**NRC-103**
**Submitted: 9/28/2015**

September 28, 2015

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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| In the Matter of | ) | |
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| CROW BUTTE RESOURCES, INC. | ) | Docket No. 40-8943-OLA |
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| (License Renewal for the In Situ Leach | ) | ASLBP No. 08-867-02-OLA-BD01 |
| Facility, Crawford, Nebraska) | ) | |

NRC STAFF'S SUPPLEMENTAL REBUTTAL TESTIMONY

## Introduction

**Q.1 Please state your name, position, and employer, and briefly describe your role in reviewing the Crow Butte Resources (CBR) License Renewal Application (LRA) associated with the Crow Butte project.**

**A.1a** My name is David Back. I am a Hydrogeologist at Sanford Cohen and Associates Inc. (SC&A). Exhibit NRC-002 provides a statement of my professional qualifications. I provided technical support to the lead Environmental Project Manager, Mr. Nathan Goodman, for the NRC Staff's environmental review of the CBR License Renewal application. I prepared the sections of the final environmental assessment (EA) that address water resources, including affected environment, impacts, and 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 Fuel Cycle Safety, Safeguards, Uranium Review and Licensing Branch. Exhibit NRC-005 provides a statement of my professional qualifications. I serve as the alternate Safety Project Manager for the Crow Butte license renewal. As a technical reviewer, I provided support to the lead

Safety Project Manager, Mr. Ron Burrows, in the NRC Staff's safety review of hydrology- and hydrogeology-related sections of the Crow Butte License Renewal application. In addition, I have provided technical support for several onsite inspections of the CBR facility.

**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 Fuel Cycle Safety, Safeguards, Uranium Review and Licensing Branch. Exhibit NRC-008 provides a statement of my professional qualifications. I provided support to the lead Safety Project Manager, Mr. Ron Burrows, for the NRC Staff's safety review of hydrology- and hydrogeology-related sections of the Crow Butte License Renewal application. I also provided support to the lead Environmental Project Manager, Mr. Nathan Goodman, in preparing the EA for the NRC Staff's environmental review of the CBR License Renewal application.

**Q.2** **Are you familiar with the supplemental testimony and exhibits filed by the Oglala Sioux Tribe and Consolidated Intervenors and by CBR in this proceeding?**

**A.2** (D. Back, T. Lancaster, E. Striz) Yes. We have reviewed the supplemental testimony of Dr. Kreamer (Ex. INT-079), Dr. LaGarry (Ex. INT-080), and Mr. Wireman (Ex. INT-081), filed by the Oglala Sioux Tribe and Consolidated Intervenors. We have also reviewed the supplemental testimony of Mr. Beins, Mr. Lewis, Mr. Pavlick, Mr. Spurlin, and Mr. Teahon, filed by CBR (Ex. CBR-067), as well as supporting exhibits (Exs. CBR-063R to CBR-066).

**<u>Issue 1:</u>** **<u>Whether the water levels in the Brule aquifer have lowered due to mining activities</u>**

**Q.1.1** **Dr. Kreamer testified that "[t]estimony in the August 2015 NRC Hearings in Crawford, Nebraska showed significant water table decline in the Brule aquifer between pre mining conditions (1982) and active mining operations in 2008 in**

**the underlying Chamberlain Pass/ Basal Chadron Formation" (Ex. INT-079 at 10). Mr. Wireman echoes Dr. Kreamer's concern, stating that the Brule water level at well #11 shown in Exhibits BRD-008A and BRD-008B show a 40 foot decline from 1982 to 2008 (Ex. INT-081 at 2). Are they correct?**

**A.1.1** (D. Back, T. Lancaster, E. Striz) No. Dr. Kreamer and Mr. Wireman are referring to the water-level data posted for well #11 in Exhibit BRD-008A. As explained in A.1.4 of our Supplemental Direct Testimony (Ex. NRC-095 at 4-5), the apparent water level decrease in well #11 is the result of an apparent transcription error from Table 2.7-5 of the LRA (Ex. CBR-011 at 2-194) to Figure 2.7-3a of the LRA (Ex. BRD-008A). Hydrographs for nearby wells SM 7-17 (Ex. CBR-063) and SM 7-22 (Ex. CBR-064), in addition to pre- and post-mining water levels for wells PM-6 and PM-7, and in the vicinity of well 27 (Ex. BRD-002A at 2.7A(5); Ex. NRC-096-R at 2), show no indication of mining impacts on the Brule water levels.

To further support this conclusion, we have annotated the location and pre-mining water level of well BMW-1 on Figure 2.73b of the LRA (Ex. NRC-104 at 2). The Brule water level was measured in this well as 3808.0 feet prior to CBR initiating Aquifer Test 2 in 1987 (Ex. BRD-002B). The Brule water level in this location was very similar in 2008, indicating no impacts from mining activities on the Brule water levels (Ex. NRC-104 at 2).

**Q.1.2** **Dr. Kreamer further testified that Exhibits BRD-008A and BRD-008B show a visible decline in the Brule water levels at "numerous well points" in the active mining area, "not just a single location" (Ex. INT-079 at 10). Can you respond?**

**A.1.2** (D. Back, T. Lancaster, E. Striz) Dr. Kreamer does not provide any supporting evidence for this statement. He cites no specific locations or figures to show such a decline.

**Q.1.3 Mr. Wireman testified that Exhibits BRD-008A and BRD-008B indicate "that the Brule water level elevation has decreased . . . 5 feet in the northwest part of the Class III permit area" (Ex. INT-081 at 3). Can you respond?**

**A.1.3** (D. Back, T. Lancaster, E. Striz) Mr. Wireman does not provide any justification for this claim. It is unclear how he reached this conclusion, as there are no 1982-1983 Brule water levels shown in the northwest part of the Class III permit area in Exhibit BRD-008A. The two wells nearest the northwest part of the License Area—well #29 and well #66—are too far from the data points in Exhibit BRD-008B to make such a comparison, particularly within an accuracy of 5 feet.

**Q.1.4 Exhibits CBR-063 and CBR-064 are hydrographs of Brule water levels measured biweekly from 1999 to 2015. But Dr. Kreamer testifies that "[m]ining activities began . . . in 1991 not in 1999, and no data were presented from the critical period from these eight years after mining began" (Ex. INT-079 at 10), and Mr. Wireman echoes his concern (Ex. INT-081 at 3). Can you respond?**

**A.1.4** (D. Back, T. Lancaster, E. Striz) Mining activities were not initiated simultaneously in all of the eleven mine units. As shown in Table 1.7-1 of the LRA, production was initiated in the mine units (MU) as follows: MU 1 in 1991, MU 2 in 1992, MU 3 in 1993, MU 4 in 1994, MU 5 in 1996, MU 6 in 1998, MU 7 in 1999, MU 8 in 2002, MU 9 in 2003, MU 10 in 2007, and MU 11 post-2007 (Ex. CBR-011 at 1-13). The hydrographs in Exhibits CBR-063 and CBR-064 show data from wells SM 7-17 and SM 7-22, respectively. Both of these wells are completed in the Brule aquifer above MU 7 (Ex. NRC-105). As noted above, mining activities began in MU 7 in 1999. Therefore, all of the data from the initiation of the mine unit is available in the hydrographs for SM 7-17 and SM 7-22 (i.e., 1999 through 2015). These hydrographs do not indicate that the mining activities have had any impact on the water levels in the Brule aquifer.

In addition, CBR has provided several hydrographs of other overlying Brule monitoring wells in support of their supplemental direct testimony, showing that there has and continues to be no significant change in Brule water levels across the license area during operations (Exs. CBR-065 and CBR-066).

**Q.1.5 Mr. Wireman testified that Exhibits CBR-063 and CBR-064 appear to show an increase in the Brule water levels in wells SM 7-22 and SM 7-17 from 2008 to 2012. He argues that this increase may result from "stopping or reducing mining operations in the vicinity of these two wells, which is another indication that pumping the Basal Chadron/Chamberlain Pass [Formation] affects the water level in the Brule aquifer" (Ex. INT-081 at 3). Can you respond?**

**A.1.5** (D. Back, T. Lancaster, E. Striz) Both SM7-22 and SM 7-17 are completed in the Brule aquifer above Mine Unit (MU) 7 and adjacent to MU 9 (Ex. NRC-105). Production in MU 7 was initiated in 1999, and production in MU 9 was initiated in 2003 (Ex. CBR-011 at 1-13). As Mr. Teahon testified during the evidentiary hearing, MUs 7 and 9 are currently both in production (Tr. at 1091). Therefore, mining activities have not stopped in the vicinity of SM 7-22 and SM-17. Furthermore, if the effects of mining activities are reflected in the hydrographs, as Mr. Wireman states, then they would have shown increased drawdown at the beginning of the mining activities. The hydrographs show no such increased drawdown (Exs. CBR-063R and CBR-064R). Additionally, the water level increase referred to by Mr. Wireman may reflect an improvement in water levels after the 2007 drought in northwest Nebraska.

**Q.1.6 Dr. Kreamer testified that "there is a water level rise in the reported Brule wells after some mining units completed operations and ceased pumping" (Ex. INT-079 at 10). Does Dr. Kreamer point to specific data to support his claim?**

**A.1.6** (D. Back, T. Lancaster, E. Striz) No. Dr. Kreamer makes this assertion without providing any evidence or supporting discussion. The best quality data, however, for determining whether the Brule water levels have been impacted by pumping are the hydrographs for wells distributed through the entire License Area. As shown in the hydrographs, there are no long term increasing or decreasing trends in the water levels (Exs. CBR-065 and CBR-066).

