UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

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)	

Hearing Exhibit

Exhibit Number: CBR001-R

Exhibit Title: Initial Written Testimony of Crow Butte Resources Witnesses Douglas Pavlick, Walter Nelson, and Robert Lewis on Contention 2, dated August 17, 2018

August 17, 2018

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CROW BUTTE RESOURCES, INC.	)	
	)	ASLBP No. 08-867-02-OLA-BD01
(Marsland Expansion Area)	)	

INITIAL WRITTEN TESTIMONY OF CROW BUTTE RESOURCES WITNESSES ROBERT LEWIS, WALTER NELSON, AND DOUGLAS PAVLICK ON CONTENTION 2

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INITIAL WRITTEN TESTIMONY OF CROW BUTTE RESOURCES WITNESSES ROBERT LEWIS, WALTER NELSON AND DOUGLAS PAVLICK

EXPERT WITNESSES

A. Robert Lewis

Q1. Please state your full name, your employer, and your position.

A1. Robert Lewis ("RL"). I am the owner and Principal Hydrogeologist of AquiferTek LLC, providing specialized hydrogeologic and environmental consulting services.

Q2. Please summarize your professional qualifications.

A2. (RL) A copy of my qualifications statement is attached to Exhibit CBR002. I have over 30 years of experience as a groundwater scientist and environmental consultant, and am a registered Professional Geologist in Wyoming. I have been involved in more than 300 consulting projects and environmental investigations worldwide. I was previously an expert witness in the Crow Butte license renewal proceeding on hydrogeology, aquifer testing, and groundwater restoration issues. I have expertise in the areas of groundwater flow and transport modeling, mine hydrology, soil and groundwater contamination investigation and remediation, fate and transport of organic, inorganic, and radiological constituents, and water

resource development. I also have authored technical papers, peer-reviewed journal articles, and book chapters concerning mine hydrology and water quality, groundwater modeling, and water resource evaluation. I have served as Associate Editor of *Ground Water* journal, and have been a member of ASTM subcommittees D18.04 (Determination of Hydrogeological Parameters) and D18.21.10 (Ground Water Modeling).

Q3. What is the purpose of your testimony?

A3. (RL) The purpose of my testimony is to address the issues raised by Oglala Sioux Tribe ("OST" or "Intervenors") in Contention 2.

Q4. What documents have you reviewed to prepare your testimony?

A4. (RL) I am fully familiar with the Crow Butte Resources, Inc. ("CBR") License Amendment Application ("LAA") including the Environmental Report ("ER")[1]; the CBR Technical Report;[2] the final Safety Evaluation Report submitted on May 23, 2018 ("SER");[3] and the draft and final Environmental Assessment ("EA") (NRC006). I have reviewed the filings made in this proceeding to date by the Intervenors, as well. I am also familiar with documents related to prior Crow Butte NRC licensing matters and groundwater permitting matters before the NRC and the State of Nebraska.

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[1] CBR, "Application for Amendment of USNRC Source Materials License SUA-1534 Marsland Expansion Area, Environmental Report" (consolidated) (CBR005).

[2] CBR, "Application for Amendment of USNRC Source Materials License SUA-1534 Marsland Expansion Area, Technical Report" (consolidated) (CBR006-CBR009).

[3] NRC, Safety Evaluation Report for the Marsland Expansion Area ISR facility (ML18009A976) (NRC008).

B. Walter Nelson

Q5. Please state your full name, your employer, and your position.

A5. Walter Nelson ("WN"). I am employed by Crow Butte Resources as the Safety, Health, Environment, and Quality (SHEQ) Coordinator at the Crow Butte facility. I oversee radiation protection, health and safety, and environmental programs at the site and ensure compliance with all applicable regulatory requirements. I assist in the development and review of radiological and environmental sampling and analysis procedures and am responsible for routine auditing of the programs.

Q6. Please summarize your professional qualifications.

A6. (WN) A copy of my qualifications statement is attached to Exhibit CBR003.

Q7. What is the purpose of your testimony?

A7. (WN) The purpose of my testimony is to respond to issues raised by OST in Contention 2.

Q8. What documents have you reviewed to prepare your testimony?

A8. (WN) I am fully familiar with the CBR LAA, ER, and TR, the NRC Staff review documents, including the EA and the SER, and the filings made to date by the OST. I have also reviewed documents related to prior Crow Butte NRC licensing matters and permitting matters before the NRC and the State of Nebraska.

C. Douglas Pavlick

Q9. Please state your full name, your employer, and your position.

A9. Douglas Pavlick ("DP"). I am employed by Crow Butte Resources as the General Manager for U.S. Operations.

Q10. Please summarize your professional qualifications.

A10. (DP) A copy of my qualifications statement is attached to Exhibit CBR004. I also previously provided expert testimony in the Crow Butte license renewal proceeding on operational and permitting matters.

Q11. What is the purpose of your testimony?

A11. (DP) The purpose of my testimony is to address the issues raised by OST in Contention 2.

Q12. What documents have you reviewed to prepare your testimony?

A12. (DP) I am fully familiar with the CBR LAA, ER, and TR, the NRC Staff review documents, including the EA and the SER, and the filings made to date by the OST. I have also reviewed documents related to prior Crow Butte NRC licensing matters and permitting matters before the NRC and the State of Nebraska.

BACKGROUND

Q13. What is your understanding of Contention 2 as a whole?

A13. (RL, WN, DP) OST Contention 2, as admitted by the Board in this proceeding and limited as described in its Memorandum and Order of March 16, 2018 (LBP-18-02), reads as follows:

> The application and draft environmental assessment fail to provide sufficient information regarding the geological setting of the area to meet the requirements of 10 C.F.R. Part 40, Appendix A, Criteria 4(e) and 5G(2); the National Environmental Policy Act; and NUREG-1569 section 2.6. The application and draft environmental assessment similarly fail to provide sufficient information to establish potential effects of the project on the adjacent surface and ground-water resources, as required by NUREG-1569 section 2.7, and the National Environmental Policy Act.

In LBP-18-02, the Board specified that the contention includes four Concerns, as migrated (restricting the scope of the second Concern to safety issues only), as follows:

Concern 1: [T]he adequacy of the descriptions of the affected environment for establishing the potential effects of the proposed MEA operation on the adjacent surface water and groundwater resources;

Concern 2: [E]xclusively as a safety concern [and not with regard to the EA], the absence in the applicant's technical report, in accord with NUREG-1569 section 2.7, of a description of the effective porosity, hydraulic porosity, hydraulic conductivity, and hydraulic gradient of site hydrogeology, along with other information relative to the control and prevention of excursions;

Concern 3: [T]he failure to develop, in accord with NUREG-1569 section 2.7, an acceptable conceptual model of site hydrology that is adequately supported by site characterization data so as to demonstrate with scientific confidence that the area hydrogeology, including horizontal and vertical hydraulic conductivity, will result in the confinement of extraction fluids and expected operational and restoration performance; and

Concern 4: [W]hether the draft EA contains unsubstantiated assumptions as to the isolation of the aquifers in the ore-bearing zones.

Q14. What is your understanding of Contention 2, Concern 1?

A14. (RL, WN, DP) Concern 1 challenges "the adequacy of the descriptions of the affected environment for establishing the potential effects of the proposed MEA operation on the adjacent surface water and groundwater resources." Concern 1 as migrated is the broadest of the four concerns, encompassing 10 C.F.R. Part 40, Appendix A, Criteria 4(e) (related to local faults and earthquake risk) and 5G(2) (related to underlying soil and geological formations), and the requirements of NUREG-1569 Section 2.6 (addressing information on geology and seismology). Both of these authorities address the requirements for information provided in an application, rather than information in the EA, and thus require a review of the LAA including the TR and ER submitted to support it.

