LBP-16-13

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

ATOMIC SAFETY AND LICENSING BOARD

Before Administrative Judges:

Michael M. Gibson, Chairman
Dr. Richard E. Wardwell
Brian K. Hajek

In the Matter of	Docket No. 40-8943
CROW BUTTE RESOURCES, INC.	ASLBP No. 08-867-02-OLA-BD01
(License Renewal for the In Situ Leach Facility, Crawford, Nebraska)	December 6, 2016

SECOND PARTIAL INITIAL DECISION

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ACRONYMS AND ABBREVIATIONS

ACL	Alternate Concentration Limit
BC/CPF	Basal Chadron/Chamberlain Pass Formation
cm/sec	Centimeters per second
EA	Environmental Assessment
EIS	Environmental Impact Statement
FWS	United States Fish and Wildlife Service
GEIS	Generic Environmental Impact Statement
gpm	Gallons per minute
gal/sq. ft.	Gallons per square foot
ISL	In Situ Leach
LCU	Lower Confining Unit
LRA	License Renewal Application
MBRP	Model-Based Restoration Plan
MIT	Mechanical Integrity Testing
NDEQ	Nebraska Department of Environmental Quality
NEPA	National Environmental Policy Act of 1969
NMSS	Office of Nuclear Material Safety and Safeguards
NPDES	National Pollutant Discharge Elimination System
NRC	United States Nuclear Regulatory Commission
NTEA	North Trend Expansion Area
NTS	Not to Scale
PRIR	Pine Ridge Indian Reservation
SDDENR	South Dakota Department of Environment and Natural Resources
SER	Safety Evaluation Report
SPCC	Spill Prevention, Control, and Countermeasures
Th	Thorium
U	Uranium
UCL	Upper Control Limits
UCU	Upper Confining Unit
UIC	Underground Injection Control
ug/L	micrograms/liter
USGS	United States Geological Survey

I. INTRODUCTION

This proceeding arises from a challenge by the Oglala Sioux Tribe and Consolidated Intervenors (together "Intervenors")[1] to the application of Crow Butte Resources, Inc. (Crow Butte), to renew its Source Materials License No. SUA-1534 for the continued operation of its in situ leach (ISL) uranium recovery facility near Crawford, Nebraska.[2] We admitted nine of Intervenors' contentions,[3] and held an evidentiary hearing on those environmental contentions in Crawford, Nebraska, from August 24–28, 2015,[4] and in Rockville, Maryland, on October 23, 2015.[5] On May 16, 2016, we resolved Contention 1 in part for Intervenors and in part for the NRC Staff.[6]

This order and memorandum resolves the eight remaining contentions in this proceeding. Six of these contentions—Contention A, Contention C, Contention D, Contention F, Contention 6, and Contention 9—address various issues regarding the NRC Staff's analysis of the subsurface hydrogeology at or near the Crow Butte License Area. Intervenors are concerned that contaminants escaping from Crow Butte's operations could migrate offsite, potentially as far as the Pine Ridge Indian Reservation (PRIR), which is home to members of

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[1] Request for Hearing and/or Petition to Intervene, Oglala Sioux Tribe (July 28, 2008) [hereinafter Tribe Petition]; Consolidated Request for Hearing and Petition for Leave to Intervene (July 28, 2008).

[2] Ex. CBR-011, Application for 2007 License Renewal USNRC Source Materials License SUA-1534 Crow Butte LA (Nov. 27, 2007) [hereinafter LRA].

[3] <u>See</u> LBP-15-11, 81 NRC 401, 404 (2015), <u>petition for interlocutory review denied</u>, CLI-15-17, 82 NRC 33, 47 (2015); LBP-08-24, 68 NRC 691, 699 (2008), <u>aff'd in part and rev'd in part</u>, CLI-09-9, 69 NRC 331 (2009). The lengthy procedural background of this case is set forth in our first Partial Initial Decision, LBP-16-7, 83 NRC 340, 347–49 (2015), and so will not be repeated here.

[4] Tr. at 945–2,375.

[5] Tr. at 2,404–2,640.

[6] LBP-16-7, 83 NRC at 411–12.

the Oglala Sioux Tribe, and that excessive groundwater consumed during post-operational aquifer restoration may adversely impact the environment. The remaining two contentions do not directly implicate the hydrogeology of the License Area. Contention 12 concerns the environmental risk of tornadoes and the possible land application of ISL wastewater, while Contention 14 concerns the environmental risk of earthquakes. Intervenors generally argue that the NRC Staff did not adequately address these issues in the Environmental Assessment (EA) associated with Crow Butte's renewed license.[7]

For seven of these contentions and for part of the eighth (Contention 12), we conclude that, supplemented by the evidentiary record in this proceeding, the EA satisfies the NRC Staff's obligation to conduct a thorough environmental review. For the remaining part of Contention 12, we find for Intervenors and conclude that the EA is deficient as to its discussion of the possible land application of ISL wastewater. Given that the record with respect to the land application of ISL wastewater, as authorized by Crow Butte's renewed license, is inadequate to support the NRC Staff's Finding of No Significant Impact, we have determined that the NRC Staff must augment its EA analysis and reach its own independent conclusion on land application of ISL wastewater, in conformance with the National Environmental Policy Act (NEPA).

A. Legal Standards

NEPA requires the NRC Staff to take a hard look at any significant environmental consequences of a proposed licensing action,[8] which, in this case, is the renewal of Crow

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[7] Consolidated Intervenors' and Oglala Sioux Tribe's Joint Position Statement at 108–24 (May 8, 2015) [hereinafter Intervenors' Joint Position Statement]; see Ex. NRC-010, Office of Nuclear Material Safety And Safeguards, Division of Fuel Cycle Safety, Safeguards, and Environmental Review, Final Environmental Assessment for the License Renewal of U.S. Nuclear Regulatory Commission License No. SUA-1534 (Oct. 2014) [hereinafter EA].