**Q.1.7 Dr. Kreamer testified that "[n]o data are presented comparing pumping rates in the Chamberlain Pass/Basal Chadron to the water levels in the Brule," preventing a "correlation analysis [from being] carried out by the intervening parties, by NRC staff, or by other external reviewers" (Ex. INT-079 at 10). Can you respond?**

**A.1.7** (D. Back, T. Lancaster, E. Striz) The first step in a correlation analysis is to establish whether any trends exist in the data. Except for minor climatic influences, the water levels depicted on the hydrographs are relatively constant and do not exhibit increasing or decreasing trends (Exs. CBR-063R, CBR-064R, and CBR-065). Therefore, attempting to correlate the Brule water levels with the mine unit pumping and injection rates would not be meaningful.

**Q.1.8 Mr. Wireman testified that the "hydraulic gradient on the Brule water table surface . . . increased significantly from 0.012 in 1982 to 0.25 /0.43 in 2008," which could indicate "downward leakage caused by pumping the underlying Basal Chadron / Chamberlain Pass [Formation]" (Ex. INT-081 at 3). Can you respond?**

**A.1.8** (D. Back, T. Lancaster, E. Striz) Mr. Wireman presents results for several hydraulic gradient calculations for which he does not provide any supporting documentation. He further contends that the hydraulic gradients in the Brule aquifer in 2008 (i.e., 0.25/0.43) are significantly greater than those observed in 1982-83 (i.e., 0.012), which he postulates may have been caused by pumping-induced leakage from the Brule aquifer to the Basal Chadron Sandstone aquifer.

We conducted an independent hydraulic gradient analysis, which is presented in Exhibit NRC-106. For our analysis, we chose points for which both 1982-83 and 2008 water levels could be approximated based on water table elevation measurements and contours. As shown in Exhibit NRC-106, the water level elevation points were also selected to maximize the distance across the mine in order to best reflect the horizontal gradients. The actual calculations for both the 1982-83 and 2008 water levels are shown in Exhibit NRC-106. The gradient calculated for 1982-83 is 0.0111 ft/ft and for 2008 is 0.0103 ft/ft. These gradients are essentially the same and provide additional evidence that the mining activities have not impacted the water levels in the Brule.

**Q.1.9 Mr. Wireman further testified that Exhibits CBR-062 and BRD-008B indicate a downward vertical gradient in the northwestern part of the License Area (Ex. INT-081 at 4). Does the Staff agree?**

**A.1.9** (D. Back, T. Lancaster, E. Striz) We agree that the hydraulic gradient is downward. However, as explained in our testimony above, there is substantial evidence demonstrating that the aquifers are hydraulically separated, and there is no evidence indicating that the aquifers are hydraulically connected. Therefore, the downward vertical gradient does not affect the Staff's conclusion that CBR's mining activities have not affected water levels in the Brule aquifer.

**Issue 2: What is the available head in the Basal Chadron/Chamberlain Pass formation and the maximum anticipated drawdown during Crow Butte's operation and restoration of its mining facility**

**Q.2.1 Mr. Wireman testified that "the available head above the top of the Basal Chadron / Chamberlain Pass [Formation] in 2009 was less than 150 [feet] in the northwest part of the Class III permit area," which is a concern "as mining activities move to the northwest" toward Crawford (Ex. INT-081 at 4). How does the Staff respond?**

**A.2.1** (D. Back, T. Lancaster, E. Striz) Mine Units 6, 8, and 10 are the mine units that are located in the northwest in the License Area. As shown in Table 1.7-1 of the LRA, production was initiated in these mine units in 1998, 2002, and 2007, respectively (Ex. CBR-011 at 1-13). In the Staff's previously-filed Rebuttal Testimony, we compared CBR's predicted potentiometric surface elevations in the vicinity of Crawford to the actual 2009 measured values (Ex. NRC-076-R2 at 66-67; Ex. NRC-087). This comparison demonstrates that the drawdowns in the vicinity of Crawford are less than those originally anticipated.

As CBR's witnesses have testified, the current consumptive use rates are presently at or near their projected maximum (Ex. CBR-067 at 6). The NRC Staff calculated that consumptive use rates would have to be about 495 gallons per minute to decrease the available head above the top of the Basal Chadron Sandstone by 147 feet (Ex. NRC-095 at 7-8). This consumptive use rate is not realistic.

**Q.2.2** **Mr. Wireman notes that the available head above the Basal Chadron Sandstone aquifer is lower in the northwest part of the License Area than in the central and southeastern parts of the License Area. He testifies that "[t]his could be due to: (a) the fact that mining was more active in the northwest part of the Permit area in 2009; (b) a change in the thickness of the Basal Chadron / Chamberlain Pass [Formation]; (c) or the effects of a geologic structure ([W]hite River fold/fault) on the flow system" (Ex. INT-081 at 4). Does the Staff agree with Mr. Wireman's possible explanations?**

**A.2.2** (D. Back, T. Lancaster, E. Striz) While changes in the available head could be a function of thickness and local mine unit consumptive use rates, Mr. Wireman's speculation that the White River feature has anything to do with the available head in the northwestern portion of the license area is unfounded.

The most likely explanation for the current smaller available head in the northwestern portion of the license area is twofold. First, the original, pre-mining available head was lower in this area than in other areas of the License Area. Figure 2.7-3a of the LRA, which shows the 1982-1983 pre-mining potentiometric surface of the Basal Chadron Sandstone aquifer, demonstrates that the original head was much lower over the northwestern portion of the license area than the central and southeastern portions (Ex. CBR-011 at 2-173). Second, the depth to the top of the Basal Chadron Sandstone aquifer is shallower in the northwestern part of the License Area, as shown in Figures 2.6-11 and 2.6-14 of the LRA (Ex. CBR-011 at 2-124, 2-137).

**Q.2.3 Mr. Wireman testified that "[r]educing the available head will affect the uranium recovery operations, potentially induce or increase downward leakage from the overlying Brule aquifer, and decrease well yields and discharge from [the] Basal Chadron / Chamberlain Pass [Formation] downgradient of the mine" (Ex. INT-081 at 4-5). Can you respond to his concerns?**

**A.2.3** (D. Back, T. Lancaster, E. Striz) With respect to Mr. Wireman's assertion that reducing the available head will affect the uranium recovery operations, we testified in the evidentiary hearing that recovery operations will be significantly impacted only if the potentiometric surface decreases below the top of the Basal Chadron Sandstone and the aquifer becomes unconfined (Tr. at 1407-09). As the Staff has shown, the consumptive use rates that would be required for this to occur are not realistic (Ex. NRC-095 at 7-8).

With respect to Mr. Wireman's claim that reducing the available head may cause leakage from the Brule aquifer, as discussed in our initial testimony at A.D.3, there is no evidence of any permeable pathway which would which would "induce or increase downward leakage" from the Brule aquifer in response to a reduction in head in the Basal Chadron Aquifer (Ex. NRC-001-R at 27-31).

Finally, Mr. Wireman asserts that reducing the available head may decrease well yields downgradient of the License Area. However, decreased well yields and discharge from the Basal Chadron in response to the current and expected reduction in head may only require that pumps be set lower. Because this will not destabilize the resource, the Staff's conclusion that short-term ground water quantity impacts from consumptive use will be no greater than MODERATE is appropriate.

**<u>Issue 3</u>: <u>Whether the results from the four pump tests demonstrate a hydraulic connection between the Brule and Basal Chadron/Chamberlain Pass formations</u>**

**Q.3.1 On pages 1-2 of his supplemental testimony (Ex. INT-079), Dr. Kreamer states that "Test 4 included evidence of a recharge boundary in the data (indicating potential vertical leakage) in a Cooper- Jacob Plot of data, and atmospheric response in wells both in the Brule Formation and the Chamberlain Pass Formation indicating vertical communication." Can you please respond to those assertions?**

**A.3.1** (D. Back, T. Lancaster, E. Striz) Dr. Kreamer first asserted at the evidentiary hearing that the Cooper-Jacob plot from Test 4 (Ex. CBR-012 at 11, "Test 4 Cooper-Jacob Time-Drawdown CM9-14") shows evidence of a recharge boundary (Tr. at 1276). Dr. Kreamer's testimony that the "diversion" in the drawdown curve for the Aquifer Test 4 results is evidence of a recharge boundary is based on several transient responses in the time-drawdown curve at about 700 minutes which are outlined in red on Ex. NRC-107, an annotated version of the Cooper-Jacob plot. As we testified at the hearing, the curve does not behave as it would if there was a recharge boundary. If there was a recharge boundary, the curve would move off of the straight line with increasing time —it would curve up and would never get back to the straight line again (Tr. at 1304-

05). The definition of a recharge boundary is one that continuously replenishes water to the aquifer. This influx of water will cause the rate of drawdown to decrease, resulting in a deviation from the theoretical drawdown that deflects the straight line upward. This classic behavior is shown in Ex. NRC-108, an excerpt from the textbook “Applied Hydrogeology” by Fetter (Ex. NRC-108 at PDF 3). The curve looks the way it does because it is being supplied water at a constant rate.

Also, as we explained at the hearing, in the Test 4 response curve, not only are the drawdown effects transient, but the response curve settles back on the theoretical drawdown curve (Tr. at 1304-05). As CBR testified at the hearing, when the production is turned off within adjacent well fields, the drawdown is decreased and, therefore, has the appearance of a recharge condition (Tr. at 1304-05). Once the water level recovery in the adjacent well field is complete, the observed drawdown would trend back to the theoretical line. Thus, this Test 4 curve does not indicate that a continuous influx of water is replenishing the aquifer.