In order to avoid any ambiguity or the need for the Board to hunt for evidence that the information provided to support the CBR application adequately addresses OST's alleged deficits, a detailed breakdown of the each of the technical

requirements associated with the authorities cited in the Board ruling is provided in this testimony.

Local Faults and Earthquake Risk: 10 C.F.R. Part 40, Appendix A, Criteria 4(e) requires evaluation of local faults and potential impacts on the site, showing that "[t]e impoundment [is not] located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand. … The term 'maximum credible earthquake' means that earthquake which would cause the maximum vibratory ground motion based upon an evaluation of earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material."

Underlying Soil and Geologic Formations: 10 C.F.R. Part 40, Appendix A, Criteria 5G(2) requires the applicant to supply the information related to the "characteristics of the underlying soil and geologic formations particularly as they will control transport of contaminants and solutions." Specifically, Criterion 5G(2) requires the Applicant to provide the following:

- Detailed information concerning extent, thickness, uniformity, shape, and orientation of underlying strata.
- Determination of hydraulic gradients and conductivities of the various formations based on information must be gathered from borings and field survey methods taken within the proposed impoundment area and in surrounding areas where contaminants might migrate to groundwater.
- Information gathered on boreholes including both geologic and geophysical logs in sufficient number and degree of sophistication to allow determining significant discontinuities, fractures, and channeled deposits of high hydraulic conductivity. If field survey methods are used, they should be in addition to and calibrated with borehole logging.

- Hydrologic parameters such as permeability [based on] sufficient field testing (e.g., pump tests) to assure actual field properties are adequately understood, conducted to allow estimating chemi-sorption attenuation properties of underlying soil and rock.

Information on Geology and Seismology: NUREG-1569 Section 2.6.3 sets forth review criteria and procedures for information related to geology and seismology, including the following thirteen acceptance criteria:

(1) The application includes description of the local and regional stratigraphy . . . [accompanied by] (i) maps such as geologic, topography, and isopach maps that show surface and subsurface geology and locations for all wells used in defining the stratigraphy; (ii) cross sections through the ore deposit roughly perpendicular and parallel to the principal ore trend; [and] (iii) fence diagrams showing stratigraphic correlations among wells

(2) All maps and cross sections are at sufficient scale and resolution to show clearly the intended geologic information. Maps show the locations of all site explorations such as borings, trenches, seismic lines, piezometer readings, and geologic cross sections.

(3) In the local stratigraphic section, all mineralized horizons, confining units, and other important units such as drinking water aquifers and deep well injection zones are clearly shown, with their depths from the surface clearly indicated. Isopach maps are prepared showing the variations in thickness of the mineralized zones and the confining units over the proposed mining area.

(4) A geologic and geochemical description of the mineralized zone and the geologic units immediately surrounding the mineralized zone is provided.

(5) An inventory of economically significant mineral and energy-related deposits, in addition to the uranium mineralization, is provided. Locations of all known wells, surface and underground mine workings, and surface impoundments that may have an effect on the proposed operations are provided [] on a map of sufficient scale and clarity to identify their relationship to the proposed facility. For existing wells, the depth should be shown, if possible. To allow evaluation of connections between the mineralized zone and underground sources of drinking water, plugging and abandonment records provided from state, federal, and local sources, as appropriate, should be provided. The applicant should provide evidence that action has been undertaken to properly plug and abandon all wells that cannot be documented in this manner.

(6) A description of the local and regional geologic structure, including folds and faults, is provided. Folds and faults can be shown on the geologic maps used to describe the stratigraphy. Major and minor faults traversing the proposed site should be evaluated for the likely consequences of any future effects of faulting on the uranium production activities and on the ability of the strata to contain lixiviant should fault motion occur. Geologic structures that are preferential pathways or barriers to fluid flow must be described and the basis for likely effects on flow given.

(7) A discussion of the seismicity and the seismic history of the region is included. Historical seismicity data should be summarized on a regional earthquake epicenter map, including magnitude, location, and date of all known seismic events. Where possible, seismic events should be associated with the tectonic features described in the geologic structures.

(8) A generalized stratigraphic column, including the thicknesses of rock units, representation of lithologies, and definition of the mineralized horizon, is presented.

(9) The sources of all geological and seismological data are documented in U.S. Geological Survey open files or other published documents. If data have been generated by the applicant, the documentation should include a description of the investigations and data reduction techniques.

(10) Maps have designation of scale, orientation (e.g., North arrow), and geographic coordinates.

(11) Short-term seismic stability has been demonstrated for the *in situ* leach facility in accordance with Regulatory Guide 3.11, "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills," Section 2.6 (NRC, 1977).

(12) A general description of the site soils and their properties has been provided to support an evaluation of the environmental effects of construction and operation on erosion.

(13) A detailed description of soils and their properties has been provided for any areas where land application of water is anticipated to support an assessment of the impacts.

As demonstrated below, each of the technical requirements of the authorities cited in Contention 2 with respect to Concern 1 have been fulfilled.

Q15. What is your understanding of Contention 2, Concerns 2 and 3?

A15. (RL, WN, DP) Concern 2 as admitted by the Board in this proceeding is limited to safety concerns (as addressed by the SER) regarding "the absence in the applicant's technical report [and/or NRC's SER], in accord with NUREG-1569 section 2.7, of a description of the effective porosity, hydraulic porosity, hydraulic conductivity, and hydraulic gradient of site hydrogeology, along with other information relative to the control and prevention of excursions." Concern 3 as migrated, like Concern 2, is specifically limited to the requirements of NUREG-1569 section 2.7, raising the question of whether an "acceptable conceptual model of site hydrology that is adequately supported by site characterization data so as to demonstrate with scientific confidence that the area hydrogeology, including horizontal and vertical hydraulic conductivity, will result in the confinement of extraction fluids and expected operational and restoration performance".

NUREG-1569 Section 2.7.3 sets forth review criteria and procedures for information related to geology and seismology, including the following six acceptance criteria:

(1) The applicant has characterized surface-water bodies and drainages within the licensed area and affected surroundings. Maps provided in the application identify the location, size, shape, hydrologic characteristics, and uses of surface-water bodies near the proposed site, including likely surface drainage areas near the proposed facilities. An acceptable application should also identify the zones of interchange between surface water and ground water.

(2) The applicant has provided an assessment of the potential for flooding and erosion that could affect the *in situ* leach processing facilities or surface impoundments.

(3) The applicant has described the local and regional hydraulic gradient and hydrostratigraphy. The applicant has shown that subsurface water level measurements were collected by acceptable methods, such as American Society for Testing and Materials D4750 (American Society for Testing

and Materials, 2001). Potentiometric maps are the recommended means for presenting hydraulic gradient data. These maps should include two levels of detail: regional and local. The regional map should represent the mineralized zone aquifer and should encompass the likely consequences on any affected highly populated areas. The local (site-scale) map should encompass the entire licensed area. If overlying and underlying aquifers exist, local-scale potentiometric or water surface elevation maps of these aquifers should also be included. These maps should clearly show the locations, depths, and screened intervals of the wells used to determine the potentiometric surface elevations.

Alternatively, this information can be provided in separate maps and/or tables. The appropriate contour interval will vary from site to site; however, contour intervals should be sufficient to clearly show the ground-water flow direction in the ore zone and in the overlying and underlying aquifers. The number of piezometer elevation measurements used to construct each map should be sufficient to determine the direction of ground-water flow in the mineralized zone(s) and the overlying aquifer. To construct a regional potentiometric map, a reasonable effort should be made to consider as many existing wells as possible. Hydrogeologic cross sections are recommended for illustrating the interpreted hydrostratigraphy. These cross sections should be constructed for the area within the license boundary. … Cross sections must be based on borehole data collected during well installation or exploratory drilling. All significant borehole data should be included in an appendix. Staff should verify that, an adequate number of boreholes is used to support the assertion of hydrogeologic unit continuity, if shown as such in the cross sections.