[8] Pa'ina Hawaii, LLC (Materials License Application), CLI-10-18, 72 NRC 56, 74–75 (2010); see also LBP-16-7, 83 NRC at 351–53.

Butte's license for an additional ten years. As part of its analysis, the NRC Staff categorizes the potential environmental impacts on a scale from small to large:

> SMALL—environmental effects are not detectable or are so minor that they will neither destabilize nor noticeably alter any important attribute of the resource.
>
> MODERATE—environmental effects are sufficient to alter noticeably, but not to destabilize, important attributes of the resource.
>
> LARGE—environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource.[9]

Intervenors argue that the EA did not adequately assess and categorize a variety of environmental impacts related to the renewal of Crow Butte's license, primarily hydrogeological impacts related to the ore-bearing body and associated aquifer from which Crow Butte obtains its uranium. At an evidentiary hearing, the NRC Staff bears the ultimate burden of showing that it satisfied NEPA's information-disclosure mandate by meaningfully considering significant impacts and addressing those impacts in the EA.[10]

At issue is not just the extent of the discussion in the EA itself, but also the adequacy of other documents that the NRC Staff has purported to incorporate by reference. To incorporate outside documents into a NEPA document, the Council on Environmental Quality regulations provide that "[t]he incorporated material shall be cited in the statement and its content briefly described."[11] The NRC Staff's guidance states more specifically:

> The EA or EIS [Environmental Impact Statement] should identify documents that are incorporated by reference and indicate where these references are available

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[9] EA at 8; see Ex. NRC-014, Environmental Review Guidance for Licensing Actions Associated with [Office of Nuclear Material Safety and Safeguards] Programs, NUREG-1748, § 4.2.5.3 at 4-14 (Aug. 2003) [hereinafter Ex. NRC-014, NUREG-1748]; Areva Enrichment Servs., LLC (Eagle Rock Enrichment Facility), LBP-11-26, 74 NRC 499, 546 (2011).

[10] Duke Power Co. (Catawba Nuclear Station, Units 1 & 2), CLI-83-19, 17 NRC 1041, 1049 (1983); see also Entergy Nuclear Operations, Inc. (Indian Point Nuclear Generating Units 2 & 3), CLI-16-7, 83 NRC 293, 306–07 (2016); see also Hydro Res., Inc. (P.O. Box 777 Crownpoint, New Mexico 87313), CLI-04-11, 63 NRC 483, 493 (2006).

[11] 40 C.F.R. § 1502.21; see also 10 C.F.R. Pt. 51, subpt. A, app. A, § 1(b).

> for public review. Relevant portions of the incorporated analysis should be referenced by page or section number and summarized in the EA or EIS. Incorporating by reference should not result in a loss of comprehension to the reader.[12]

One particular form of incorporation by reference at issue here is tiering. Tiering occurs when an agency incorporates a Generic Environmental Impact Statement (GEIS) into a site-specific analysis.[13] The Council on Environmental Quality regulations require that, just as with incorporation by reference, an agency must reference and summarize the specific issues addressed in the GEIS that are to be tiered into a site-specific EIS or EA.[14] Thus, the mere existence of a GEIS is not sufficient to tier its contents into a site-specific EIS or EA.[15]

B. Parties' Witnesses

A total of thirteen witnesses testified about the contentions addressed in this second Partial Initial Decision. No party challenged the qualifications of any witness to give the testimony provided.

Four witnesses testified for Intervenors: Dr. Hannan LaGarry, Michael Wireman, Dr. David Kreamer, and Linsey McLean. Dr. LaGarry received his Ph.D. in Geology from the University of Nebraska-Lincoln and is a conservation biology instructor/researcher and co-chair in the Department of Math, Science and Technology at Oglala Lakota College in South Dakota.[16] Mr. Wireman is a hydrogeologist with over 29 years of experience, including serving

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[12] Ex. NRC-014, NUREG-1748 § 1.6.4 at 1-11.

[13] 40 C.F.R. §§ 1502.20, 1508.28.

[14] 40 C.F.R. § 1502.20; see also 10 C.F.R. § 51, app. A.1(b) (adopting "[t]he techniques of tiering and incorporation by reference described respectively in 40 CFR 1502.20 and 1508.28 and 40 CFR 1502.21 of CEQ's NEPA regulations" (footnote omitted)); Ex. NRC-014, NUREG-1748 § 1.6.2 at 1-10.

[15] LBP-15-11, 81 NRC at 440 n.258 (citing Powertech USA, Inc. (Dewey-Burdock In Situ Uranium Recovery Facility), LBP-13-9, 78 NRC 37, 67 (2013)).

[16] Ex. INT-062, Curriculum Vitae of Hannan E. LaGarry (Mar. 4, 2010).

as the EPA Region VIII National Ground-Water Expert.[17] Dr. Kreamer received his Ph.D. in hydrology from the University of Arizona and is a Professor of Hydrology/Geoscience at the University of Nevada, Las Vegas.[18] Ms. McLean is an environmental biochemist with 40 years of experience researching toxic environmental exposures in animals and humans.[19]

Four witnesses testified for the NRC Staff: David Back, Dr. Elise Striz, Thomas Lancaster, and Nathan Goodman. Mr. Back received his M.S. in Geology with a hydrogeology concentration from Oklahoma State University and is a hydrogeologist at an environmental consulting firm.[20] Dr. Striz received her Ph.D. in Petroleum Engineering from the University of Oklahoma and is a hydrogeologist in the NRC's Uranium Recovery Licensing Branch.[21] Mr. Lancaster is a hydrogeologist and regulatory Project Manager in the NRC's Uranium Recovery Licensing Branch.[22] Mr. Goodman received his M.S. in Environmental Science from Johns Hopkins University and is a Project Manager and Terrestrial and Aquatic Biologist at the NRC.[23]

Five witnesses testified for Crow Butte: Wade Beins, Matthew Spurlin, Larry Teahon, Robert Lewis, and Doug Pavlick. Mr. Beins is a Senior Geologist at Crow Butte and has approximately 20 years of experience as a geologic technician and geologist at the Crow Butte

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[17] Ex. INT-064, Curriculum Vitae of Michael Wireman (June 2014).