A fundamental principle in hydrogeology is the law of superposition, which means that cones of depression caused by different pumping wells are additive. Therefore, if wells from a nearby well field caused one foot of drawdown at the aquifer test pumping well location and the pumping of the aquifer test well caused ten feet of drawdown, there would be eleven feet of drawdown in the vicinity of the well. Impacts from other pumping wells on the aquifer test data are not a concern as long as those pumping rates are constant. When they are not held constant, the test data may be affected in the manner shown in this plot from Test 4 and their effects need to be factored into the analysis.

With respect to Dr. Kreamer’s assertion that the atmospheric pressure response in the Brule and Basal Chadron monitoring wells during Test 4 indicates a hydraulic connection, in his rebuttal testimony (Ex. INT-069 at 5), Dr. Kreamer provided the following testimony on barometric effects during Test 4:

> Petrotek's data show another possible relationship that supports vertical hydraulic connectivity between the Chamberlain Pass Formation and the overlying Brule Formation. The first figure in Appendix A shows background water levels of wells, before pumping, in the Chamberlain Pass and Brule Formations, CPW2002 and SM9-10, respectively, along with barometric pressure changes. This figure shows a response of water levels in the Brule observation well to barometric pressure changes, indicating a connection between the Brule and the land surface. Importantly, what is not articulated in the report, is that there is also is apparently a muted and lagged response in the Chamberlain to pressure changes in the Brule. This would indicate a hydraulic response of piezometric level changes in the Chamberlain to water level fluctuations in the Brule, and suggest a level of vertical communication between the two, even if the well in the Brule were not optimally placed to show complete, representative response.

This discussion demonstrates a misunderstanding of how barometric pressure effects propagate through an aquifer, similar to the one that led Mr. Wireman to correct his testimony regarding barometric effects (Tr. at 1320-21). As we explained in A.D.16 of our rebuttal testimony (Ex. NRC-076-R2 at 40):

> The more confined an aquifer is, the more likely the pressures recorded at the monitoring well will be affected by barometric pressure (Ex. NRC-081 at 83). Water levels measured in wells penetrating confined aquifers at depth can incorrectly record the real potentiometric pressure in the aquifer adjacent to the well screen due to the difference in pressure being transmitted directly to the free surface of a well and the pressure being transmitted to ground water in the aquifer itself (Ex. NRC-081 at 84).

Page 1 of Exhibit NRC-109 is the barometric response curve from the Test 4 Report (Ex. CBR-012) that Dr. Kreamer was referring to in the above quote from Exhibit INT-069. This graph shows a classic response to barometric pressure effects on unconfined and confined (artesian) aquifers. The graph shows that the impact on water levels in the Brule aquifer monitoring well (SM9-10) is muted because there is direct communication of the entire water table of the aquifer with the atmosphere (i.e., the aquifer is unconfined) and the pressure is applied uniformly to the water table. In contrast, atmospheric pressure exhibits a much more profound effect on the potentiometric level measured in the Basal Chadron aquifer monitoring well (CPW2002) because the aquifer is confined. In a confined aquifer, any change in barometric pressure is directly transmitted only down the open wellbore because the confining layers prevent the direct transmission of the atmospheric pressure change to the water stored within the confined aquifer. As stated in Ex. NRC-081 (at 4):

> It is evident therefore that in an artesian situation there will be a pressure differential between an observation well where the water is directly subject to the full change in atmospheric pressure, and a point out in the aquifer where the water is required to accept only part of the change in atmospheric pressure.

Finally, we note that if a well had been completed below the Pierre Shale (the lower confining unit) the potentiometric surface would show barometric effects similar to the ones Dr. Kreamer is interpreting as hydraulic communication between the Brule and the Basal Chadron Sandstone. The Intervenors have testified, however, that they do not dispute the integrity of the lower confining unit (Tr. at 1028).

**Q.3.2 On page 2 of his supplemental testimony, Dr. Kreamer claims that the atmospheric response of six Basal Chadron wells during Aquifer Test 1 "is indicative of vertical communication of groundwater pressure between the land surface, the Brule aquifer and the Chamberlain (Basal Chadron) Formation, and therefore the ability of groundwater to have a vertical pressure response." Could you please respond to this claim?**

**A.3.2** (D. Back, T. Lancaster, E. Striz) We agree with Dr. Kreamer that all six wells in the Basal Chadron exhibit a strong correlation with barometric pressure. We are unsure what Dr. Kreamer means by a "vertical pressure response," but, for the reasons explained in A.3.1 above, we disagree with his assertion that this "corollary response" indicates vertical hydraulic communication between aquifers.

**Q.3.3 Dr. Kreamer asserts on page 2 of his supplemental testimony that the head response of the deep wells is a positive correlation with barometric pressure**

**and apparently negative correlation to head changes in the Brule, and that Figure 2.7-3A shows positive correlation of water levels in the Basal Chadron Sandstone with barometric pressure variation. Does Staff agree?**

**A.3.3** (D. Back, T. Lancaster, E. Striz) The degree of hydraulic intercommunication (i.e., movement of water) among aquifers cannot ascertained by the response to barometric pressure regardless of whether it is negatively or positively correlated. The response to barometric pressure is simply a change in pore pressure due to higher or lower atmospheric pressures. A good illustration of this concept is that earthquakes can create pressure pulses that can be detected as pressure responses in deep monitoring wells hundreds of miles away. The units through which the pulse is moving, however, are not hydraulically connected.

We agree with Dr. Kreamer that water levels in the shallow Brule aquifer showed negative correlation in response to barometric pressure. However, we disagree with Dr. Kreamer's subsequent claim that piezometric water levels in the Basal Chadron Sandstone were positively correlated to barometric pressure changes. The graphs in Figure 2.7A-3 (Ex. BRD-002A at 2.7A(11)) show a <u>negative</u> correlation because the water level depth (i.e., depth from ground surface to top of water surface in well) increases with higher barometric pressure. It appears that Dr. Kreamer misread the y-axis of these figures, which show depth increasing from the origin (as opposed to the shallow Brule well graphs in Figure 2.7A-2, in which depth decreases from the origin).

**Q.3.4** **On page 2 of his supplemental testimony, Dr. Kreamer states that "The conclusion therefore that piezometric head changes in the Chamberlain Pass (Basal Chadron) respond to surface barometric pressure changes and head changes in the shallow Brule aquifer is reasonable and consistent with evidence discussed in the hearing concerning head changes in the Brule and**

**Chamberlain Pass before Aquifer Test 4." Does the Staff agree with Dr. Kreamer that this evidence indicates hydraulic connection?**

**A.3.4** (D. Back, T. Lancaster, E. Striz) No, we do not agree. The degree of hydraulic communication cannot be determined from the barometric pressure effects. However, because Dr. Kreamer asserts in Section 1.1.1 of his supplemental testimony (Ex. INT-079 at 2) that the barometric pressure effects can be used to determine whether vertical communication between aquifers exists, we explain below the problems with Dr. Kreamer's analysis.

In referring to the figure entitled "Background Water Levels" from the Aquifer Test 4 report (Ex. NRC-109 at 1), Dr. Kreamer stated at the evidentiary hearing that "the line that goes upward right away is the well response in the Brule" (Tr. at 1365). This statement is incorrect. Although the points are not clearly labeled in this figure, the data in Figure 9 from the Test 4 report (Ex. NRC-109 at 2) provides clarification. That figure shows that when the barometric pressure ranges between 25.8 and 26.45 inches Hg, the change in head ranges from -0.2 to 0.05 feet. In the Background Water Levels graph (Ex. NRC-109 at 1), the change in barometric pressure is similar, ranging from about 25.68 to 26.38 inches Hg. The change in head of the flatter line on the Background Water Levels graph (Ex. NRC-109 at 1) ranges between about 0.08 and 0.18 feet, which is very similar to the range observed for the Brule well in Figure 9 (Ex. NRC-109 at 2). The change in head of the steeper curve in the Background Water Levels graph (Ex. NRC-109 at 1) ranges from about 0.4 to 0.9 feet. Since the barometric efficiency will not change with time, we can ascertain from Figure 9 (Ex. NRC-109 at 2) that the well that is less responsive to barometric pressure (i.e., flatter) in the Background Water Levels graph (Ex. NRC-109 at 1) is well SM9-10, which is completed in the Brule. This is also consistent with CBR's testimony at the hearing (Tr. at 1366). Therefore, the well that Dr. Kreamer has assumed is the Brule well is actually the Basal Chadron well, and any conclusions he has drawn based on that assumption are not based on the factual data.

Dr. Kreamer also testified at the hearing that there was a lagged pressure response in the Basal Chadron Sandstone when compared to pressure responses in the Brule, and suggested that the degree to which the aquifers are connected could be calculated from the lag (Tr. at 1367). Besides being incorrect on which units the wells are completed in, the only pressure response in the Basal Chadron Sandstone is due to the pressure effects on the water within the open borehole and not the aquifer. As explained in A.3.1, these effects have absolutely nothing to do with the interconnection of the aquifers.

**Q.3.5 Dr. Kreamer states on page 3 that Aquifer Test 1 "clearly documents existence of a recharge boundary." Does the Staff agree with Dr. Kreamer's assertion and the basis he provides to support it?**

**A.3.5** (D. Back, T. Lancaster, E. Striz) No, we disagree with Dr. Kreamer's assertions. The Staff's position is that the data was matched to the correct time period. The problems inherent with using early time data are discussed in numerous text books and journal articles; a succinct explanation is provided in Ex. NRC-110 at 64 (PDF 2), which states as follows:

> 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 to 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.