The applicant should describe all hydraulic parameters used to determine expected operational and restoration performance. … The methods or standards used to analyze pumping test data should be described and referenced: acceptable methods of analysis include use of curve fitting techniques for drawdown or recovery curves that are referenced to peer-reviewed journal publications, texts, or American Society for Testing and Materials Standards. … The applicant should distinguish between total porosity estimated from borehole geophysical methods and effective porosity that determines transport of chemical constituents.

(4) Reasonably comprehensive chemical and radiochemical analyses of water samples, obtained within and at locations away from the mineralized zone(s), have been made to determine pre-operational baseline conditions. Baseline water quality should be determined for the mineralized and surrounding aquifers. These data should include water quality parameters that are expected to increase in concentration as a result of *in situ* leach activities and that are of concern to the water use of the aquifer (i.e.,

drinking water, etc.). The applicant should show that water samples were collected by acceptable sampling procedures . . .

The applicant should identify the list of constituents to be sampled for baseline concentrations. … Alternatively, applicants may propose a list of constituents that is tailored to a particular location. In such cases, sufficient technical bases must be provided for the selected constituent list. At least four sets of samples, spaced sufficiently in time to indicate seasonal variability, should be collected and analyzed for each listed constituent for determining baseline water quality conditions. Some samples should be split and sent to different laboratories as part of a quality assurance program. Sets of samples should be taken with a minimum of a week or two between sampling to provide an indication of how the water quality of the aquifers changes with time. The applicant should document any variability in the ground-water flow rates or recharge that are observed in the collected data. Additional sampling to establish the natural cyclical fluctuations of the water quality is necessary if natural ground-water flow rates and recharge conditions vary considerably. Where perennial surface-water sources are present, surface-water quality measurements should be taken on a seasonal basis for a minimum of 1 year before implementation of *in situ* leach operations. Surface-water samples can be obtained by grab sampling and should be taken at the same location each time. The average water quality for each aquifer zone and the range of each indicator in the zone have been tabulated and evaluated. If zones of distinct water quality characteristics are identified, they are delineated and referenced on a topographic map.

(5) The applicant has provided an assessment of seasonal and the historical variability for potentiometric heads and hydraulic gradients in aquifers and water levels of surface-water bodies. This assessment should include water levels or water potentials measurements over at least 1 year and collected periodically to represent any seasonal variability.

(6) The applicant has provided information on past, current, and anticipated future water use, including descriptions of local ground-water well locations, type of use, amounts used, and screened intervals. This information must be sufficient to evaluate potential risks to ground-water or surface-water users in the vicinity of the *in situ* leach facility.

As explained in detail below and as confirmed by NRC Staff review, CBR has provided information meeting all of the NUREG-1569 section 2.7 acceptance criteria.

Q16. What is your understanding of Contention 2, Concern 4?

A16. (RL, WN, DP) Concern 4 addresses the issue of "whether the draft EA contains unsubstantiated assumptions as to the isolation of the aquifers in the ore-bearing zones." As described below, none of the Staff conclusions with regard to the isolation of aquifers in the ore-bearing zone is unsubstantiated; to the contrary, they are all supported by ample data and rigorous analysis meeting all applicable requirements.

A. Descriptions of the Affected Environment with regard to Effects on Surface and Groundwater Resources (Concern 1)

Q17. Has CBR provided adequate information on local faults and earthquake risk, as required under 10 C.F.R. Part 40, Appendix A, Criteria 4(e)?

A17. (RL, WN, DP) Yes. As explained in final EA Section 3.2.3 (NRC006) and SER Section 2.3.3.4 (NRC008), CBR provided detailed information on seismic risk in ER Section 3.3.1.4 (CBR005) and TR Section 2.6.1.4 (CBR006), including (1) catalogs of earthquakes that have occurred in Nebraska in the vicinity of the Chadron and Cambridge Arches from 1884 to 2009 and earthquakes that have occurred from 1992 through 2007 within 125 miles (201.2 km) of the city of Crawford, NE, and in the State of South Dakota (TR Tables 2.6-5 and 2.6-6) (CBR009); (2) the Modified Mercalli Scale of Intensity (MMI) for most of the significant historical earthquakes in the region, including those that occurred in Wyoming and South Dakota (TR Table 2.6-5); and (3) 2008 USGS National Seismic Hazard Maps (TR Figures 2.6-17 and 2.6-18) (CBR008). A map showing structural features of the MEA region including faults is provided as ER Figure 3.3-16.

NRC Staff rightly concluded based on these data, as well as on catalog of historical earthquakes of magnitude 2.5 or greater within a 100-mile (161 km) radius of the MEA compiled by NRC Staff, that "the MEA is located in a very aseismic region." (NRC006 at 3-17). Review of earthquakes in the region revealed only one that reached an MMI intensity sufficient to result in slight damage to structures, which was centered near Chadron in Dawes County in 1934. Not a single seismic event occurred within less than 15 miles (24.1 km) of the proposed facility in the 120 years of recording history. USGS Seismic Hazard Maps indicate a peak acceleration of 2-5 percent gravity, considered "very low" in the United States.

There can be no doubt that there is no "impoundment located near a capable fault that could cause a maximum credible earthquake larger than that which the impoundment could reasonably be expected to withstand", consistent with Criterion 4(e).

Q18. Has CBR provided adequate information on underlying soil and geologic formations, as required under 10 C.F.R. Part 40, Appendix A, Criteria 5G(2), sufficient to establish potential effects of proposed MEA operation on the adjacent surface water and groundwater resources?

A18. (RL, WN, DP) Yes. NRC Staff analyzes and evaluates the impacts of proposed operations on groundwater (both for quantity and quality) in final EA Sections 4.3.2.1 and 4.3.2.2 (NRC006) and SER Section 6.1.3 (NRC008). They conclude that all impacts on groundwater quality and quantity will be small, not only during operation but also during construction, aquifer restoration, and decommissioning. This conclusion is based on information meeting the requirements for Criterion 5G(2) provided by CBR in ER Sections 5.4.1.4 and 6.2.2.1 associated tables and

figures (CBR005); TR Section 2.7.2.4 and associated tables and figures (CBR006, CBR007, and CBR008); TR Appendix AA-2 (CBR011); and TR Appendix GG (Drawdown Impact Assessment, Marsland Expansion Area) (CBR017).[4]

Specifically, the following information is required by Criterion 5G(2) and was provided by CBR:

- detailed information concerning extent, thickness, uniformity, shape, and orientation of underlying strata. *See, e.g.*, TR at 2-41 to 2-54 (CBR006); TR Figures 2.6-1 to 2.6-16, 2.6-21 to 2.6-24 (CBR008) Regional Pumping Test Plan (CBR022).

- hydraulic gradients and conductivities of the various formations based on information gathered from borings and field survey methods taken within the proposed impoundment area and in surrounding areas where contaminants might migrate to groundwater. *See, e.g.*, TR at Section 2.7.2.1, *Groundwater Occurrence and Flow Direction* (CBR006)**;** TR Figures 2.9-4a to 2.9-6d (CBR008); TR Table 2.9-7 (CBR007).

- information gathered on boreholes including both geologic and geophysical logs in sufficient number and degree of sophistication to allow determining significant discontinuities, fractures, and channeled deposits of high hydraulic conductivity. *See, e.g.*, TR Figures 2.6-1 to 2.6-

[4] TR Appendix GG, AquiferTek, Drawdown Impact Assessment, Marsland Expansion Area (May 11, 2016), provided in CBR Response to Open Issues – Marsland Expansion Area Technical report, May 20, 2016 (ML16155A268) (CBR017).

