shows that there are not major impermeable or permeable features that would indicate significant heterogeneity and that would impact the aquifer test analysis results (Ex. CBR016 at 5). The lack of significant heterogeneity is also reflected on the potentiometric surface of the Basal Chadron Sandstone aquifer (Ex. CBR008-R at 113-116), which is smooth and has an essentially flat and relatively constant hydraulic gradient. The smoothness of potentiometric surface indicates that there are no significant changes in transmissivity that impact the groundwater flow in the Basal Chadron Sandstone aquifer. In addition, the aquifer drawdown from the aquifer pumping test, as shown in Figure 16 of the MEA aquifer pumping test report, is apparently circular, not elliptical, indicating there is no evidence of significant directional conductivity from lateral anisotropy (Ex. CBR016 at PDF 47).

The second assumption Dr. Kreamer questions is that the aquifer is confined and of apparent infinite lateral extent. By definition, the Basal Chadron Sandstone aquifer is a confined aquifer because, as explained in A.21 of our initial testimony (Ex. NRC001 at 30), its potentiometric surface rises above the top elevation of the aquifer. In A.21 of our initial testimony (Ex. NRC001 at 28-31), we presented this fact plus several other lines of evidence supporting the conclusion that there is a high degree of confinement. Furthermore, the fact that the majority of the data collected during the aquifer test fall on the classic Theis type curve indicates that the aquifer is confined (Ex. CBR016 at PDF 79-95).

With respect to the assumption of apparent infinite lateral extent, the site-specific and regional cross-sections, based on boreholes and geophysical logging, demonstrate that the Basal Chadron Sandstone aquifer is present over the entire MEA site and well beyond (Ex. CBR008-R at 49-62, 87-90 (Figs. 2.6-3a to 2.6-3n, 2.6-21 to 2.6-24)). This conclusion is also supported by the lack of boundary conditions observed during the aquifer pumping test, especially in the most distant observations wells (Ex. CBR016 at 13).

The final assumption Dr. Kreamer questions is that the aquifer has effective uniform thickness. CBR's data (cross-sections and isopach maps) indicate that the thickness of the Basal Chadron Sandstone varies from about 30 to 90 feet over the MEA. This level of variation is expected in sedimentary systems, and, as pointed out by Driscoll in the quoted language above, will not preclude obtaining reliable results from an aquifer pumping test.

With respect to the Basal Chadron Sandstone thickness, Dr. Kreamer asserts that the EA contains "conjecture" about the reason for "lack of continual thickness". This statement by Dr. Kreamer reflects a misunderstanding of what was written in the EA. The only statements related to thickness on the page Dr. Kreamer cites are the following (Ex. NRC006 at 3-28):

> As discussed in Section 3.2.2.1, the Basal Chadron Sandstone was deposited in a fluvial stream environment within a regional paleochannel. The aquifer transitions to less permeable silts and clays (zero sandstone thickness) 9 miles to the east and 12 miles to the west of the MEA.

These sentences in the EA represent two separate concepts and, more importantly, says nothing about the variation in thickness of the Basal Chadron Sandstone at (or near) the MEA. Section 3.2.2.1 of the EA describes the thickness of the Basal Chadron Sandstone based on site-specific cross-sections and geophysical log data (Ex. NRC006 at 3-10).

Finally, Dr. Kreamer asserts that assuming homogeneity and isotropy "wrongly implies that the local geology is simple." However, based on CBR's subsurface investigation, discussed in detail in A.9 and A.19 of our initial testimony (Ex. NRC001 at 10-11, 24-25), there is ample evidence that the local stratigraphy around the MEA is relatively uniform and uncomplicated. In particular, as explained in A.10 of our initial testimony (Ex. NRC001 at 12-13), the site-specific and regional cross-sections provided by CBR (Ex. CBR008-R at 49-62, 87-90) (Figs. 2.6-3a to 2.6-3n and 2.6-21 to 2.6-24)) show that the stratigraphic units, and particularly the Basal Chadron Sandstone, are essentially flat and relatively uniform in thickness over the site.

Q.24 On page 5 of his testimony, Dr. Kreamer asserts that further analysis of anisotropy is necessary. How do you respond?

A.24 (D. Back, T. Lancaster, E. Striz) Dr. Kreamer provides no support for his assertion that further analysis of anisotropy is critical to meeting the objectives of the MEA aquifer pumping test. Heterogeneity and anisotropy in a production zone aquifer are only important in ISR operations if either affects the ability of the operator to balance the wellfields and maintain an inward gradient. They are unrelated to the vertical confinement of a production zone aquifer.