In Exhibit 1 of Dr. Kreamer's supplemental testimony (Ex. INT-079 at 4), three of his five data points fall within the first ten minutes of pumping. In Exhibit 2 of his supplemental testimony (Ex. INT-079 at 4), four of his five points fall within the first twenty minutes. The matching to the early time data in those graphs will make it appear that a recharge boundary has been encountered where, in actuality, one does not exist. We disagree that this is an acceptable interpretation of the aquifer test data.

**Q.3.6 Dr. Kreamer asserts on page 3 of his supplemental testimony that "evidence in the report shows that drawdowns of piezometric surfaces with time are much less than would be expected from early data, i.e., leakage." Dr. Kreamer quotes page 2.7A-15 of the report, which states that "Figures 2.7A-4 through 2.7A-7 give the apparent indication of leakage especially noticeable at late times." He also quotes page 2.7A-22, which states that, based on the drawdown/time curves for the observation well, "some leakage from confining bed occurred during the pumping test." Finally, on page 5 of his supplemental testimony, he cites a statement on page 2.7A-13 that recovery tests have hysteresis compared to pumping tests, which could indicate vertical leakage. Could you please comment on Dr. Kreamer's assertion and these statements from the report, and their significance, if any, on the validity of the pumping test and conclusions drawn from it?**

**A.3.6** (D. Back, T. Lancaster, E. Striz) With regard to the first two statements that Dr. Kreamer cites (on pages 2.7A-15 and 2.7A-22 of Ex. BRD-002A), we understand those statements to describe leakage that is derived from storage within the aquitard that is squeezed out due to a pore pressure change, not leakage from interaquifer flow. This interpretation is supported by the statement on page 2.7A(26) of Exhibit BRD-002A that the volume of leakage derived from storage within the confining units was calculated to be about 1,000 gallons over the entire test period. Furthermore, as stated in A.3.2 of our supplemental direct testimony (Ex. NRC-095 at 9), the authors of the aquifer test report explained that the water being released from the aquitard is entirely derived from the several feet of Red Clay located immediately above the top of the Basal Chadron Sandstone. We agree with this explanation based on the very small deviation of the drawdown curve (Ex. BRD-002a at. 2.7A-19) from the theoretical prediction. The change in pore pressure caused by the pumping essentially squeezed the water out of the clay and into the adjacent aquifer. In addition, based on the low conductivity values obtained from the consolidation tests, movement of water through the clay from the overlying claystone would be unlikely as the hydraulic gradient required would be very high (Ex. BRD-002A at 2.7A(26)). Also, neither of the wells completed in the overlying Brule aquifer (i.e., PM-6, PM-7) show any response to pumping in the Basal Chadron aquifer, which provides empirical evidence that interaquifer leakage is not occurring (Ex. BRD-002A at 2.7A(15)).

With regard to the third statement Dr. Kreamer cites regarding hysteresis as a sign of vertical leakage (Ex. BRD-002A at 2.7A(13)), Dr. Kreamer provides no explanation for this assertion. It is widely accepted that hysteresis within a recovery test is due to the way aquifer storage behaves differently during pumping and recovery, as well as the observation that recovery occurs at a constant rate whereas pumping rates may vary slightly during the test.

**Q.3.7 On page 5 of his supplemental testimony, Dr. Kreamer questions the statement in the report suggesting that leakage in Test 1 is due to the varying thickness of the Basal Chadron Sandstone, and that the water comes from the Basal Chadron Sandstone and not from vertical leakage. He asserts that for the statement in the report to be valid, the aquifer thickness would have to increase in all directions radially from the pumping well. Could you please comment on this?**

**A.3.7** (D. Back, T. Lancaster, E. Striz) First, Dr. Kreamer asserts that the authors of the aquifer test report assume that the leakage shown in the late time data is caused by varying thickness of the Basal Chadron Sandstone (Chamberlain Pass Formation). In actuality what the authors state is that “the data were analyzed using a two-stage fit to the Theis type curve” and that “[t]his two-stage analysis was based on changes in aquifer thickness and permeability” (Ex. BRD-002A at 2.7A(8)). The report then states, “In addition, an analysis of leakage was performed based on laboratory testing of core samples” (Ex. BRD-002A at 2.7A(8)). One of the primary goals of the aquifer test was to determine a transmissivity (i.e., aquifer thickness multiplied by hydraulic conductivity). The approach that the report authors took in interpreting the test is common when there are significant changes in transmissivity.

On page 5 of his supplemental testimony, Dr. Kreamer states:

> . . . the aquifer thickness would have to <u>increase in all directions radially from the pumping well</u>. This is not the case as the thickness actually decreases in some directions, the transmissivity would be expected to lessen in those directions, and less water would be available as the radius of influence of the pumping well increases, not more as indicated by the data.

The assertion that the aquifer thickness would have to increase in all directions radially from the pumping well is incorrect because many aquifer features other than aquifer thickness may lead to this behavior in an aquifer test. For example, if the cone of depression intersected a high conductivity zone in one direction from the pumping well, the response of the Theis curve would show a break in slope.

Dr. Kreamer’s claim that transmissivity would be expected to decrease in directions in which thickness decreases is also incorrect. Because the aquifer test measures average transmissivity over the radius of influence of the test (i.e., aquifer thickness multiplied by permeability), it cannot differentiate between transmissivity changes due to thickness and/or permeability. Therefore, if the aquifer was getting thinner but the permeability was increasing the transmissivity could also rise. This was the point that the report authors were expressing when they stated that the core logs reveal a marked change in the grain size and sorting of material comprising the aquifer (Ex. BRD-002A at 2.7A(13)), because these are controlling factors of formation permeability.

**Q.3.8 On page 3 of his supplemental testimony, Dr. Kreamer noted that the NRC had questioned the use of a non-leaky analysis method for Test 1. On page 5 of his supplemental testimony, Dr. Kreamer notes that in response, CBR's consultant conducted a Modified Hantush analysis to characterize vertical leakage. Dr. Kreamer appears to offer a number of criticisms of this analysis. Could you please comment on his criticisms and their validity?**

**A.3.8** (D. Back, T. Lancaster, E. Striz) Dr. Kreamer has previously raised concerns regarding the applicability of the methods used to analyze aquifer pumping tests (e.g., Theis, Cooper/Jacob, Hantush) due to their inherent assumptions (e.g., homogeneous, isotropic). We addressed these concerns in A.D.11 and A.6.9 of our rebuttal testimony (Ex. NRC-076-R2 at 33-34, 66-67). We also address them in A.3.18 below.

Dr. Kreamer also raises the concern that no faults and fractures are considered in the analytical models used by the Applicant (e.g., Hantush). If faults and fractures were present in the overlying material, the pressure-response curves would have deviated significantly from the theoretical responses, but they did not. The assumptions with respect to the properties of the overlying aquitard were consistent with the primary objectives of the test, which were to gain additional information on the average transmissivity and behavior of overlying confining layers.

Dr. Kreamer's concern regarding the use of single values of hydraulic conductivity is addressed in A.3.15 below, which questions the relevance of collecting additional data in order to use averages (as suggested by Dr. Kreamer) when the clay has such low permeabilities.

In general, we believe that Dr. Kreamer seems to be missing the point of the drawdown curve analysis, which is to determine the average permeability of the formation being tested and its confinement. Dr. Kreamer's suggestion to test the hydraulic response of the Basal Chadron Sandstone aquifer over a range of hydraulic conductivity values within the aquifer and in the overlying confining layers (Ex. INT-079 at 5, end of paragraph 2) would require the development of a detailed ground water flow model, which is subject to even greater uncertainty. Such modeling is beyond the objectives of the aquifer testing required for NRC safety or environmental reviews of ISR facilities.

**Q.3.9 On page 5, Dr. Kreamer asserts that instead of using ensemble field data to characterize the hydraulic conductivity of the underlying and overlying formations, CBR used laboratory analysis of disturbed samples from a single borehole. Could you comment on this?**

**A.3.9** (D. Back, T. Lancaster, E. Striz) It is not clear what Dr. Kreamer means by ensemble field data; however, the important aspect of the overlying and underlying confining units are their confinement properties. It is common knowledge that laboratory data will not be as representative as field data. This is why scientists place far more reliance on the results of the large scale aquifer tests than on the core results. The primary reason that core samples were collected in conjunction with the aquifer test is that there was no response in any of the overlying wells from which vertical hydraulic conductivity data could be determined.

Dr. Kreamer is also misrepresenting the degree to which the hydraulic properties of the upper and lower confining units have been characterized. CBR has installed over 10,000 boreholes and has performed lithologic descriptions of the drill cutting as well as geophysical logging on each of the boreholes, from which hydraulic properties can be estimated (Tr. at 1059-60). Furthermore, it does not really matter if the hydraulic conductivities of the confining units vary by several orders of magnitude provided they provide adequate confinement, which the aquifer tests clearly demonstrate.