16, 2.6-21 to 2.6-24 (CBR008); TR Appendix C (Geophysical Boring Logs).

- hydrologic parameters such as permeability [are based on] sufficient field testing (e.g., pump tests) to assure actual field properties are adequately understood, conducted to allow estimating chemi-sorption attenuation properties of underlying soil and rock. *See, e.g.*, TR at Section 2.7.2.1, *Groundwater Occurrence and Flow Direction* (CBR006)**;** TR at Section 2.7.2.2, *Aquifer Testing and Hydraulic Parameter Identification Information*; TR Figure 2.7-7 (CBR008)**;** TR Appendix F (CBR016); TR Appendix EE (Kozeny-Carman Calculation) (CBR015).

All of the requirements of 10 C.F.R. Part 40, Appendix A, Criterion 5G(2) have been fulfilled by CBR, and NRC Staff's conclusion that CBR provided adequate information to determine the effects of operations is well-supported.

Q19. Has CBR provided adequate information on geology and seismology, as noted by NUREG-1569 Section 2.6, sufficient to establish potential effects of proposed MEA operation on the adjacent surface water and groundwater resources?

A19. (RL, WN, DP) Yes. NUREG-1569 Section 2.6 sets forth a range of technical requirements and guidance for fulfilling them, as well as procedures for review of information on geology and seismology, including the thirteen distinct acceptance criteria listed in Section 2.6.3. The information to meet each of these criteria was provided by CBR in ER Section 3.3.1 (CBR005) and TR Section 2.6.1 (CBR006) as follows:

- **Criterion 2.6.3(1):** A description of the local and regional stratigraphy is provided in ER Sections 3.3.1.1 and summarized in ER Tables 3.3-1 and 3.3-2 (CBR005), as well as TR Section 2.6.1.1 (CBR006).

- **Criterion 2.6.3(2):** The maps and cross sections provided by CBR, such as ER Figures 3.3-1, 3.3-2, 3.3-3a through 2.3-3t (CBR005), TR Figures 2.6-2 and 2.6-3a through 2.6-3t, and TR Figures 2.6-21 to -24, Appendix AA-3 (CBR008, CBR012), clearly show the locations of all site explorations such as borings, trenches, seismic lines, piezometer readings, and geologic cross sections. *See also* Regional Pumping Test Plan (CBR022).

- **Criterion 2.6.3(3):** Maps showing all mineralized horizons, confining units, and other important units such as drinking water aquifers and deep well injection zones in the local stratigraphic section, with their depths from the surface clearly indicated, are provided by CBR as TR at 7-36 (CBR006); TR Figures 2.6-3a to 2.6-3n, Figure 2.6-5; Deep Disposal Well Location Information (location and depth) (CBR027). Isopach maps showing the variations in thickness of the mineralized zones and the confining units over the proposed mining area are provided as ER Figures 3.3-6, 3.3-7, and 3.3-8 (CBR005) and TR Figures 2.6-6, 2.6-7, 2.6-8, and 2.6-9 (CBR008). *See also* Regional Pumping Test Plan (CBR022).

- **Criterion 2.6.3(4):** A geologic and geochemical description of the mineralized zone and the geologic units immediately surrounding the mineralized zone is provided in ER Section 3.3.1.2 (CBR005) and TR Section 2.6.1.2 (CBR006).

- **Criterion 2.6.3(5):** An inventory of economically significant mineral and energy-related deposits, in addition to the uranium mineralization, is provided in ER Section 3.3.1.5 (CBR005) and TR Section 2.6.1.5 (CBR006). Maps showing locations of all known wells, surface and underground mine workings, surface impoundments that may have an effect on the proposed operations, and the depths of existing wells (when possible) are provided as TR Figure 2.9-3 (CBR008). Plugging and abandonment records from state, federal, and local sources, as appropriate are provided as Appendices D-1 and D-2 (CBR028, CBR014). Evidence of actions to properly plug and abandon all wells that cannot be documented in this manner, should any be identified, is presented in ER Section 5.1.3.1 (CBR005).

- **Criterion 2.6.3(6):** A description of the local and regional geologic structure, including folds and faults, is provided as ER Section 3.3.1.3 (CBR005) and TR Section 2.6.1.3 (CBR006), including evaluation of major and minor faults traversing the proposed site for the likely consequences of any future effects of faulting on the uranium production activities and on the ability of the strata to contain lixiviant should fault motion occur. Geologic structures that are preferential pathways or barriers to fluid flow are described and the basis for likely effects on flow are also provided in TR Section 2.6.1.3 (CBR006).

- **Criterion 2.6.3(7):** A discussion of the seismicity and the seismic history of the region is provided in ER Section 3.3.1.4 (CBR005) and TR Section 2.6.1.4 (CBR006). Historical seismicity data is summarized on a regional earthquake epicenter map, including magnitude, location, and date of all known seismic

events, provided as ER Figure 3.3-19 (CBR005). Where possible, seismic events are associated with the tectonic features described in the geologic structures.

- **Criterion 2.6.3(8):** A generalized stratigraphic column, including the thicknesses of rock units, representation of lithologies, and definition of the mineralized horizon, is presented as ER Tables 3.3-1 and 3.3-2 (CBR005), as discussed in ER Section 3.4.3.3 (CBR005). *See also* TR Table 2.6-1 and -2 (CBR009).

- **Criterion 2.6.3(9):** For all geological and seismological data generated by the applicant, CBR has provided documentation including a description of the investigations and data reduction techniques. *See generally* Technical Report, including appendices (CBR006-CBR020); *see also* Pump Test Plans (CBR022-CBR023).

- **Criterion 2.6.3(10):** Maps provided by CBR in its ER and TR have designations of scale, orientation (e.g., North arrow), and geographic coordinates.

- **Criterion 2.6.3(11):** Information provided in ER Section 3.3.1.4 (CBR005) and accompanying tables and figures, and TR Section 2.6.1.4 (CBR006) demonstrates short-term seismic stability for the MEA, in accordance with Regulatory Guide 3.11, "Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills," Section [2.2.1] (NRC, 1977).

- **Criterion 2.6.3(12):** A general description of the site soils and their properties to support an evaluation of the environmental effects of construction and operation on erosion has been provided as ER Section 3.3.1.6. *See, e.g.*, TR Appendix K-1 (CBR019).

- **Criterion 2.6.3(13):** A detailed description of soils and their properties for areas where land application of water is anticipated to support an assessment of the impacts is provided in ER Section 3.3.1.6, supported by Figure 3.3-20 and Table 3.3-7 (CBR005) and TR Section 2.6.1.6 (CBR006). CBR does not intend to apply for an NPDES permit to allow land application at the satellite facility and there are no plans for land application as an alternate groundwater disposal option. *See* TR at 4-13 and 5-32 (CBR006).

B. Information Regarding Site Hydrogeology (Concerns 2 and 3)

Q20. Are the criteria in NUREG-1569 Section 2.7 for information regarding site hydrogeology met as they relate to safety by information provided by CBR?

A20. (RL, WN, DP) Yes. SER Section 2.4.3.2.2 (NRC008) provides analysis of site hydrogeology based on the information and model provided in TR Sections 2.7.2.1, 2.7.2.2, and 2.7.2.3 (CBR006) and accompanying figures and tables, which meet all of the criteria set forth in NUREG-1569 Section 2.7.

Q21. Has CBR provided an adequate information regarding surface-water bodies and drainages within the licensed area and affected surroundings to comply with NUREG-1569 acceptance criterion 2.7.3(1)?