[18] Ex. INT-063, Curriculum Vitae of David Kenneth Kreamer (Mar. 30, 2015).

[19] Ex. INT-048, Expert Opinion Testimony of Linsey McLean at 1 (May 1, 2015); Ex. INT-065, Curriculum Vitae of Witness Linsey McLean (undated).

[20] Ex. NRC-002, Curriculum Vitae of David Back (May 8, 2015).

[21] Ex. NRC-008, Curriculum Vitae of Dr. Elise A. Striz (May 8, 2015).

[22] Ex. NRC-005, Curriculum Vitae of Thomas R. Lancaster (May 8, 2015).

[23] Ex. NRC-004, Statement of Professional Qualifications of Nathan E. Goodman (May 8, 2015).

site.[24] Mr. Spurlin received his M.S. in Geology from the University of California, Los Angeles, and is a Senior Geologist at an environmental consulting firm.[25] Mr. Teahon received his B.A. in Chemistry and Biology from Chadron State College and is the Crow Butte Manager of Safety, Health, Environment, and Quality.[26] Mr. Lewis is a certified professional geologist and the owner and Principal Hydrogeologist of an environmental consulting firm.[27] Mr. Pavlick is the general manager for three uranium mines, including Crow Butte, and has 20 years of experience processing uranium and sodium carbonate ore in the western United States.[28]

C. Intervenor Issues and Admitted Contentions

In their written submissions and at the evidentiary hearing, Intervenors did not present evidence on a contention-by-contention basis for Contentions A, C, D, F, 6, and 9. Instead, they challenged the EA's analysis of a variety of related hydrogeologic issues that cut across these contentions. Furthermore, these related overarching issues apply to all of these contentions, either as direct issues raised by Intervenors, or as an indirect influence on understanding the background hydrogeologic conditions in and around the License Area, and so they serve to impact our findings of facts for each contention. Given this presentation of evidence, we address these overarching factual issues and disputes concerning the hydrogeological conditions at or near the License Area separately from our consideration of the individual issues raised in each specific contention.

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[24] Ex. CBR-001, Initial Written Testimony of Crow Butte Resources Witnesses Wade Beins, Bryan Soliz, Robert Lewis, Matthew Spurlin and Larry Teahon on Contentions A, C, D, F, and 14 at 1 (May 8, 2015); Ex. CBR-002, Affidavit of Wade Beins (May 8, 2015).

[25] Ex. CBR-005, Affidavit of Matthew Spurlin (May 8, 2015).

[26] Ex. CBR-006, Affidavit of Larry Teahon (May 8, 2015).

[27] Ex. CBR-003, Affidavit of Robert Lewis (May 8, 2015).

[28] Ex. CBR-009, Affidavit of Doug Pavlick (May 8, 2015).

To provide context for our technical findings of fact, we briefly review the bases for each contention. First, Contention A challenges the adequacy of the NRC Staff's required bi-weekly testing of monitoring wells and its omission of uranium as a parameter to detect an excursion (i.e., the unintended spread of processing liquids beyond Crow Butte's mining units). Contention C challenges the EA's conclusion that the impact from accidental surface spills will be minimal because there are no nearby surface water features. In Contention D, Intervenors claim the EA incorrectly states that there is no communication among the aquifers in the general area of the License Area, and that, based on potential connections between such aquifers, the EA's Environmental Justice analysis should be expanded to consider the impacts of the renewal of Crow Butte's license on the drinking water supplies within the PRIR. Contention F alleges the EA fails to include the results of recent research that would have resulted in the EA adopting an updated and more accurate depiction of the geologic formations in the general vicinity of the License Area. Contention 6 takes issue with the EA's estimations of restoration impacts and asserts that water consumption during restoration will produce a LARGE impact to the ore-bearing aquifer, rather than the MODERATE one the EA projected. Contention 9 alleges that the EA does not adequately discuss groundwater restoration mitigation measures and, in particular, whether Crow Butte will be able to return the License Area to pre-operational water quality levels.

Apart from the above contentions that involve factual disputes over the hydrogeologic features in the general area of the License Area, there are two other contentions we address as standalone issues at the end of this decision. Contention 12 has two separate parts that we address as Contention 12A—concerning the EA's lack of discussion of tornadoes—and Contention 12B—addressing the adequacy of the EA's analysis of the environmental impacts from land application of ISL wastewater. Finally, Contention 14 asserts that the EA fails to analyze the impacts of earthquakes on contaminant migration due to seismic-induced alteration of the geologic formation.

For each contention, we have considered all the pre-filed testimony, the evidence presented at the hearing, and the parties' proposed findings of facts and conclusions of law. Insofar as the parties' evidence directly relates to and impacts our decision, it is summarized for each contention. On the other hand, where we deemed the evidence to be of no relevance to our decision, we did not summarize it. Where there is an evidentiary dispute, we make any necessary factual findings based on a preponderance of the evidence.[29]

Immediately below is Section II, which summarizes undisputed background information relating to Crow Butte's mining operations, the regional geologic setting, and the regional hydrogeologic conditions surrounding the License Area.[30] It is followed by Section III, which presents an analysis of the overarching geologic and hydrogeologic disputes raised by Intervenors. That, in turn, is followed by Section IV, which addresses all of the individual contentions.

II. BACKGROUND INFORMATION

Many of the contentions herein raise factual issues concerning mining operations and the geology and hydrogeology of the Crow Butte License Area. Some of these are in dispute, while others are not. This section is devoted only to the latter, i.e., uncontested facts that provide needed background information on mining operations and the region's geologic and hydrogeologic conditions.

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[29] Pac. Gas & Elec. Co. (Diablo Canyon Power Plant Indep. Spent Fuel Storage Installation), CLI-08-26, 68 NRC 509, 521 (2008); see also Entergy Nuclear Operations, Inc. (Indian Point, Units 2 & 3), CLI-15-6, 81 NRC 340, 388 n.258 (2015).