In addition, if there was a significant heterogeneity in an aquifer, such as an impermeable or permeable feature, it would be apparent on the potentiometric surface. As discussed in A.23 above, the potentiometric surface of the Basal Chadron Sandstone aquifer does not show heterogeneity. Similarly, if there is a significant anisotropy within the production zone, such as a large difference in directional conductivity, K_x and K_y, the aquifer test will show an elliptical drawdown. As discussed in A.23 above, that was not apparent for the MEA aquifer pumping test. Finally, if vertical anisotropy exists within the production zone aquifer (i.e., K_x and K_y are greater than K_z), that is considered beneficial for ISR operations because it creates the preferred horizontal flow.

Q.25 On page 3 of his testimony, Dr. Kreamer cites CBR's statement in the report regarding historical aquifer testing at the existing Crow Butte license area, stating that the Basal Chadron Sandstone aquifer is "relatively homogeneous and isotropic within the current Class III UIC [Underground Injection Control] area." Dr. Kreamer claims this statement about the existing Crow Butte license area is contradicted by data from previous aquifer pumping tests conducted at the existing license area (Tests 1, 2 and 3). What is your response?

A.25 (D. Back, T. Lancaster, E. Striz) The statement Dr. Kreamer questions was provided to give historical context to the MEA aquifer pumping test results. The statement reads in its entirety (Ex. CBR016 at 6):

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

In that discussion of historical results, CBR also discusses the tests performed at the proposed Three Crow and North Trend sites, and recognizes stratigraphic differences between those sites and the existing Crow Butte license area. Later in the MEA aquifer pumping test report, when discussing the analysis method assumptions, CBR acknowledges that the Basal Chadron Sandstone aquifer is not homogeneous and isotropic on a local scale, but states that the assumptions are "reasonably satisfied" and that "over the scale of the pumping test" the Basal Chadron Sandstone can be treated as homogeneous and isotropic for analytical purposes" (Ex. CBR016 at 11). We agree with this statement for the reasons discussed in A.23 above.

For the above reasons, we do not believe the statement in the report "mischaracterizes" the results of previous tests. Furthermore, it is not clear how this statement about the homogeneity and isotropy at the existing Crow Butte license area is

relevant to the interpretation of the results of the MEA aquifer pumping test or, more generally, to the demonstration of confinement of the Basal Chadron Sandstone aquifer at the MEA. The existing Crow Butte license area is 11 miles away from the MEA, and is not the subject of this licensing proceeding. Dr. Kreamer repeats arguments he made in the Crow Butte license renewal proceeding, where he reanalyzed the aquifer pumping test data to match early time data and asserted that this showed recharge boundaries. We discuss in A.17 above why matching early time data is inappropriate. Dr. Kreamer's only reference to the MEA test data in his discussion of this claim is that the MEA response curves show departures from the Theis curve that are consistent with leakage. We addressed that claim in A.18 above. Again, we do not see how Dr. Kreamer's reanalysis of aquifer pumping test data for the existing Crow Butte license area has any bearing on the interpretation of the MEA aquifer pumping test or the demonstration of confinement at the MEA.

Q.26 Does this conclude your testimony?

A.26 (D. Back, T. Lancaster, E. Striz) Yes.

September 4, 2018

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	Docket No. 40-8943-MLA-2
CROW BUTTE RESOURCES, INC.	)	
	)	ASLBP No. 13-926-01-MLA-BD01
(Marsland Expansion Area)	)	

AFFIDAVIT OF DAVID BACK

I, David Back, do hereby declare under penalty of perjury that my statements in the foregoing testimony and in prefiled Exhibit NRC002 (Statement of Professional Qualifications of David Back) are true and correct to the best of my knowledge and belief.

Executed in Accord with 10 CFR 2.304(d)

____

David Back
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Executed in Falls Church, VA
this 4th day of September, 2018

September 4, 2018

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
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CROW BUTTE RESOURCES, INC.	)	
	)	ASLBP No. 13-926-01-MLA-BD01
(Marsland Expansion Area)	)	

AFFIDAVIT OF THOMAS LANCASTER

I, Thomas Lancaster, do hereby declare under penalty of perjury that my statements in the foregoing testimony and in prefiled Exhibit NRC003 (Statement of Professional Qualifications of Thomas Lancaster) are true and correct to the best of my knowledge and belief.

Executed in Accord with 10 CFR 2.304(d)

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this 4th day of September, 2018

September 4, 2018

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	Docket No. 40-8943-MLA-2
CROW BUTTE RESOURCES, INC.	)	
	)	ASLBP No. 13-926-01-MLA-BD01
(Marsland Expansion Area)	)	

AFFIDAVIT OF ELISE STRIZ

I, Elise Striz, do hereby declare under penalty of perjury that my statements in the foregoing testimony and in prefiled Exhibit NRC004 (Statement of Professional Qualifications of Elise Striz) are true and correct to the best of my knowledge and belief.

Executed in Accord with 10 CFR 2.304(d)

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