A21. (RL, WN, DP) Yes. CBR characterizes surface-water bodies and drainages within the licensed area and affected surroundings in TR Section 2.7.1.1 (CBR006). Maps identifying the location, size, shape, hydrologic characteristics, and uses of

surface-water bodies near the proposed site, including likely surface drainage areas near the proposed facilities are provided as TR Figures 2.7-2, 2.7-3 and 2.7-4 (CBR008). CBR identifies and discusses zones of interchange between surface water and ground water in TR Section 2.7.2.3 (CBR006).

Q22. Has CBR provided assessment of the potential for flooding and erosion that could affect the *in situ* leach processing facilities or surface impoundments adequate to comply with NUREG-1569 acceptance criterion 2.7.3(2)?

A22. (RL, WN, DP) Yes. CBR provided two separate studies assessing the potential for flooding and erosion to affect the *in situ* leach processing facilities or surface impoundments, as explained in TR 3.1.4. A hydrologic and erosion study is provided as TR Appendix K-1 (CBR019), and a complete report of a hydrologic and floor study is provided as TR Appendix K-2 (CBR020). The studies focus on catchment and watershed delineation, hydrological characteristics, determination of areas most prone to flooding and erosion due to rainfall runoff, and determination of flood flow characteristics. The analysis presented in Appendix K-1 identifies proposed wells and facilities in areas of moderate to high risk of erosion that may require mitigation measures. The analysis presented in Appendix K-2 provides estimates of storm-related discharge rates and velocities within the MEA. Detailed discussion of the data collection processes used for both of the studies is provided in TR Section 3.1.4.1 (CBR006), and discussion of analysis procedures is provided in TR Section 3.1.4.2 (CBR006).

Q23. Has CBR provided a description of local and regional hydraulic gradient and hydrostratigraphy adequate to comply with NUREG-1569 acceptance criterion 2.7.3(3)?

A23. (RL, WN, DP) Yes. CBR provides a description of local and regional groundwater hydrology including local and hydraulic gradient and hydrostratigraphy in TR Section 2.7.2 (CBR006) and relevant information regarding hydrogeology in TR Section 2.6.1 (CBR006). Specific elements of this description required by criterion 2.7.3(3) include the following:

- The method used for collecting subsurface water level measurements is described in CBR procedures, see CBREMP-003, Water Monitoring (CBR026), and is based on American Society for Testing and Materials methods (ASTM D 4448-01).
- Hydraulic gradient data, at both the regional and local levels, is presented in potentiometric maps provided as TR Figures 2.9-4a through 2.9-4d, 2.9-5a through 2.9-5d, and 2.9-6a through 2.9-6d (CBR008).
- Hydrogeologic cross sections illustrating the interpreted hydrostratigraphy are provided, as discussed in Section 2.6.1 (CBR006). *See also* Regional Pumping Test Plan (CBR022). Figure 2.6-2 is a cross-section index map depicting the locations of 14 north-south and east-west cross-sections through the MEA depicted on Figures 2.6-3a through 2.6-3n (CBR008). Expanded views of two cross-sections are presented as Figures 2.6-3o through 2.6-3u to provide more detailed examples of the geophysical logs within the basal sandstone of the Chadron Formation.
- A description of hydraulic parameters used to determine expected operational and restoration performance is provided in TR Section 6.1.3 (CBR006) and in TR at Section 2.7.2.1, *Groundwater Occurrence and Flow Direction*

(CBR006); TR Figures 2.9-4a to 2.9-6d (CBR008); and TR Table 2.9-7 (CBR007).

- Methods and standards used to analyze pumping test data are described in Appendix AA-3 (CBR012).
- Information distinguishing total porosity estimated from borehole geophysical methods and effective porosity that determines transport of chemical constituents is provided in TR at 3-7 to 3-9 and 3-25 to 3-27 (CBR006). *See also* Regional Pumping Test Plan (CBR022).

Q24. Has CBR provided reasonably comprehensive chemical and radiochemical analyses of water samples adequate to satisfy NUREG-1569 acceptance criterion 2.7.3(4)?

A24. (RL, WN, DP) Yes. As discussed in TR Section 2.9.3 (CBR006), CBR provides comprehensive chemical and radiochemical analyses of water samples, obtained within and at locations away from the mineralized zone that were conducted to determine pre-operational baseline conditions, and has identified water quality parameters that are expected to increase in concentration as a result of *in situ* leach activities and that are of concern to the water use of the aquifer (*i.e.*, drinking water, etc.) as Table 2.9-4 through 2.9-11 and 2.9-37 through 2.9-43 (CBR007). CBR collected water samples by accepted sampling procedures, specifically CBR-EMP-003, *Water Monitoring* (CBR026).

Q25. Has CBR provided an assessment of seasonal and historical variability for potentiometric heads and hydraulic gradients in aquifers and water levels of surface-water bodies adequate to comply with NUREG-1569 acceptance criterion 2.7.3(5)?

A25. (RL, WN, DP) Yes. As explained in TR Section 2.9.3.2 (CBR006), in 2013, a sampling program was implemented for all MEA Arikaree, Brule and Chadron

wells to monitor water level changes to those aquifers over a one-year time span to determine what effect, if any, seasonal flow, annual variation, or nearby irrigation wells may have upon the observed groundwater movement. Water level data was collected in October 2013, January 20, April 2014, and July 2014 and is presented in TR Appendix FF (CBR030). Potentiometric surface maps for the three aquifers for each sampling period are shown on TR Figures 2.9-4a through 2.9-4d, 2.9-5a through 2.9-5d, and 2.9-6a through 2.9-6d (CBR008).

Q26. Has CBR provided adequate information on past, current, and anticipated future water use to comply with NUREG-1569 acceptance criterion 2.7.3(6)?

A26. (RL, WN, DP) Yes. CBR provided information on past, current, and anticipated future water use, including descriptions of local ground-water well locations, type of use, amounts used, and screened intervals sufficient to evaluate potential risks to ground-water or surface-water users in the vicinity of the *in situ* leach facility in TR Section 2.2.3 (CBR006). CBR also assessed the potential effects of nearby agricultural wells on the migration potential of MEA regulated material releases in the overlying groundwater zone toward these wells. TR Appendix AA-1 and AA-2 (CBR010 and CBR011).

Q27. Does NUREG-1569 Section 2.7 include any specific criteria related to information regarding the prevention of incursions?

A27. (RL, WN, DP) No. NUREG-1569 Section 2.7 does not expressly address information regarding the prevention of incursions. However, CBR has provided required information about the likelihood of erosion, flooding and groundwater flow in accordance with NUREG-1569 Section 5.7.8 (NRC010). CBR evaluated the likelihood of incursions and provided a plan for identifying, preventing and

addressing them in TR 5.7.8 and 5.7.9 (CBR006). SER Section 5.7.9.3.1.3 (NRC008) includes the following detailed description of the plan for Groundwater Excursion Monitoring and Corrective Action provided by CBR:

> Per License Condition 11.4, the upper control limits (UCLs) for the excursion monitoring program will be established by collecting four samples from each designated monitoring well at a minimum density of: 1) one upper aquifer monitoring well per 0.4 hectares (5 ac) of mine unit area, and 2) all perimeter monitoring wells. These samples will be collected at least 14 days apart. The samples will be analyzed for the indicator parameters: chloride, conductivity, and total alkalinity. The UCLs will be calculated for each indicator parameter, in each monitoring well, as equal to 20 percent above the maximum concentration measured for that parameter among the background samples. For those indicator parameters with background concentrations that average 50 mg/L or less, the UCL for that parameter may be calculated as equal to 20 percent above the maximum background concentration, the background average plus five standard deviations, or the background average plus 15 mg/L. This license condition will not change with the MEA license amendment and will also apply at the MEA.
>
> TR Section 5.7.9.3 indicates that excursion monitoring will be conducted using chloride, conductivity, and total alkalinity as excursion indicators. The applicant also states that monitoring wells will be sampled for these excursion indicators on a biweekly basis during operations. If two UCLs are exceeded in a well, or if a single UCL is exceeded by 20 percent, a confirming water sample will be taken within 48 hours after the results of the first analyses are received and the applicant will analyze the sample for the indicator parameters. If the second sample does not indicate an exceedance of the UCLs, a third sample will be taken and analyzed in a similar manner within 48 hours after the second set of samples was acquired. If neither the second nor the third sample indicates an exceedance of the UCLs, the first sample will be considered in error. In accordance with License Condition 11.5, if the resampling verifies UCL exceedance, the well will be placed on excursion status and the NRC Project Manager will be contacted by e-mail or telephone within 24 hours and in writing within 7 days. Once the monitoring well does not exceed excursion criteria for three consecutive weeks, the monitoring well is taken off excursion status.
>
> TR Section 5.7.9.3 states that upon verification of an excursion, the applicant will take corrective actions appropriate to the specific circumstances using the following approach (though not necessarily in this order):
>
> - Preliminary investigation of the probable cause;

- Adjustments as needed to increase the recovery in the vicinity of the monitoring well and hydraulic gradient toward the production zone; and
- Enhancement of recovery through extraction at individual wells.

> The applicant states that injection adjacent to the monitoring well may be suspended and the monitor well will be sampled weekly while on excursion status. In accordance with License Condition 11.5, a written report describing the excursion event, corrective actions taken, and the corrective action results will be submitted to the NRC within 60 days of the excursion confirmation.
>
> In accordance with License Condition 11.5, if an excursion is not corrected within 60 days of confirmation, the applicant will either: (a) terminate injection of lixiviant within the production area until the excursion is corrected; or (b) increase the surety in an amount to cover the full third-party cost of correcting and cleaning up the excursion. The surety increase will remain in force until the NRC has verified that the excursion has been corrected and cleaned up. For all wells that remain on excursion after 60 days, the applicant will provide further status updated in quarterly reports required by license condition." (internal citations omitted).

NRC Staff approved the proposed CBR groundwater and surface water monitoring program, including the Groundwater Excursion Monitoring and Corrective Action Plan described in SER 5.7.9.3.1.3 (NRC008), subject to certain updated and additional license conditions, as stated in SER Section 5.7.9.4.

Q28. Has CBR provided an acceptable conceptual model of site hydrology that is adequately supported by site characterization data so as to demonstrate with scientific confidence that the area hydrogeology, including horizontal and vertical hydraulic conductivity, will result in the confinement of extraction fluids and expected operational and restoration performance?

A28. (RL, WN, DP) Yes. This was the issue posed by Concern 3, and unlike Concern 2 issues, it encompasses both the safety and environmental aspects of the model. CBR provides a conceptual model of site hydrology in TR Section 2.7.2.3 (CBR006), which is discussed in SER Section 2.4 (NRC008). Site

characterization data supporting this model was provided in TR tables, maps, and appendices, including the following:

- Appendix F, Pump Test #8 Report (CBR016)
- Appendices G-1 and G-2, Mineralogical and Particles Sixe Distribution Analyses (2011 and 2013) (CBR031, CBR032)
- Appendices K-1 and K-2, Hydrologic, Erosion and Flood Study Reports for Marsland Expansion Area (CBR019, CBR020)
- Appendix AA-1, MEA Agricultural Well Impact Analysis (CBR010)
- Appendix AA-2, Validation of Agricultural Well Analysis (CBR011)
- Appendix AA-3, Aquifertek Hydraulic Containment (CBR012)
- Appendix EE, Kozeny-Carman Calculations (CBR015)
- Appendix GG, Drawdown Impact Assessment MEA (CBR017)
- Appendix HH, Deep Brule Monitor Well Installation Program (CBR018)
- Regional Pumping Test Plan (CBR022)

Tables 2.6-1 and 2.6-2 (CBR009) present the regional and local stratigraphic columns in the vicinity of MEA. As discussed in TR Section 2.7.2.1 (CBR006), aquifers within the stratigraphic section present at the MEA include permeable intervals of the Arikaree Group, permeable intervals in the Brown Siltstone Member of the shallow Brule Formation, and the deeper confined basal sandstone of the Chadron Formation. Later in our testimony, we discuss the basis for determining the upper and lower confining units, including the aquifer pumping test, and our assessment of the hydrologic conditions for the water-bearing intervals present at the MEA.

Q29. Please describe the aquifer pumping test and discuss its adequacy.

A29. (RL, WN, DP) During the initial permitting and development activities within the MEA, an aquifer pumping test was performed between May 16 and May 20, 2011. The final report on pumping test activities in the MEA (Marsland Regional Hydrologic Testing Report – Test #8) is included in Appendix F (CBR016). The

pumping test was performed in accordance with the NDEQ approved Regional Pumping Test Plan, dated September 27, 2010 (CBR022), and subsequent approved changes to the Regional Pumping Test Plan, dated March 16, 2011 (CBR023). Testing activities and findings from pumping test activities in the MEA are summarized below.

Prior to testing activities, CBR installed 14 monitoring wells in the basal sandstone of the Chadron Formation (CPW-2010-1, CPW-2010-1A, Monitor-1, Monitor-2, Monitor-3, Monitor-4, Monitor 4A, Monitor-5, Monitor-6, Monitor-7, Monitor-8, Monitor-9, Monitor-10, and Monitor-11) and nine wells in the Brule Formation (BOW-2010-1, BOW-2010-2, BOW-2010-3, BOW-2010-4, BOW-2010-4A, BOW-2010-5, BOW-2010-6, BOW-2010-7, and BOW-2010-8). *See* Figure 2.7-6) (CBR008). Well information for wells used during the 2011 pumping test is summarized in Table 2.7-2 (CBR007). Monitor-4 and BOW-2010-4 were replaced by Monitor-4A and BOW-2010-4A, respectively, prior to pumping test activities. To assess pre-test baseline water level fluctuations, water level data and barometric pressure data were recorded prior to the pumping period starting on May 6, 2011 for a period of 7 days before initiating the pumping test. The locations of wells used during pumping test #8 are also shown in Figure 2.7-7 (CBR008). These data were interpreted as representative of static conditions within the aquifer. Based on these data, groundwater in the Brule Formation was interpreted to flow predominantly to the southeast toward the Niobrara River with a lateral hydraulic gradient of 0.011 ft/ft. (Appendix F, CBR016).

To provide baseline groundwater elevation data for the pumping test, static water levels were collected from all 12 wells in the monitoring network on November 12, 2010 from the Brule Formation and the basal sandstone of the Chadron Formation. Water levels ranged from approximately 4,134 to 4,213 feet amsl in the Brule Formation and 3,709 to 3,714 feet amsl in the basal sandstone of the Chadron Formation (Table 2.7-2). Static water levels of the Arikaree Group, Brule Formation, and Chadron Formation measured for existing and new CBR monitor wells in 2013 are discussed in TR Section 2.9.3.2 .

The 2011 regional groundwater pumping test was designed to accomplish the following:

- Evaluate the degree of hydraulic communication between the production zone pumping well and the surrounding production zone observation wells
- Evaluate the presence or absence of the production zone aquifer within the test area
- Assess the hydrologic characteristics of the production zone aquifer within the test area including the presence or absence of hydraulic boundaries
- Demonstrate sufficient confinement (hydraulic isolation) between the production zone and the overlying aquifer for the purpose of ISR mining

The 2011 pumping test was conducted while pumping at CPW-2010-1A at an average discharge rate of 27.08 gpm for 103 hours (4.29 days). Based on the drawdown response observed at the most distant observation well locations (Monitor 2 and Monitor 8), the radius of influence (ROI) during the pumping test was estimated to be in excess of approximately 8,800 feet. More than 0.8 foot of drawdown was achieved during testing in all observation wells completed in the basal sandstone of the Chadron Formation in the observation well network, with a

maximum drawdown of 23.40 feet observed in CPW-2010-1A (pumping well) during the test.