[30] To assist in understanding the geography of the site surrounding the License Area and the sequencing of the subsurface geology, we have prepared a schematic layout of the region and the varying profiles of the geologic strata and have included it in an appendix to this decision. These sketches are based on our understanding of the site features and their relative positions based on the testimony in the record. The aspects of these figures are not drawn to any scale and are provided for illustrative purposes only.

A. Mining Operations at Crow Butte

The Crow Butte ISL facility is located southeast of Crawford, Nebraska, in Dawes County.[31] Crow Butte's license renewal application (LRA) shows that the area of review for its license renewal is defined by a 2.25 mile radius that surrounds a series of mine units—i.e., Mine Units 1 through 11.[32]

In these mine units, Crow Butte injects a liquid "lixiviant" into wells screened[33] in the Ore Zone Aquifer to mobilize the uranium. The uranium is then recovered through a production well and piped to a processing facility for uranium capture via an ion exchange process.[34] Each mine unit has a "seven spot" well design, a production well at the center of the mine unit, surrounded by six injection wells in a hexagon pattern, with equal 75-foot spacing between each of the injection wells and the production well.[35] To detect potential excursions around the Ore Zone, Crow Butte installed a perimeter ring of monitoring wells about 300 feet from each active mining wellfield, with no more than 400 feet of distance between each monitoring well.[36] These excursion monitoring wells are screened at the depth of the Ore Zone, where mining occurs, in order to detect contaminants that move horizontally and that may have the potential to escape the mining operation.[37] To detect contaminants that migrate vertically from the Ore Zone up

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[31] EA § 1.1 at 14.

[32] LRA, fig. 2.6-3, at 2-109; see also EA, fig. 4-3, at 97; Ex. CBR-024, Crow Butte Resources, Inc., fig. 2.6-3 Cross Section Location (Apr. 9, 2009).

[33] A well is screened if a well screen is added to the bottom the well casing.

[34] EA § 1.3 at 14–15.

[35] Tr. at 1028–29.

[36] EA § 4.6.2.2.4 at 91–92; Tr. at 1030.

[37] EA § 4.6.2.2.4 at 91–92; Tr. at 1030.

through the overlying Upper Confining Unit (UCU) into the Upper Brule Aquifer, additional excursion wells (one in every four acres of mine unit) are placed in this overlying aquifer.[38]

B. Undisputed Regional Geologic Setting

1. General Stratigraphic Units

EA §§ 3.4.1 and 3.5.2 discuss regional and on-site stratigraphy (i.e., geologic layers beneath the License Area) and hydrostratigraphy (i.e., groundwater within those geologic layers).[39] As described in EA § 3.4.1, the geologic formations in the Crow Butte region are (starting from the youngest to oldest and including the thicknesses of the unit underlying the License Area): (a) the White River alluvium;[40] (b) the Upper Aquifer consisting in places of the Arikaree Aquifer (200 to 400 feet thick) and the Upper Brule Aquifer of the Brule Formation[41] (200 to 400 feet thick); (c) the UCU consisting of the Lower Brule Formation (200 to 300 feet thick) and the underlying Upper and Middle Chadron Formations (approximately 28 feet thick); (d) a sandstone layer, called the Basal Chadron Formation by some and the Chamberlain Pass Formation by others[42] and referred to in this decision as the "Basal Chadron/Chamberlain Pass

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[38] EA § 4.6.2.2.4 at 91–92; Ex. CBR-001 at 36; Ex. CBR-074, Supplemental Rebuttal Testimony of Crow Butte Resources at 5 (Sept. 28, 2015).

[39] EA § 3.4.1 at 37–40; id. § 3.5.2 at 47–53.

[40] Alluvium is surface soil, usually consisting of sand, silt, and gravel, deposited by surface water, and, as such, is found in isolated areas underlying a river channel and its floodplain. See Ex. INT-003, Hannan E. LaGarry, Expert Opinion Regarding ISL Mining in Dawes County, Nebraska at 2–3 (undated).

[41] The Brule Formation varies in lithology with depth, transitioning from a more permeable aquifer-type material labeled as the Upper Brule Formation to a much less permeable confining zone labeled as the Lower Brule Formation. In this decision, the Brule Formation refers to the combined geologic strata, the Upper Brule Formation refers to the upper portion of the Brule Formation, the Upper Brule Aquifer refers to the groundwater contained in the pores and fractures in the formation, and the Lower Brule Formation refers to the lower portion of the formation which forms one layer of the upper confining unit overlying the Ore Zone.

[42] See infra § IV.D.1.b, Parties' Positions on Nomenclature for the Ore Zone Formation at 171–74.

Formation," (BC/CPF);[43] and (e) the Lower Confining Unit (LCU) consisting of the Pierre Shale (1,500 to 2,000 feet thick).[44] The Chadron and Brule Formations are collectively known as the "White River Group."[45] The Ore Zone (10 to 80 feet thick) being mined in the License Area is part of the BC/CPF. While Intervenors' witnesses agreed with the EA's characterization of these stratigraphic units,[46] they also noted that in regions beyond the mines at the License Area, the Ogallala Aquifer overlies the Arikaree Aquifer as part of the High Plains Aquifer.[47]

The NRC Staff's witnesses testified that "[t]he cross-sections provided in Figures 2.6-4 to 2.6-11 of the LRA provide[] the best depiction of the stratigraphy at and in the vicinity of the Crow Butte [In Situ Recovery] facility"[48] as augmented with the presentation of the actual geophysical logs and Crow Butte's picks (i.e., elevation contact between different units) of those individual sedimentary strata.[49] Crow Butte's witnesses noted that within these continuous

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[43] Intervenors' witnesses challenged the appropriateness of continuing to use the historic terminology of the "Basal Chadron" for this formation, and instead advocated for the use of the more recent name of "Chamberlain Pass Formation." We discuss the correct nomenclature for this formation elsewhere, see infra § IV.D.2.b, Board Findings on Nomenclature for the Ore Zone Formation at 171–74; for purposes of this decision, we use the combined term of Basal Chadron/Chamberlain Pass Formation (BC/CPF). In addition, when used alone, BC/CPF refers to the geologic formation or structure. By contrast, BC/CPF Aquifer refers to the groundwater contained in the pores and fractures of this formation.