**Q.3.10 On page 5, Dr. Kreamer asserts that the report fails to provide information on several aspects of the laboratory testing, including test methodologies, number of replications, sampling technique, number of samples, or statistical analysis of the representativeness of the samples. He also asserts that there is no visual documentation of the samples, no information on fracture analysis, and no geophysical analysis. Can you please comment on this?**

**A.3.10** (D. Back, T. Lancaster, E. Striz) Hydraulic properties are rarely determined from cores as part of an aquifer test. ASTM standards for aquifer testing do not specify that core samples of the overlying and underlying aquitards be collected and analyzed. The degree of description provided in the Test 1 report is commensurate with the relative unimportance of the data since the aquifer test demonstrated confinement (i.e., through lack of response in overlying aquifer wells). As explained in A.3.9 above, the important aspects of the overlying and underlying confining units are their confinement properties. Dr. Kreamer's claims that no geophysical analysis was reported are misleading because these were aquifer pumping tests that were not intended to describe all of the investigative work that has been completed at the site. For example, as we mention in A.3.9 above, CBR has collected geophysical data at the site from over 10,000 boreholes (Tr. at 1059-60). In conclusion, we emphasize that none of the information that Dr. Kreamer refers to or the extra investigations he suggests (e.g., visual documentation, fracture and statistical analysis) is necessary to conduct an aquifer test to demonstrate confinement.

**Q.3.11 In several places in his supplemental testimony (e.g., pages 3 and 6), Dr. Kreamer asserts that there is a lack of information that makes independent peer review and further analysis of Test 1 difficult. Could you please comment on this?**

**A.3.11** (D. Back, T. Lancaster, E. Striz) The aquifer test reports provide a description of the test objectives, field methodology, plots of all of the relevant pressure-drawdown and barometric data, and analytical model results. Dr. Kreamer has not explained why the information provided was insufficient for the Staff to complete its safety and environmental reviews of these tests.

**Q.3.12 On page 6, Dr. Kreamer asserts that all of the analytical methods used in the report assume homogeneous, isotropic strata of uniform thickness, and he cites information in the report (pages 2.7A-13, 20 and 22) to support this assertion. Could you please comment on this?**

**A.3.12** (D. Back, T. Lancaster, E. Striz) Dr. Kreamer cites the discussion on page 2.7(A)-13 of Exhibit BRD-002B-R in asserting that the Basal Chadron Sandstone is not uniform in thickness and therefore the analytical methods are invalid. We disagree. Our position is that the authors' discussion of how the traditional Theis analysis was modified due to changes observed in transmissivity (thickness multiplied by hydraulic conductivity) illustrates perfectly the process described in our oral testimony (Tr. at 1284-85), where we stated that the shape of the drawdown curve leads to the selection of the analytical method used for the data analysis. In Test 1, the Theis method was used to provide transmissivity matches to the two areas where the transmissivity was significantly different.

Dr. Kreamer also cites pages 2.7A-20 and 2.7A-22 of Exhibit BRD-002B-R, asserting that they provide information that demonstrates the Basal Chadron Sandstone has a variable transmissivity and is anisotropic. The information provided on page 2.7A-20 is a table that shows the ranges of transmissivity that were obtained from the aquifer test. As described on page 2.7A-22, the directional properties of transmissivity of the aquifer were obtained by having four observation wells located in different directions from the pumping well. We find Dr. Kreamer's logic somewhat circular in that he cites the range of transmissivities actually calculated from the aquifer test as a reason for not being able to apply the methods. Analyzing the data from the different wells at different locations provides another means to reduce the impact of the uniform assumptions for the analytical models.

Finally, we addressed Dr. Kreamer's broader concerns regarding the applicability of the selected analytical methods used in the aquifer pumping tests (e.g., Theis, Cooper/Jacob, Hantush) in A.D.11 and A.6.9 of our rebuttal testimony (Ex. NRC-076-R2 at 33-34, 66-67), and summarize those discussions in A.3.18 below.

**Q.3.13 On page 7 of his supplemental testimony, Dr. Kreamer states that Figure 2.7-14 in the Test 2 Report (Ex. BRD-002B-R at 2.7(40)) incorrectly considers only late time data, and that when early data is considered (as shown in his redrawn plot in Exhibit 3 of Ex. INT-079), it demonstrates a recharge boundary. He also asserts that Figure 2.7-20 of the Test 2 Report (Ex. BRD-002B-R at 2.7(46)) also illustrates this boundary. How does the Staff respond?**

**A.3.13** (D. Back, T. Lancaster, E. Striz) We disagree with Dr. Kreamer and find several problems with his reinterpretation of the data. Dr. Kreamer's Exhibit 3 (Ex. INT-079 at 7) is a modified version of Figure 2.7-14 from the Test 2 Report (Ex. BRD-002B-R), which he has redrawn to match to the early time data. He subsequently concludes that a recharge boundary is indicated at the break between the early and late drawdown lines (Ex. INT-079 at 7). Dr. Kreamer has used the data from the first 30 minutes of the test to establish that there is a recharge boundary. But, as stated in

A.3.5 above, the early time data is not representative of the aquifer properties and system behavior. Additionally, as explained in Exhibit NRC-111:

> The graph of drawdown vs log (time) may be divided into three zones, the early one being influenced by storativity, pumping well pipe capacity and skin effects (among others), the latest by boundary effects, and the intermediate one by the transmissivity and storativity of the aquifer. The differences between the theoretical solutions are maximal in the early data zone. Because both solutions consider a pumping well of infinitesimal diameter, the early time data graph may be distorted by the influence of real well pipe storage capacity and, consequently, may yield a poor estimate of the parameters of the aquifer.

In essence, this explanation says to use the middle time data to establish aquifer properties, the late time data to assess whether recharge boundaries exist, and not to use the early time data for anything. Second, as explained in A.3.1 above, when a recharge boundary is encountered the drawdown does not continue along the same slope but continues to curve upward, as opposed to following a line of a constant slope as the cone of depression moves outward and encounters greater recharge. Third, as shown in Table 2.7.3 of the Test 2 Report, the piezometer (UCP-1) was placed approximately 81 feet away from the pumping well and only 15 feet above the top of the Basal Chadron Sandstone (Ex. BRD-002B-Rat 2.7(21)). If a recharge boundary had been encountered within the first 30 minutes of the test the water would have to have been derived from the overlying and underlying confining units, and water level changes would have been detected in UCP-1. As shown in Figure 2.7-21 of the Test 2 Report, however, no response to pumping was observed at the monitoring point (UCP-1) during the pumping test (Ex. BRD-02BR at 2.7(49)).

**Q.3.14 On page 8 of his supplemental testimony, Dr. Kreamer again asserts for Test 2 that assumptions were made that are not supported by test data. These assumptions include uniform, continuous, horizontal "layer-cake" strata. He cites information in the report that illustrates non-uniform thickness, anisotropy,**

**and lack of homogeneity of the Basal Chadron Sandstone (pages 2.7(15) and 2.7(53)). How does the Staff respond?**

**A.3.14** (D. Back, T. Lancaster, E. Striz) As stated in A.3.12 above, we addressed Dr. Kreamer's broader concerns regarding the applicability of the selected analytical methods used in the aquifer pumping tests (e.g., Theis, Cooper/Jacob, Hantush) in A.D.11 and A.6.9 of our rebuttal testimony (Ex. NRC-076-R2 at 33-34, 66-67), and summarize those discussions in A.3.18 below.

With regard to his specific criticisms, Dr. Kreamer cites text on pages 2.7(15) of Exhibit BRD-002B-R that indicates the regional thicknesses of the Basal Chadron Sandstone range from 0 to 350 feet and only provides an approximate average thickness of 40 feet at the site. We are not sure what his concern is with respect to this information. The report indicates that the thickness at the site was determined from logs (Ex. BRD-002B-R at 2.7(15)). Dr. Kreamer also asserts that the discussion on page 2.7(53) of Exhibit BRD-002B-R demonstrates that there are directional components to transmissivity which indicate a complete lack of homogeneity. Again, we find this logic circular in that the directional components of the transmissivity were determined by the aquifer tests and analysis.

Dr. Kreamer seems to lose sight of the fact that the aquifer tests are used for determining average aquifer properties and most importantly to assess hydraulic confinement of the production zone aquifer from overlying aquifers. When no impact from the aquifer test was observed in the overlying Brule aquifer monitoring wells during aquifer testing, hydraulic confinement was confirmed. To support this finding, CBR also provided data in Test 2 which showed no response in a piezometer (UCP-1) in the overlying clay layer, as well as laboratory core testing results for the clay layer, as further confirmation of hydraulic confinement of the Basal Chadron aquifer from overlying aquifers.

We believe that the results of the aquifer tests/analysis and the core tests performed by CBR provided sufficient information for the Staff to perform its review of hydrogeology and hydrology, and although Tests 1, 2 and 3 were reviewed prior to the adoption of NUREG-1569, we believe that they would satisfy acceptance criterion 2.7.3(3) in NUREG-1569 (Ex. NRC-013 at 62).

**Q.3.15 On page 8, Dr. Kreamer again asserts that the hydraulic conductivity and hydraulic resistance values assigned to the overlying strata are based solely on lab tests on material from a single borehole known to represent a zone of low hydraulic conductivity. He asserts that the variation in coefficient of consolidation and hydraulic conductivity of samples taken from within a few vertical feet of each other demonstrates lack of homogeneity. He also states that the report does not quantify vertical or horizontal variation of properties, does not provide visual documentation of samples or fracture analysis. Could you please comment on these criticisms?**

**A.3.15** (D. Back, T. Lancaster, E. Striz) Dr. Kreamer's concern regarding the use of geotechnical test results on samples from a single borehole does not seem logical to us. The core samples were collected as the hole was being drilled to install UCP-1 and prior to conducting the aquifer test. Furthermore, since CBR reported that the Basal Chadron Sandstone is overlain by clay throughout the License Area, we are unsure how areas of high hydraulic conductivity would be present much less identified.