The drawdown response measured in all basal sandstone of the Chadron Formation observation wells monitored during the test confirm hydraulic communication between the production zone pumping well and the surrounding observation wells across the entire test area. During the test (pumping and recovery periods), no discernible drawdown or recovery responses attributed to the test were observed in overlying Brule Formation observation wells, which supports the conclusion that adequate confinement exists between the overlying Brule Formation and the basal sandstone of the Chadron Formation.

Drawdown and recovery data collected from observation wells were graphically analyzed to determine the aquifer properties, including transmissivity and storativity. The methods of analysis included the Theis (1935) drawdown and recovery methods (CBR024) and the Jacob Straight-Line Distance-Drawdown method (Cooper and Jacob 1946) (CBR025).

Estimated hydraulic parameters for individual well locations for the 2011 pumping test are summarized in Table 2.7-3 (CBR007). Results of the 2011 pumping test within the basal sandstone of the Chadron Formation indicate a mean hydraulic conductivity of 25 feet per day (ft/day; ranging from 7 to 62 ft/day) or 8.82 x 10-3 centimeters per second (cm/sec) based on an average net sand thickness of 40 feet and a mean transmissivity of 1,012 square feet per day (ft2/day; ranging from 230 to 2,469 ft2/day). Based on both the drawdown and recovery analyses, hydraulic conductivities of the aquifer materials in the vicinity

of the pumping well (CPW-2010-1A, CPW-2010-1, and Monitor-3) were approximately three to nine times greater than hydraulic conductivities estimated for other observation wells in the pumping test area. An apparent higher conductivity boundary condition effect in these wells was indicated by a flattening of drawdown and recovery curves.

Transmissivities for the recovery data were slightly higher than for the drawdown data and are considered more representative of the aquifer properties due to the slight variability in the discharge rate during the drawdown phase of the test. The mean storativity was 2.56 x 10-4 (ranging from 1.7 x 10-3 to 8.32 x 10-5). Storativity units are a measure of the volumes of water that a permeable unit will absorb or expel from the storage unit per unit of surface area per unit of change in head. Storativity is a dimensionless quantity. The hydrologic parameters observed at the MEA are consistent with, although slightly higher than, the aquifer properties determined for the areas of the Central Processing Facility, Three Crow, and North Trend areas (TR Table 2.7-4) (CBR007). No water level changes of concern were observed in any of the overlying wells during testing.

The pumping test results demonstrate the following important conclusions:

- The pumping well and all observation wells completed in the basal sandstone of the Chadron Formation exhibited significant and predictable drawdown during the test, demonstrating that the production zone has hydraulic continuity throughout the MEA test area.
- The average transmissivity of the basal sandstone of the Chadron Formation within the portion of the MEA investigated during the test is significantly higher than the areas investigated within the TCEA, NTEA, and existing Crow Butte operations.
- A zone of relatively lower permeability is apparent in the vicinity of the pumping well (CPW-2010-1A) and observation wells CPW-2010-1 and

Monitor-3, with significantly higher transmissivity noted elsewhere within the ROI of the test.

- Adequate confinement exists between the overlying Brule Formation and the basal sandstone of the Chadron Formation, as evidenced by no discernible drawdown in the Brule Formation observation wells.
- The hydrologic properties of the basal sandstone of the Chadron Formation have been adequately characterized within the majority of the proposed MEA.

These conclusions indicate that, though variance in thickness and hydraulic conductivity may impact mining operations (*e.g.*, well spacing, completion interval, and injection/production rates), it is not anticipated to impact regulatory issues, such as the adequacy of confinement or ability to control mining fluids.

Based on conclusions drawn from the geophysical and geologic sample logging and well development results, the lower Brule Formation is composed of non-aquifer sediments and it does not produce water in usable, significant or economic amounts and cannot be classified as an aquifer. Therefore, additional testing such as water quality, water level measurements and pumping tests were not recommended (Appendix HH) (CBR018). The first overlying aquifer to the mining zone at MEA should remain the Brown Siltstone Member of the upper Brule Formation.

Q30. Are additional pumping tests needed?

A30. (RL, WN, DP) No. The pumping test that was performed is sufficient to demonstrate confinement, assess aquifer properties, and confirm ability to control mining fluids. Additional pumping tests are not necessary. Moreover, it is clearly unreasonable to expect that "all feasible pump tests and other analyses be performed" in order to provide adequate information for safety and environmental review. CBR has performed extensive, rigorous tests and provided extensive

analysis of hydrology and hydrogeography sufficient to fulfill all applicable regulations and requirements. As NRC Staff pointed out in response to the same question posed in Comment 15-7 (*see* Final EA at A-24 (NRC-006)), “there are several lines of evidence other than aquifer pumping test results that demonstrate the confinement of the Basal Chadron Sandstone aquifer, including the thickness, continuity, and low permeability of the confining units; the height of the potentiometric surface of the Basal Chadron aquifer; and differences in geochemical signatures between the Basal Chadron Sandstone and overlying aquifers.” Additional pumping tests would provide little incremental value given the quality and reliability of existing data and analyses.

Q31. Please describe the particle size analyses and core sampling results that support your conceptual site model.

A31. As described in TR Section 2.7.2.3 (confining layer) (CBR006), the upper Chadron and middle Chadron Formation constitute the confining unit between the basal sandstone of the Chadron Formation and overlying aquifers of the Brule Formation and Arikaree Group. Aquifer properties of the basal sandstone of the Chadron Formation are discussed in Section 2.7.2.2 in relation to aquifer pumping tests conducted in 2011.

Hydraulic conductivities for the Arikaree Group and Brule Formation were estimated using particle grain-size distribution data from core samples. Results of the particle size distribution analyses indicate sediments variably dominated by sands, silts, and clays. Hydraulic conductivity estimates were developed using the Kozeny-Carman equation, which is appropriate for sands and silts, but not for cohesive clayey soils with a high degree of plasticity. For samples that have high

plasticity, Kozeny-Carman equation likely overestimates hydraulic conductivity values. Therefore, the Kozeny-Carman equation provides a conservative estimate of hydraulic conductivity. Additionally, Falling Head Permeameter Tests were completed on one Brule Formation core sample (M-2169C, Run 5, Sample 1) and one Upper Chadron Formation core (M-1635C, Run 3, Sample 1). Both permeameter tests indicate measured hydraulic conductivity values two orders of magnitude lower than the estimated Kozeny-Carman results demonstrating the conservative nature of the Kozeny-Carman values. The TR at Section 2.2.7.1 (CBR006) and Appendix EE (CBR015) contains additional details regarding the testing, data collection, and analysis.

Q32. Please describe the hydrologic information that supports your conceptual site model.

A32. (RL, WN, DP) Potentiometric maps and cross-sections of the basal sandstone of the Chadron Formation indicate confined groundwater flow (Figures 2.9-6a through 2.9-6d and 2.6-3a through 2.6-3n) (CBR008). *See also* Basal Chadron Conceptual Flow (CBR021). Elevations of the potentiometric surface of the basal sandstone of the Chadron Formation indicate that the recharge zone must be located above a minimum elevation of 3,715 feet amsl. Confined conditions exist at the MEA as a result of an elevated recharge zone most likely located west or southwest of the MEA. The top of the basal sandstone of the Chadron Formation occurs at much lower elevations within the MEA, ranging from approximately 3,210 to 3,290 feet amsl (Figures 2.6-3a through 2.6-3n, CBR008).