[44] EA § 3.4.1 at 37–40; see also Ex. NRC-009, Safety Evaluation Report (Revised), License Renewal of the Crow Butte Resources ISR Facility Dawes County, Nebraska Materials License No. SUA-1534, § 2.3.3.2 at 33–35 (Aug. 2014) [hereinafter SER]; Ex. CBR-001 at 11; LRA § 2.6.2 at 2-106–31.

[45] EA § 3.4.1.3 at 39; see also Ex. INT-003, Hannan E. LaGarry, Expert Opinion Regarding ISL Mining in Dawes County, Nebraska at 2 (undated).

[46] Tr. at 1036–37.

[47] Tr. at 1045.

[48] Ex. NRC-001-R, NRC Staff's Initial Testimony at 55 (May 8, 2015) (citing LRA, figs. 2.6-4 to 2.6-11, at 2-111–19).

[49] Tr. at 1041–43 (citing Ex. CBR-024).

geologic units, physical characteristic heterogeneities[50] are present, but the overall interpretation of lateral continuity is not affected by local rock unit variations.[51]

Dr. LaGarry testified for Intervenors that the northwest portion of Nebraska is underlain by sedimentary formations that vary from consolidated layers (i.e., compacted, cemented, rock-like material) to unconsolidated zones (i.e., small particles like beach sand, silt, and clay), and everything in between.[52] According to Dr. LaGarry, the sedimentary rocks in the Crow Butte region are loosely consolidated, poorly hardened, and "in places one can work them with one's hands."[53]

2. Upper Aquifers

Regionally, the surface aquifers include the aquifer associated with the White River alluvium, the Ogallala Aquifer, the Arikaree Aquifer, and the Upper Brule Aquifer.[54] The White River alluvium borders the White River and is derived from the weathering of the surficial stratigraphic units.[55] The White River runs approximately two miles northerly from the northwest edge of the License Area and then runs northeasterly from Crawford towards Chadron and thence to the PRIR in South Dakota (i.e., about 50 miles northeast of the License Area).[56] Where the White River alluvium is not present, the surficial aquifer in the License Area is

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[50] We use the term "heterogeneous" when referring to a geologic formation that has varying hydraulic properties with location, e.g., permeability varies with distance and depth within the aquifer.

[51] Ex. CBR-001 at 11.

[52] Ex. INT-003 at 2; Tr. at 1034–36, 1040.

[53] Tr. at 1035.

[54] LRA, figs. 2.6-2 to 2.6-4, at 2-107–11; id., fig. 2.6-6, at 2-115; id., fig. 2.6-11, at 2-124; Ex. NRC-001-R at 41–55; INT-003 at 2–3; Tr. at 1223–24.

[55] Ex. NRC-001-R at 55.

[56] Id. at 28, 34; Ex. NRC-095, NRC Staff's Supplemental Direct Testimony at 26–27 (Sept. 18, 2015); Tr. at 1224.

associated with the Upper Brule Aquifer and, in one isolated location, with the Arikaree Formation. As shown in LRA Figure 2.6-1, the Arikaree Formation, composed of sandstones, is only present at the farthest southeast portion of Mine Unit 11.[57] While the Ogallala Formation overlies the Arikaree Aquifer under the PRIR in South Dakota,[58] it is not present anywhere in the License Area, and is only found several miles to the south.[59]

As a result, most of the License Area is underlain by 130 to 480 foot thick portions of the Upper Brule Aquifer,[60] which is often encountered at depths from 60 to 100 feet below the surface. This aquifer is underlain by the less permeable aquitard (i.e., a geologic layer that restricts the vertical flow of groundwater between aquifers) formed by the Lower Brule and the Upper and Middle Chadron Formations (i.e., the UCU discussed below).[61] The EA states that the Upper Brule Aquifer is an important aquifer in that it produces sufficient quantities of water suitable for domestic and agricultural purposes, both regionally and locally.[62] As such, the EA states that Crow Butte designated the Upper Brule Aquifer as the overlying aquifer for the Ore

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[57] LRA, fig. 2.6-1, at 2-99; id., fig. 2.6-9, at 2-120; id., fig. 2.6-11, at 2-124; see also Ex. NRC-001-R at 41, 55.

[58] Ex. BRD-003, Kyle W. Davis, Larry D. Putnam & Anneka R. LaBelle, U.S. Geological Survey, Conceptual and Numerical Models of Groundwater Flow in the Ogallala and Arikaree Aquifers, Pine Ridge Indian Reservation Area, South Dakota, Water Years 1980–2009, Scientific Investigations Report 2014–5241, tbl. 3, at 10 (Feb. 2015); LRA, fig 2.6.1, at 2-99; Ex. NRC-001-R at 41, 55.

[59] LRA, fig. 2.6-1, at 2-99; Ex. NRC-001-R at 41, 55.

[60] EA § 3.4.1.6 at 39.

[61] Id. § 3.4.1.6 at 39; id. § 3.5.2.2 at 48–50; Tr. at 1039–40.

[62] EA § 4.13.6.2 at 128–29.