With regard to Dr. Kreamer's concerns regarding variation in coefficient of consolidation and hydraulic conductivity for samples taken within a few vertical feet of each other, the calculated values of hydraulic conductivity shown in the table that Dr. Kreamer cites range from $2.22 \times 10^{-11}$ to $4.46\times10^{-11}$ cm/sec. Engineered clay liner hydraulic conductivities range from about $10^{-6}$ to $10^{-11}$ cm/sec. The fact that the hydraulic conductivities of the red clay vary by a factor of two at these extremely low values does not demonstrate to us that these results indicate the clay is heterogeneous. Further, we do not consider homogeneity assumptions in the analytical models to be a serious limitation in the analysis. From an application standpoint, the analytical mathematical models treat the overlying confining layer as resistance to flow based on the net effect of the properties within the aquitard and the assumed homogeneity is not a serious limitation.

**Q.3.16 Dr. Kreamer states on page 8 of his supplemental testimony that laboratory test values were used not only for the overlying red clay layer but for other formations, including the Upper Chadron and lower Brule, and that there is no basis to arbitrarily assign low hydraulic conductivity values to these strata without measuring them. How does the Staff respond?**

**A.3.16** (D. Back, T. Lancaster, E. Striz) We disagree with this assertion. First, the Test 2 Report stated (Ex. BRD-002B-R at 2.7(50)):

> Analysis of drill cuttings and geophysical logs of UCP-1 and exploration holes in the vicinity of the test site show that the lithology of the strata between the Red Clay and the overlying Brule aquifer (Upper Chadron and Lower Brule Formations) is similar to the Red Clay. Therefore, it is reasonable to assume that the hydraulic characteristics of these strata are similar to those of the Red Clay.

Second, the predicted travel time through the upper confining layer would be about 2,860,000 years based on the entire confining unit having the properties of the red clay. If the hydraulic conductivity in the units above the red clay was assumed to be ten times greater, the travel time would still be about 286,000 years. Since the intent of the travel time calculations in the report was to show how incredibly long these times are, the Staff's position is that the assumption of uniform hydraulic conductivity is appropriate. Furthermore, these predicted travel times are for water. The travel times of dissolved constituents that are slowed by retardation processes (e.g., precipitation, sorption) would be significantly longer.

**Q.3.17 On pages 8-9 of his supplemental testimony, Dr. Kreamer states that single, averaged values were used for hydraulic conductivity in confining layers rather than a range of values to simulate field drawdown scenarios. He claims that this is "unusual and restrictive." Does the Staff agree?**

**A.3.17** (D. Back, T. Lancaster, E. Striz) We are not sure what Dr. Kreamer is referring to in this statement. The only vertical hydraulic conductivity value that was calculated in the field was for the underlying Pierre Shale. This is why only one field value is reported. Since there was no response to pumping above the Basal Chadron Sandstone, vertical hydraulic conductivity in the overlying layer could not be determined from the aquifer test. If Dr. Kreamer is referring to the hydraulic conductivity data obtained from the consolidation tests, as discussed in A.3.15 above, all of the values ranged from $2.22 \times 10^{-11}$ to $4.46 \times 10^{-11}$ ft/day. At these low values the aquifer test results would be insensitive to the assumption of a single averaged value or changes over the range of hydraulic conductivities. They would all demonstrate confinement.

**Q.3.18 On page 9 of his supplemental testimony, Dr. Kreamer asserts that the analysis methods used in Test 3 (Theis, Jacob and Cooper-Jacob) are based on assumptions that do not reflect field conditions.**

**A.3.18** (D. Back, T. Lancaster, E. Striz) In his initial testimony, Dr. Kreamer raised these same criticisms about the analytical methods employed in the analysis of aquifer tests. In A.D.11 and A.6.9 of our rebuttal testimony (Ex. NRC-076-R2 at 33-34, 66-67), we addressed these criticisms in detail. Furthermore, Dr. Kreamer does not explain why these methods are inappropriate for the stated field conditions.

As we stated in our earlier rebuttal testimony, these methods are widely used and accepted standard methods taught in hydrogeology and hydrology courses today, and they have been incorporated into ASTM standards related to aquifer testing (Ex. NRC-080). Dr. Kreamer suggests that these methods are only reliable for systems that are isotropic and homogeneous, but if that is the case, these methods would never be applicable, since no hydrogeologic systems are truly homogeneous and isotropic. Furthermore, as we testified during the hearing, the drawdown curves determine which analytical method to select in order to best match the data (Tr. at 1284-85).

**Q.3.19 On page 9, Dr. Kreamer asserts that no vertical leakage analysis was performed, and quotes the report as stating that Test 3 "was not performed to quantitatively assess the nature of the confining layer above the Chadron Sandstone." He also states that no testing was done to support the assumption that hydraulic characteristics of the overlying layers would be the same as in Tests 1 and 2. Can you comment on these statements?**

**A.3.19** (D. Back, T. Lancaster, E. Striz) Dr. Kreamer misunderstands the reasons that no vertical leakage analysis was performed in Test 3. Because the authors of the test indicate that there was no response to pumping in the overlying aquifer a quantitative leakage analysis could not be performed on the confining layer. Furthermore, no leakage analysis was necessary because these results demonstrated hydraulic isolation.

With regard to the statement that the test was "not performed to quantitatively assess the nature of the confining layer above the Chadron Sandstone," Dr. Kreamer goes on to state that the report authors "simply make a broad statement that the hydraulic characteristics of the overlying layers would be the same as in Aquifer tests 1 and 2," and that "[n]o geotechnical testing on geologic material, geophysical testing, or fracture analysis was documented for this third site to support this summary assumption" (Ex. INT-079 at 9). We disagree with his characterization. The authors of the report indicate that they expected the hydraulic characteristics of the central portion of the License Area to be similar to those of the northern area because of similar geology and thicknesses. We agree with the authors that this is a perfectly reasonable conclusion that was confirmed by the aquifer test results, which indicated confinement over the entire area of influence for the 3 tests.

With respect to Dr. Kreamer's assertions regarding other characterization activities that were not performed as part of the aquifer testing, those activities (e.g., geotechnical, geophysical tests) he suggests are not included in any ASTM standards associated with aquifer testing, nor are they required to allow the Staff to complete its safety and environmental reviews. Furthermore, as discussed in A.3.9 above, CBR has installed over 10,000 boreholes at the site, and performed lithologic descriptions of the drill cutting as well as geophysical logging on each of the holes (Tr. at 1059-60).

**Q.3.20 On page 9, Dr. Kreamer states that the reports for Tests 1, 2 and 3 give "great weight" to a lack of immediate response in the Brule formation water levels to pumping in the Basal Chadron Sandstone, but that no long term response was considered or measured. How does the Staff respond?**

**A.3.20** (D. Back, T. Lancaster, E. Striz) The pumping phases of the aquifer tests ranged between 51 and 72 hours. The pressure response data in the Brule was collected, plotted and analyzed over the entire test period and showed no pumping-induced water level changes in the Brule. We do not consider these tests to represent a short-term, immediate response. On the contrary, aquifer pumping tests of this length are considered long-term tests which are designed to stress an aquifer sufficiently to see its behavior over a large radius of influence. Each of these tests stressed the Basal Chadron aquifer over a radius of influence of between 4,000 and 5,700 feet (Ex. CBR-011 at pg. 2-213). The tests also stressed the aquifer in the vertical direction through the overlying confining layers which showed no vertical communication with the Brule aquifer in any test. If any vertical communication was present it would have been seen in the Brule during these long term tests. The lack of response demonstrated a lack of hydraulic communication. This conclusion is also supported by the long-term monitoring data collected from the Brule aquifer and discussed in this supplemental rebuttal testimony under Issue 1. In A.1.4 above, we discuss the record of water levels collected in several Brule wells since the startup of each well field, and explain that none of the associated hydrographs indicate any responses due to pumping in the Basal Chadron Sandstone aquifer.

**Q.3.21 Dr. Kreamer claims on page 9 of his supplemental testimony that the interpretation made based on lack of immediate response presupposes that the few monitoring wells in the overlying Brule were optimally placed and truly representative. He states that this is unlikely because the Brule is documented to be heterogeneous and there was no documentation that piezometers or wells were optimally placed. Could you please respond?**

**A.3.21** (D. Back, T. Lancaster, E. Striz) The monitoring wells in the overlying Brule were placed almost directly above the pumping well which would be the most likely area to see an impact. The Staff consider this an optimal location to see a response if a vertical connection was present. The fact that the Brule is heterogeneous does not adversely affect the results because the connecting permeability across the entire Brule aquifer is still high enough to allow the water table to be affected by pumping if the aquifers were hydraulically connected, which they are not.

**Q.3.22 On pages 9-10 of his supplemental testimony, Dr. Kreamer claims that standard practice is to measure response in an array of wells rather than one or two. He claims that given the lack of homogeneity in geological and hydrological characteristics of the overlying strata, the interpretation of the water level response based on so few monitoring points is flawed. How does the Staff respond?**

**A.3.22** (D. Back, T. Lancaster, E. Striz) Dr. Kreamer provides no supporting documentation (e.g., citation to a particular ASTM standard) to support his claim that standard practice requires an array of wells in an overlying aquifer. In fact, that decision is based entirely on what design will meet the objectives of the test. For the pumping tests at the CBR facility, the objective was to assess if there was any evidence of lack of if confinement. As explained in A.3.21 above, the placement of the overlying Brule well next to the pumping well is the optimal location to see if vertical communication is present, because the drawdown stress from the pumping in the Basal Chadron Sandstone aquifer would be greatest in this location. If any response had been seen in the overlying aquifer observation well, further testing with more Brule wells would have been indicated. Because no response was seen, no additional testing was needed. In addition, as described in A.1.4 above, there has been no response in the Brule aquifer, as measured by water levels in the over 200 overlying excursion monitoring wells, after more than 20 years of continuous pumping of the Basal Chadron Sandstone aquifer.