In the vicinity of the MEA, groundwater flow in the basal sandstone of the Chadron Formation is predominantly to the northwest toward the White River

drainage at a lateral hydraulic gradient of 0.0004 ft/ft (CBR016). Regional water level information for the basal sandstone of the Chadron Formation suggests a discharge point at an elevation of at least 3,700 feet amsl (or below) north and east of Crawford, where flowing wells discharge to the surface and at a locations where the basal sandstone of the Chadron Formation is exposed (outcrops). *See* Basal Chadron Conceptual Flow (CBR021)

Regional water level information for the Brule Formation is currently only available in the vicinity of the current production facility. However, within the MEA, groundwater generally flows to the southeast across the entire MEA toward the Niobrara River at a lateral hydraulic gradient of 0.011 ft/ft (CBR016). Though the Brule Formation is the primary groundwater supply in the vicinity of the MEA, low production rates indicate that the discontinuous sandstone lenses of the Brown Siltstone Member may not be hydraulically well connected. Recharge to this unit likely occurs directly within the MEA, as the unit is unconformably overlain by 50 to 210 feet of overlying Arikaree Group and 0 to 30 feet of unconsolidated alluvial and colluvial deposits (depending on local topography). Alluvial deposits along the margins of the Niobrara River may offer limited groundwater storage depending on river levels.

At MEA, groundwater elevations for the Arikaree Group and the Brule Formation are distinctly different from those of the basal sandstone of the Chadron Formation (Figures 2.6-3a through 2.6-3n, Table 2.9-7) (CBR008 and CBR007). The available water level data suggest hydrologic isolation of the basal sandstone

of the Chadron Formation with respect to the overlying water-bearing intervals in the MEA.

This inference is further supported by the difference in geochemical groundwater characteristics between the basal sandstone of the Chadron Formation and the Brule Formation. *See* Section 2.9.3 (CBR006); Tables 2.9-8, 2.9-9, 2.9-10, and 2.9-11 (CBR007).

C. *Isolation of Aquifers in Ore-Bearing Zones (Concern 4)*

Q33. Please describe the fourth migrated concern of Contention 2 as set forth in LBP-18-02.

A33. (RL, WN, DP) Concern 4 of Contention 2 is stated in LBP-18-02 is "whether the [ ] EA contains unsubstantiated assumptions as to the isolation of the aquifers in the ore-bearing zones."

Q34. Please describe the basis for the conclusion that there is isolation of the aquifers in the ore-bearing zones.

A34. (RL,WN, DP). As described above in detail, there is extensive data and analyses that support the conclusion of isolation of aquifers in the ore-bearing zones, including the aquifer pumping test, particle grain size analyses and core samples, and hydrologic conditions (*e.g.*, water level data, water quality differences). In summary, the following lines of evidence indicate adequate hydrologic confinement of the basal sandstone of the Chadron Formation within the MEA:

- Results of the May 2011 aquifer pumping test demonstrate no discernible drawdown in the overlying Brule Formation observation wells screened throughout the MEA (see Section 2.7.2.2, CBR006).

- Large differences in observed hydraulic head (330 to 500 feet) between the Brule Formation and the basal sandstone of the Chadron Formation indicate strong vertically downward gradients and minimal risk of naturally occurring impacts to the overlying Brule Formation (see Section 2.7.2.1, CBR006).
- Significant historical differences exist in geochemical groundwater characteristics between the basal sandstone of the Chadron Formation and the Brule Formation (Section 2.9.3.3, CBR006).
- Site-specific XRD analyses, particle grain-size distribution analyses, and geophysical logging confirm the presence of a thick (between 360 and 450 feet), laterally continuous upper confining layer consisting of low permeability mudstone and claystone, and a thick (more than 750 feet), regionally extensive lower confining layer composed of very low permeability black marine shale (see Section 2.7.2.3, CBR006).
- Falling Head Permeameter testing of two core samples M-2169C, Run 5, Sample 1 (Brule Formation) and M-1635C, Run 3 (Chadron Formation), measured hydraulic conductivities of 1.31 x 10-7 and 1.32 x 10-7 cm/s, respectively (see Section 2.7.2.3, CBR006).
- Analyses of particle size distribution results using the Kozeny-Carman equation suggests a conservative maximum hydraulic conductivity of 5.9 x 10-5 cm/s for core samples from the upper confining layer and an average estimated hydraulic conductivity of 3.7 x 10-5 cm/s. Actual hydraulic conductivities are expected to be at least one to two orders of magnitude lower

as demonstrated by Falling Head Permeameter Testing of the core samples (see Section 2.7.2.3, CBR006).

- Hydraulic resistance to vertical flow is expected to be high due to the significant thickness of the upper confining zone within the MEA (see Section 2.7.2.3, CBR006).
- The vertical hydraulic conductivity across the upper and lower confining layers is likely to be even lower than 10-5 cm/sec due to vertical anisotropy (*see* TR Section 2.7.2.3, CBR006).

CONCLUSIONS

Q35. What are your overall conclusions regarding Contention 2?

A35. (RL,WN, DP). Contention 2 is almost entirely concerned with whether the factual information provided by CBR meets regulatory and statutory requirements. We have provided a detailed description of the regulatory and statutory requirements cited in the migrated contention, and identified where the required information is provided. NRC Staff has reviewed all of the required information and requested substantial additional submissions, which CBR has fulfilled. Though the OST's objections lacked specificity and included sweeping generalizations, CBR has addressed those objections with great specificity. This testimony is intended to enable the Board to easily review and verify information provided is adequate and complete.

Q36. What are your overall conclusions regarding the adequacy of the descriptions of the affected environment for establishing the potential effects of the proposed MEA operation on the adjacent surface water and groundwater resources (Concern 1)?

A36. (RL, WN, DP) CBR has provided in-depth and extensive discussion of the environment at the MEA, including groundwater resources. The ER and TR describe the data collected, the analyses performed, and the conclusions reached. The level of detail and breadth of the information provided is more than sufficient to meet regulatory requirements.

Q37. What are your overall conclusions regarding the adequacy of the TR and the SER and its discussion of effective porosity, hydraulic porosity, hydraulic conductivity, and hydraulic gradient, along with other information relative to the control and prevention of excursions (Concern 2)?

A37. (RL, WN, DP) The TR includes extensive discussion of the data and methods used to determine effective porosity, hydraulic porosity, hydraulic conductivity, and hydraulic gradient. This information is presented in narrative form in the TR and further described in tables and figures. Based on this information, the NRC Staff rightly concluded that "the information provided by the applicant, as supplemented by the requirements of the erosion concern and drawdown license conditions . . . meets the applicable acceptance criteria of Section 2.7.3 of NUREG-1569." (SER Section 2.4.4, NRC008)

Q38. What are your overall conclusions regarding the adequacy of the conceptual model of site hydrology provided and its utility in determining the probable confinement of extraction fluids and expected operational and restoration performance (Concern 3)?

A38. (RL, WN, DP) The site conceptual model, and the bases for that model, are presented in extensive detail in the TR and provide an acceptable basis for assessing operational and restoration performance. CBR's conclusions are further buttressed by its experience at the Central Processing Facility.

Q39. What are your overall conclusions regarding on the information and assumptions of the EA and SER as to the isolation of the aquifers in the ore-bearing zones (Concern 4)?

A39. (RL,WN, DP). There is extensive data and analysis supporting multiple lines of evidence, all of which lead inexorably to the conclusion that the ore-bearing zones are hydrologically isolated. The NRC Staff reviewed that data, performed its own assessment of the data, and reached the same conclusions. Overall, the information in the ER and TR, as well as the EA and SER, demonstrate the isolation of the aquifer in the ore-bearing zones. Contention 2 should be resolved in favor of Crow Butte and the NRC Staff.