Zone.[63] While the Upper Brule Formation may be an important source of water, the EA notes that it exhibits rather low unfractured hydraulic conductivity.[64]

3. Upper Confining Unit (UCU)

a. Extent of the UCU

LRA § 2.6.2 states that the Ore Zone is locally separated from the overlying aquifer (the Upper Brule Aquifer) by 200 feet or more of a thick, regionally continuous UCU.[65] All parties agreed that this UCU consists of (1) the Middle and Upper Chadron Formations; and (2) the overlying Lower Brule Formation. This UCU lies between the overlying Upper Brule Aquifer and the BC/CPF Aquifer that, as noted earlier, contains the Ore Zone in the License Area.[66] The top of the UCU ranges in depth from 130 feet to 480 feet beneath the ground surface, depending on the thickness of the overlying Upper Brule Formation.[67]

The LRA describes the geological conditions at the License Area with cross-sections.[68] These cross-sections suggest that the UCU is continuous across the License Area,[69] which is consistent with the testimony of Crow Butte's expert Mr. Beins, who stated that drill cuttings and geophysical logs from over 10,000 boreholes on-site show that these strata extend over the

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[63] Id. § 4.6.2.2.4 at 91–92.

[64] EA § 3.5.2.2 at 48–50. Several exhibits use the term "hydraulic conductivity" while others use the term "permeability" to describe movement of groundwater through soil or rock in terms of velocity (i.e., distance/time). While there is some difference between the two terms, for purposes of this decision, we use the two terms interchangeably.

[65] See LRA § 2.6.2.6 at 2-135–36; see also Ex. CBR-045, Rebuttal Testimony of Crow Butte Resources Witnesses Wade Beins, Bryan Soliz, Robert Lewis, Matthew Spurlin and Larry Teahon on Contentions A, C, D, F, and 14 at 32 (June 8, 2015); Tr. at 1112–13.

[66] EA § 3.4.1.6 at 39; LRA § 2.6.2.3 at 2-128; Tr. at 1092–93.

[67] EA § 3.4.1.6 at 39.

[68] LRA, figs. 2.6-4, to 2.6-11 at 2-111–24; see also Ex. NRC-001-R at 29.

[69] LRA, figs. 2.6-4 to 2.6-11, at 2-111–24; see also Ex. NRC-001-R at 29.

entire License Area.[70] Based on this drilling and geophysical measurements, Crow Butte's witnesses maintained that the thickness of the UCU ranges from approximately 100 feet along the northwest boundary of the area of review to over 500 feet along its southeast boundary.[71] In the immediate vicinity of the mining wellfields, the thickness of the UCU ranges from 200 feet on the north to 500 feet on the south,[72] of which 40 to 100 feet of this thickness is attributable to the Middle Chadron Formation.[73] While Intervenors' witnesses did not dispute this description of the on-site strata, Dr. LaGarry added that the Chadron Formation portion of the UCU outcrops (i.e., manifests itself as exposed bedrock) about 15 miles northwest of the License Area.[74]

b. Composition of the UCU

The formations making up the UCU consist of clays and fine-grained mudstones of the Middle and Upper Chadron Formations, and interbedded siltstone, mudstone, and claystone of the Lower Brule Formation.[75] Both the Middle and Upper Chadron Formations contain significant amounts of montmorillonite (i.e., a type of clay that absorbs water easily and, in absorbing water, expands to seal cracks in the formation) and other plastic clays with low vertical permeability.[76] The LRA states that the contact between the Upper Chadron Formation and the Lower Brule Formation is "gradational and cannot be consistently picked accurately in drill cuttings or on [geophysical] logs. Therefore, the upper part of the Chadron Formation and

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[70] Tr. at 1058–59.

[71] Ex. CBR-001 at 20; Tr. at 1093–95.

[72] Ex. CBR-001 at 20.

[73] Ex. NRC-021, Stephen P. Collings and Ralph H. Knode, Geology and Discovery of the Crow Butte Uranium Deposit, Dawes County, Nebraska, 7 Ann. Symp. on Uranium and Precious Metals 5–14 at 3 (1984).

[74] Tr. at 1076.

[75] EA § 3.4.1.5 at 39; id. § 3.4.1.6 at 39.

[76] LRA § 2.6.2.2 at 2-127–28; Tr. at 1100–01.

the lower part of the Brule Formation are combined within the [License Area]."[77] Crow Butte's witnesses also testified that, across the License Area, not only is the average thickness of the UCU about 300 feet, but, because its composition is predominantly low permeability silts and clays, there are effectively more than 100 feet of clay-type materials within this zone.[78]

The Upper Chadron Formation is light green-gray bentonitic clay, which grades downward to green and red clay (Red Clay Horizon),[79] an ancient fossil soil that the LRA claims serves as "an excellent marker bed in drill cuttings" that has been observed in virtually all drill holes within the License Area.[80] According to Crow Butte's witnesses, this persistent, 25-foot thick "sticky" clay horizon (made of 44 percent montmorillonite) generally marks the upper limit of the Ore Zone.[81]

Crow Butte's witnesses testified that the remainder of the UCU above this Red Clay Horizon is characterized by interbedded silts and clays of varying composition,[82] and that samples from those zones contain more than 50 percent clay.[83] These witnesses also stated that the UCU material is only partially converted from sediments to rock (i.e., lithified), based on observations from core and drill cuttings,[84] and that some of the clay rapidly swells when

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[77] LRA § 2.6.2.3 at 2-131.

[78] Tr. at 1105.

[79] LRA § 2.6.1.5 at 2-103; Tr. at 1098–99.

[80] LRA § 2.6.2.3 at 2-131.

[81] Ex. NRC-001-R at 110; Tr. at 1107–08, 1113; see also LRA, tbl. 2.6-2, at 2-107.

[82] Tr. at 1108.

[83] Tr. at 1108.