**Issue 4**: **Whether the Basal Chadron/Chamberlain Pass formation exists beneath the Pine Ridge reservation and its connection (if any) to the Basal Chadron/ Chamberlain Pass formation beneath the license renewal area**

**Q.4.1** **Dr. LaGarry states that NRC staff has not practiced due diligence in its evaluation of the nomenclature of the Chamberlain Pass formation and its application to the Basal Chadron Sandstone at the CBR License area or its presence on the Pine Ridge Reservation. Does the Staff agree with this characterization?**

**A.4.1** (D. Back, T. Lancaster, E. Striz) We disagree with Dr. LaGarry's characterization. As discussed in our initial testimony at A.F.6 (Ex. NRC-001 at 56-58), the Staff specifically considered the proposed Chamberlain Pass nomenclature in its safety review, and discussed its findings in its Safety Evaluation Report (SER) (Ex. NRC-009 at 15).

Before making a decision to retain the Basal Chadron Sandstone nomenclature in the SER, the Staff reviewed available literature on the topic, including references cited in Exhibit INT-003, such as Swinehart (1985), Terry (1998), and Terry and LaGarry (1998). In fact, the SER (Ex. NRC-009 at 19) cites one of the papers for which Dr. LaGarry provided an abstract (Ex. INT-075).

As part of its literature review, the Staff also reviewed the current United States Geological Survey (USGS) nomenclature for Nebraska and South Dakota on the USGS National Geologic Map Database website. As reported in the SER, the USGS did not include the Chamberlain Pass Formation in the White River Group or Chadron stratigraphic description in Nebraska (Ex. NRC-009 at 15). As stated in our initial testimony at A.F.6, that has not changed (Ex. NRC-001 at 57 (citing Ex. NRC-033, Ex. NRC-034, and Ex. NRC-035)).

We believe the Staff's review of the literature on this nomenclature issue was appropriate in scope and depth and consistent with the Staff's review guidance in NUREG-1569 (Ex. NRC-013 at 2-16 to 2-19). The purpose of the SER is to describe the Staff's safety evaluation of the continued operation of the Crow Butte facility, not to assess whether a proposed lithostratigraphic change should be adopted. As the Staff explained in the SER (Ex. NRC-009 at 15), "nothing in the naming conventions for the geologic units . . . affects the interpretation of the physical and hydraulic features of the rock units." Similarly, the purpose of the Staff's EA was to describe and analyze the potential environmental impacts of renewing the CBR license. In this regard, as we explained in our initial testimony at A.F.7, "The choice of nomenclature has no effect whatsoever on the evaluation of hydrogeology and environmental impacts on surface and ground water" (Ex. NRC-001 at 58). In summary, the Staff's literature review on this issue was appropriately comprehensive, and demonstrated due diligence in the context of the Staff's safety and environmental reviews.

**Q.4.2 On page 4 of his testimony, Dr. LaGarry states that "one of the primary differences between the 1998 revision [of the Basal Chadron to Chamberlain Pass] and earlier concepts applied to these rocks is that the revised units are lithostratigraphic units based on descriptions of lithology." He then states that these descriptions "are based on precise descriptions of material constituents including heterogeneity, grain sizes (from which porosity and permeability can be inferred), and mineralogy, among others" and that these descriptions were "omitted from the older conceptual models." How does the Staff respond?**

**A.4.2** (D. Back, T. Lancaster, E. Striz) First, we note that Dr. LaGarry cites the paper by Terry and LaGarry published in 1998, which is not an exhibit in this proceeding. And in any event, Dr. LaGarry's statement is not relevant to the Staff's review of the CBR license renewal application. The work by Terry and LaGarry (1998) and LaGarry (1998) is based on observations of outcrops. In addition, the bulk of the work described by Dr. LaGarry concerning the Chamberlain Pass Formation appears to be based on observation of outcrops. As discussed in written testimony and in oral testimony at the hearing, the Staff's review is based on site-specific information provided by CBR from their analysis of geophysical logs and drill cuttings from thousands of boreholes. The descriptions of material properties in Dr. LaGarry's statements quoted above were based on outcrop observations, but there is no need to draw inferences from these descriptions of outcrops located miles away from the CBR facility when there is site-specific information from boreholes at the site that pass from the ground surface through the Brule, Upper and Middle Chadron formations, and Basal Chadron Sandstone, and ending in the Pierre Shale.

**Q.4.3 On page 4 of his supplemental testimony, Dr. LaGarry states that "NRC staff suggested that the USGS occupied the role of arbiter in stratigraphy, but that is a misperception," and in actuality the arbiter of stratigraphic protocols in the**

**North American Commission on Stratigraphic Nomenclature. Could you please comment on these statements?**

**A.4.3** (D. Back, T. Lancaster, E. Striz) We have testified, both in writing and orally, that the USGS has not recognized the Chamberlain Pass Formation in Nebraska, and that the Staff has reservations about using that terminology given that the USGS has not recognized it (Ex. NRC-001 at 57; Tr. at 1653, 1818-19). We have also stated that the USGS is the federal authority on geological nomenclature and, therefore, that the Staff defers to currently used and accepted USGS definitions with respect to nomenclature (Ex. NRC-001 at 57).

As stated at the evidentiary hearing, we are aware of the North American Stratigraphic Code and its provisions (*see* Tr. 1818-19). However, we are not aware that the Chamberlain Pass nomenclature is a widely accepted revision for the Basal Chadron Sandstone in the state of Nebraska, in part because it is not recognized by the USGS in its National Geologic Map database website for Nebraska (Exs. NRC-033, NRC-034, NRC-035). The Chamberlain Pass nomenclature is also not used in stratigraphic descriptions in several recent USGS publications (see, e.g., Exs. NRC-025 and BRD-003). Finally, as discussed in A.4.5 of our supplemental direct testimony (Ex. NRC-095 at 19), Exhibit NRC-099 shows that the "Chamberlain Pass" nomenclature is not universally used even in Nebraska.

**Q.4.4** **On page 4 of his supplemental testimony, Dr. LaGarry cites several figures in Ex. BRD-004 (Terry, 1998) that show photographs of outcrops north and west of the Pine Ridge Reservation, along with one near Red Shirt village on the reservation, and one in White Clay, Nebraska on the southern border of the reservation. He also provides some additional photographs of outcrops on the reservation and in northwest Sioux County, Nebraska. What is the significance of this information?**

**A.4.4** (D. Back, T. Lancaster, E. Striz) We acknowledge that Dr. LaGarry has provided photographs of outcrops of the Chamberlain Pass Formation, some of which are on the Pine Ridge Reservation (Ex. INT-080 at 5). All of the outcrops appear to be significant distances from the CBR facility. While the photographs may provide evidence that this formation exists at those locations, it does not provide evidence of specific pathways through which contamination could move. As summarized in our supplemental direct testimony (Ex. NRC-095 at 16-19), there is no evidence of such pathways. In his supplemental testimony, Dr. LaGarry has provided no evidence of specific pathways, but instead merely speculates about a "complex network of intersecting joints and faults" that may exist (Ex. INT-080 at 6).

**Q.4.5** **On page 6 of his supplemental testimony, Dr. LaGarry discusses Exhibit BRD-003, a USGS report that describes "conceptual and numerical models of groundwater flow in the Ogallala and Arikaree aquifers in the Pine Ridge Reservation." He states the disparities between accepted geological facts (i.e., the recognition of the Chamberlain Pass Formation) and those presented in Exhibit BRD-003 are due to (1) lack of due diligence and (2) the narrow focus of the paper on computer modeling of hydrogeology. How does the Staff respond?**

**A.4.5** (D. Back, T. Lancaster, E. Striz) We do not agree. The USGS report is a Scientific Investigations Report (SIR) which undergoes both rigorous internal and external peer review before publication. The report addresses the development of a new conceptual model of the ground water flow system at the Pine Ridge Reservation. The report therefore provides an updated description of the geology and hydrogeology at the reservation, which is based not only on historical and current research, but also on available historical and current physical data such as well borings. The description of the geology and hydrogeology is addressed at length on pages 5 to 18 of Exhibit BRD-003. In particular, Table 3 (page 10), and Figures 5-8 (pages 13 to 16) reference reports and papers from 1971-2013. The stratigraphic section in Table 3 (Ex. BRD-003 at 10) specifically describes the geology, referencing Ellis and Adolphson (1971), Heakin (2000), Clark and Heakin (2007) and Martin and others (2004). The report also states that "the lithologic database of the South Dakota Department of Environment and the Nebraska Statewide Test-hole database were the primary source of data for the interpretation of the hydrogeologic framework" (Ex. BRD-003 at iii). In our opinion, the USGS developed its geologic and hydrogeologic conceptual model of the Pine Ridge reservation in Exhibit BRD-003 based on recent research, including state-maintained historical and recent borehole test data. Therefore, we do not agree that the exclusion of the Chamberlain Pass from the description of the White River Group in Exhibit BRD-003 reflects a lack of due diligence or a narrow focus on modeling that led the authors to omit or overlook details.