[84] Ex. CBR-001 at 21.

exposed to excess water.[85] Based on laboratory tests of core samples from the UCU, this layer has a very low permeability of less than 1.0×10^{-10} centimeters per second (cm/sec).[86]

Intervenors did not dispute the existence either of the Red Clay Horizon extending over the full License Area or of the high percentage of clay in the remaining portions of the UCU. Although Intervenors' witness Mr. Wireman agreed that there is clay within the UCU, he did posit two preferential flow paths through the UCU: (1) higher transmissivity through secondary porosity (i.e., the highly fractured and jointed strata); and (2) the presence of more permeable sand or silt lenses within the clay or claystone.[87]

While we address the issue of secondary porosity below in Section III (in conjunction with our analysis of the potential fracturing of the UCU),[88] we note that, with respect to the possibility of there being more permeable sand and silt lenses, Mr. Wireman agreed that the lenses would have to be continuous in order for the groundwater to move through them.[89] However, he offered no evidence or expert opinion that such continuous layers of higher permeability sand and silt lenses are present either in the Red Clay Horizon or in the remainder of the overlying UCU. Both Mr. Wireman and Dr. LaGarry agreed that the most likely flow path would be associated with the alleged fracturing of the UCU,[90] which, as noted, is discussed below in Section III.[91]

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[85] Id.; Tr. at 1101.

[86] LRA § 2.6.2.3 at 2-131; Tr. at 1116–17.

[87] Tr. at 1120–21.

[88] See infra § III.D.2.b, Board Findings on Secondary Porosity/Permeability from Fracturing at 97–99.

[89] Tr. at 1121–22.

[90] Tr. at 1122.

[91] See infra § III.D.1.b, Parties' Positions on Secondary Porosity/Permeability from Fracturing at 80–88.

The NRC Staff agreed that the lower portion of the Brule Formation consists of interbedded siltstone, mudstone, and claystone with occasional sandstone, and that the Upper Brule Formation includes brown siltstones and sandstone members.[92] Although these units are classified as sandstones, mudstones, and siltstones, Crow Butte's descriptions during its logging of the drill holes indicated that substantial portions of these materials are unconsolidated.[93] Less clay and more sand in these upper portions of the UCU is consistent with increasing permeabilities in the higher zones.[94]

In conjunction with his explanation of the geologic condition of this portion of the UCU (i.e., the Middle and Upper Chadron Formation and Lower Brule Formation), Dr. LaGarry agreed with the NRC Staff that this lower portion of the UCU is more clay-like, with the Red Clay Horizon consisting of devitrified (i.e., converted from glass to clay) volcanic ash that fell from the sky forming a thick, widespread deposit.[95]

Crow Butte's witnesses concurred with this characterization, stating that "the sediments overlying the mined aquifer have not undergone complete lithification, as observed in cores and drill cuttings during drilling investigations."[96] From this, Crow Butte's witnesses claimed that the Upper Chadron Formation is primarily unconsolidated clays, with a few layers of dense, lithified, semi-consolidated mudstones, siltstones, and claystones.[97] Crow Butte's witnesses further testified that they encountered semi-consolidated clays, silts, and muds of the Upper and Middle Chadron Formations in every one of the 12,000 drill holes made during more than 20 years of

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[92] Ex. NRC-001-R at 29.

[93] Tr. at 1127.

[94] Tr. at 1126–28.

[95] Tr. at 1128–31.

[96] Ex. CBR-001 at 21.

[97] Tr. at 1098–99.

exploration.[98] Intervenors did not contest Crow Butte's characterization of the UCU as incompletely lithified sediments consisting of unconsolidated clays with semi-consolidated layers of clay, silt, and mudstones.

4. Basal Chadron/Chamberlain Pass Formation (BC/CPF)

The BC/CPF, a portion of which is the Ore Zone being mined by Crow Butte in the License Area, underlies the UCU. EA §§ 3.4.1 and 3.5.2.3.2 confirm that the BC/CPF is confined on the top by the UCU,[99] and on the bottom by the LCU, which is composed of the Pierre Shale.[100] The NRC Staff's witnesses testified that the Ore Zone portion of the BC/CPF trends southeast from Crawford, the result of sandstone being deposited by a major drainage feature—a west-to-east, through-flowing, historic buried valley about 25 miles wide entering present day Nebraska in northwestern Sioux County and then turning southeast in western Dawes County.[101] According to the NRC Staff's witnesses, the BC/CPF, which is not present beyond about five miles north and east of Crawford, is the only portion of the Chadron Formation that is considered an aquifer.[102] They also testified that, because the BC/CPF thins at the extremities of its 25-mile width, it is not present anywhere between the License Area and the PRIR.[103]

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[98] Tr. at 1099.

[99] EA § 3.4.1 at 37–40; id. § 3.5.2.3.2 at 51.

[100] Id. § 3.5.2.3.2 at 51.

[101] Ex. NRC-001-R at 32 (citing Ex. NRC-024, J. B. Swinehart, V. L Souders, H. M. Degraw & R. F. Diffendal, Jr., Cenozoic Paleogeography of Western Nebraska, in Cenozoic Paleogeography of the West-Central United States at 212 (R. Flores and S. Kaplan eds., 1985)).

[102] Id.

[103] Id.; Ex. NRC-023, Kendall A. Dickinson, Distribution of the basal elastic unit of the Oligocene Chadron Formation in the Alliance 2-degree quadrangle, northwestern Nebraska, U.S. Geological Survey, Open-File Report 90-416, fig. 1, at 3 (1990).

Dr. LaGarry largely agreed with the NRC Staff's witnesses, only adding that the BC/CPF sandstone deposit also follows the slope that leads south from the Black Hills.[104] He testified that, in this portion of northwestern Nebraska, the orientation of this sandstone deposit followed a historic northwest-southeast trending valley with tributaries that enter Nebraska from the northwest and head southeast towards the North Platte River.[105] Dr. LaGarry also stated that the BC/CPF is present in a semicircle running northwest of the License Area around the southeast and northern flanks of the Black Hills and that it outcrops on the land surface of the PRIR.[106] He agreed that the NRC Staff accurately described the hydraulic barrier to the northeast that lies between the License Area and the PRIR (i.e., the Chadron Arch of the Pierre Shale).[107] Dr. LaGarry also testified that the BC/CPF is located 200 to 700 feet below ground surface[108] and does not outcrop anywhere in the License Area or in Crow Butte's proposed North Trend Expansion Area (NTEA),[109] which lies northwest of the License Area.[110]

The NRC Staff's witnesses agreed with Dr. LaGarry and noted that the geologic cross-sections contained in the LRA appear to corroborate this location of the BC/CPF.[111] The NRC Staff's witnesses further testified that a United States Geological Survey (USGS) map shows

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[104] Tr. at 1068.