**Q.4.6 On page 6 of his supplemental testimony, Dr. LaGarry states that there is water contaminated with radionuclides migrating along the Whiteclay Fault in southern Oglala Lakota County on the Pine Ridge Reservation. He claims that its source "could be ISL contamination within a network of intersecting faults and joints." Does the Staff dispute this claim?**

**A 4.6** (D. Back, T. Lancaster, E. Striz) Yes, we dispute that claim, because Dr. Lagarry has presented no physical evidence to support it. In our prior testimony (e.g., Ex. NRC-001-R at 14-16, 27-33, 35-36, 38-39; 30-31, 32-33; Ex. NRC-076-R2 at 45-48), we discussed extensively the evidence demonstrating that there are no pathways that would allow contamination from the CBR facility to travel over significant distances to reach the Pine Ridge Reservation. We also explained in A.D.23 of our rebuttal testimony (Ex. NRC-076-R2 at 48-50) that "naturally-occurring uranium on and near the Pine Ridge Reservation is the most likely explanation" for water quality test results showing elevated uranium levels in ground water at wells on the reservation. Most recently, in our supplemental direct testimony at A.4.4 and A.4.5 (Ex. NRC-095 at 16-19), we summarized our prior testimony and explained why some of the Intervenors' new exhibits actually provide additional evidence supporting the explanation that uranium levels are naturally elevated.

**Issue 5: To what degree (if any) do the additional exhibits affect the conclusions regarding the structure of the White River feature and the NRC Staff's maximum likelihood modeling**

**Q.5.1 On page 12 of his supplemental testimony, Dr. Kreamer makes twelve claims about the ground water modeling conducted by the Staff which was used as input for the Bayesian maximum likelihood analysis to evaluate the behavior of the White River Structural Feature. Could you please comment on these claims?**

**A.5.1** (D. Back, T. Lancaster, E. Striz) No, none of Dr. Kreamer's claims impact the Staff's conclusions regarding the White River structural feature. We address each claim below.

Dr. Kreamer's first claim is that folds can have great vertical permeabilities, so the model results are "somewhat irrelevant." Dr. Kreamer has not provided any evidence regarding the permeability of the White River structural feature to support this assertion.

Dr. Kreamer's second and third claims are that the ground water modeling only addresses a distant, large-scale feature and ignores possible smaller faults and fractures, and that the modeling ignores evidence of vertical leakage near the CBR License Area. As we stated in A.5.4 of our supplemental direct testimony (Ex. NRC-095 at 24-25), and as the Staff stated in its modeling report (Ex. NRC-093 at 1-2), the purpose of the ground water modeling was to assess the probability of different site conceptual models of the White River structural feature at the North Trend Expansion Area as a conductive fault or non-conductive fault or not present. The White River structural feature is located approximately 2 miles from the northwest boundary of the

CBR License Area. The model is not intended to address small scale features or leakage at the CBR License Area.

Dr. Kreamer's fourth claim is that the model is rudimentary. As explained in the Staff's modeling report (Ex. NRC-093 at 2), the model was intended to be a gross scale assessment of site conceptual models to determine the likely behavior of the White River structural feature. Such models are necessarily rudimentary, addressing only features which control the ground water flow system. Once a site conceptual model is selected based on this probability analysis, any additional modeling based on it can be more rigorously defined and calibrated, as conceptual site model uncertainty has been reduced.

Dr. Kreamer's fifth and sixth claims are that the modeling is dependent on the selection of input parameters and that no sensitivity analysis of these parameters was performed. We agree that all ground water flow models are dependent on the selection of the input parameters, and those parameters should honor field-measured data whenever possible. Most of the input parameters were based on or reflected the range of field measured values, except for the value used for recharge in Simulation 1 (Ex. NRC-093 at 7). With regard to sensitivity analysis, as explained in the Staff's modeling report, the Staff does not know if a sensitivity analysis of the input parameters was conducted by the original modeler.

Dr. Kreamer's seventh claim is that no rigorous analysis justifying the mathematical uniqueness of the solutions and probabilities was presented. In A.D.21 of our initial testimony (Ex. NRC-001 at 47), A.5.4 of our supplemental direct testimony (Ex. NRC-095 at 24), and in the Staff's modeling report (Ex. NRC-093 at 7), it is clearly explained that no ground water modeling effort can be shown to provide a unique solution to the ground water flow system. It therefore follows that any probability analysis based on the calibration of the models can also never be unique.

Dr. Kreamer's eighth claim is that no justification was given for the grid layering, grid spacing, boundary conditions or grid domain. The Staff explained in its modeling report (Ex. NRC-093 at 3-4) that the original modeler did not provide justifications for the selection of these items. However, we observe that the selection of the grid features, layer definitions, boundary conditions and grid domain reflect or are based on known and measured site features. For example, the grid side length used in the models covers the range of 25 to 100 feet, which is also a typical value used in models that are calibrated to aquifer pumping tests.

Dr. Kreamer's ninth and tenth claims are that the specific model algorithms have weaknesses when applied to this geological setting and the numerical stability of the model is not addressed. We cannot comment on the claim that the specific model algorithms have weaknesses because no specific weaknesses were identified. With regard to the numerical stability of the model, this claim is also too general for us to address. We note, however, that the ground water flow model, MODFLOW 2000, is a widely accepted model which is appropriate to application in most geological settings, including the ones addressed in the modeling effort. As explained in the Staff's modeling report (Ex. NRC-093 at 7), the modeler used the pre-conjugate gradient solver option in MODFLOW 2000, which is known to be numerically stable. Also, if a ground water model is not numerically stable it generally will not converge on a solution. All of the Simulation 1 and Simulation 2 models provided by the original modeler converged to a solution, indicating the solutions were numerically stable.

Dr. Kreamer's final two claims are that modeling particulars concerning the architecture and running of the model were not well-justified, and that rigorous calibration and model validation were not carried out. The Staff explained in its modeling report (Ex. NRC-093 at 5) that the original modeler did not provide any details on the execution of the models, including their iterative calibration, and did not indicate whether any validation was done. As a result, we cannot comment on these claims. As we stated in A.5.2 of our supplemental direct testimony (Ex. NRC-095 at 20-22), we cannot defend the steady state calibration of the Simulation 1 and 2 models without justification from the original modeler.

**Q.5.2 Do the Intervenors provide any evidence in their supplemental testimony and exhibits that affect the Staff's conclusions regarding the nature of the White River structural feature or the environmental impacts to surface and ground water discussed in the EA?**

**A.5.2** (D. Back, T. Lancaster, E. Striz) No. Dr. Kreamer's observations are limited solely to the Staff's modeling effort, and the Intervenors have not provided any new exhibits related to the characterization of the White River structural feature. In A.5.3 of our supplemental direct testimony (Ex. NRC-095 at 22-24), we discussed all of the additional bases that support the Staff's conclusion that the White River structural feature is not a transmissive fault and thus is not a pathway for contamination of surface or ground water.

**<u>Issue 6</u>: <u>To what degree (if any) do the additional exhibits illustrate the ground water flow directions in the Arikaree and Brule aquifers underlying the Pine Ridge reservation and the license renewal area</u>**

**Q.6.1 In paragraph (d) on page 3 of his supplemental testimony (Ex. INT-080), Mr. Wireman repeats a statement from his initial testimony (Ex. INT-047 at 3) regarding uncertainty in direction of ground water flow in the Brule aquifer. He then states, "While local variation in flow direction is common, there is no trend data at key locations that would allow determination if the variations are seasonal, climate related or related to mining operations." Could you please respond?**

**A.6.1** (D. Back, T. Lancaster, E. Striz) We addressed Mr. Wireman's statement about the uncertainty of ground water flow direction in A.C.6 of our rebuttal testimony (Ex. NRC-

076-R2 at 15) and in A.6.3 of our supplemental direct testimony (Ex. NRC-095 at 27). In those responses, we acknowledged that ground water flow directions in the Brule aquifer may vary due to various causes, such as precipitation events or potentially pumping water from local private wells in the Brule aquifer. We also noted that all of the reported information indicates that ground water flow in the Brule is towards the White River since the river acts as a regional drain for ground water. Because Mr. Wireman merely repeats his original statement, we do not have anything further to add.

With regard to Mr. Wireman's comment about trend data, CBR has been periodically measuring the water levels in overlying Brule monitoring wells for each mine unit. Those measurements have been taken from the time production began in the mine unit, and will continue until the restoration of the mine unit is approved. Thus, hydrographs of the change in water levels over time in any mine unit are available. CBR has provided as exhibits hydrographs for wells SM 7-17 (Ex. CBR-063R) and SM 7-22 (Ex. CBR-064R). Both of these wells are completed in the Brule aquifer above Mine Unit (MU) 7 (Ex. NRC-105). Because mining activities began in MU 7 in 1999, the hydrographs for SM 7-17 and SM 7-22 provide data on Brule water levels from 1999 to the present. These hydrographs do not indicate that the mining activities have had any impact on the water levels in the Brule aquifer.

CBR provided additional hydrographs for other overlying Brule monitoring wells with their supplemental direct testimony. These hydrographs, shown in Exhibits CBR-065 and CBR-066, indicate that there has not been any significant change in Brule water levels related to operations across the License Area.

September 28, 2015

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

| | | |
|---|---|---|
| In the Matter of | ) | |
| | ) | Docket No. 40-8943-OLA |
| CROW BUTTE RESOURCES, INC. | ) | |
| | ) | ASLBP No. 08-867-02-OLA-BD01 |
| (License Renewal for the In-Situ Leach | ) | |
| Facility, Crawford, Nebraska) | ) | |

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 NRC-002 (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)***

______________________

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Executed in Fort Klamath, OR
this 28th day of September, 2015

September 28, 2015

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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| Facility, Crawford, Nebraska) | ) | |

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 NRC-005 (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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September 28, 2015

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

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| Facility, Crawford, Nebraska) | ) | |

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 NRC-008 (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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