[105] Tr. at 1068; see also Ex. INT-003 at 2–3.

[106] Tr. at 1074.

[107] Tr. at 1074, 2578.

[108] Tr. at 1075.

[109] The NTEA is the subject of a separate, pending license amendment proceeding. See Ex. NRC-001-R at 73.

[110] Tr. at 1075.

[111] Ex. NRC-001-R at 32 (citing LRA, fig. 2.6-12, at 2-129).

the extent of this valley-filled sandstone feature.[112] It was the opinion of the NRC Staff's witnesses that the BC/CPF is not present beyond about five miles north and east of Crawford between the License Area and the city of Chadron due to the presence of the Chadron Arch, which prevents sand deposition any further east.[113] Neither Crow Butte's nor Intervenors' witnesses disputed this interpretation.[114]

The EA also states that the BC/CPF Aquifer, at a depth of 400 to 900 feet below the ground surface, acts as a local supply of stock water[115] but, because of its greater depth and inferior water quality, is not routinely used as a domestic water supply in the License Area or in nearby areas.[116]

5. Pierre Shale Lower Confining Unit

The Pierre Shale that underlies the Basal Chadron sandstone reaches a thickness of over 1,500 feet in the License Area.[117] The LRA describes the Pierre Shale as a "black marine shale [that] is an ideal confining bed with measured vertical hydraulic conductivity in the [License Area] of less than 2.0 x 10^{-9} [cm/sec]."[118] There is no dispute among the parties that the very low permeability of the Pierre Shale in the LCU prevents mining liquids from flowing downward from the base of the BC/CPF Aquifer.[119]

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[112] Id.

[113] Id. at 32–33.

[114] Tr. at 1071–72, 1074–75, 2578.

[115] EA § 3.5.2.2 at 50.

[116] Id.

[117] Id., tbl. 3-5, at 38.

[118] LRA, fig. 2.6-2, at 2-107.

[119] Tr. at 1027–28.

6. White River Geologic Feature

Northeast trending geologic features have been identified or proposed in Sioux and Dawes Counties.[120] One of these is the White River Feature, a geologic unit which the White River follows north of Crawford, and which was first postulated by Crow Butte during its exploration drilling,[121] as one of the six northeast trending features near the License Area.[122] The White River Feature passes along the southeast boundary of Crow Butte's proposed NTEA, which is approximately two miles from the northern boundary of the License Area.[123]

C. Undisputed Regional Hydrogeologic Conditions in the License Area

1. Surface and Subsurface Water Resources

As summarized in the EA and as shown in Figure 2.2-3 of the LRA, the License Area lies within the watersheds of three small southern tributaries of the White River, i.e., White Clay Creek, Squaw Creek, and English Creek.[124] While White Clay Creek is located primarily outside of the License Area on the west side of the Crow Butte facility, Squaw Creek and English Creek flow from southeast to northwest within the License Area.[125] There are also eight surface water impoundments in or near the License Area, generally used for livestock watering.[126] Four of these impoundments are physically within the License Area near Squaw and English Creeks.[127] White Clay Creek, Squaw Creek, and English Creek all converge and enter the White River

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[120] EA § 3.4.2 at 40.

[121] Id.

[122] Id.

[123] Id. § 3.5.2.3.3 at 51–52.

[124] Id. § 3.5.1 at 45; LRA, fig. 2.2-3, at 2-25.

[125] Ex. NRC-001-R at 16 (citing LRA, fig. 2.2-3, at 2-25).

[126] EA § 3.5.1 at 45.

[127] Id.; LRA, fig. 2.7-1, at 2-159; id. § 2.7.1.3 at 2-163; id. § 2.7.1.4 at 2-163.

approximately three miles north of the License Area and two miles downstream from the city of Crawford.[128] The White River flows northeast towards Chadron and through Dawes County into South Dakota.[129]

As summarized in the EA, Crow Butte identified the following major water-bearing subsurface formations in the region of the License Area: (1) the aquifer associated with the White River alluvium; (2) the Upper Brule Aquifer; and (3) the BC/CPF Aquifer.[130] The first of these, the aquifer associated with the White River alluvium, occurs intermittently in ephemeral drainages and is not a reliable water source.[131] As previously mentioned,[132] the Upper Brule Aquifer is an important aquifer that produces sufficient quantities of water suitable for domestic and agricultural purposes. The EA states that the BC/CPF Aquifer has limited use as a groundwater supply because of its generally poor water quality and its high radionuclide content.[133] The base of the BC/CPF Aquifer is the low-permeability Pierre Shale that acts as an LCU for the BC/CPF.[134]

2. Groundwater Levels, Flow Directions, Hydraulic Parameters in the License Area

a. Groundwater Levels and Flow Directions

i. Upper Brule Aquifer Levels and Flow Directions

The shallowest productive aquifer within (and surrounding) the License Area is the Upper Brule Aquifer, which is unconfined and which produces usable amounts of water only

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[128] EA § 3.5.1 at 45; LRA, fig. 2.2-3, at 2-25.

[129] EA § 3.5.1 at 45.

[130] Id.

[131] Id. § 3.5.2.1 at 47.

[132] See supra § II.B.2, Upper Aquifers at 18–20.

[133] EA § 3.5.2.1 at 47.

[134] Id.

where it is sufficiently jointed to form saturated zones.[135] The saturated zones of the Upper Brule Aquifer are often encountered at depths from 60 to 100 feet,[136] but are generally discontinuous and are of limited areal extent.[137] The EA points to a 1995 water table map showing that a groundwater divide occurs to the south of the License Area along the Pine Ridge Escarpment, and that groundwater north of this divide flows to the north, northwest, and northeast, depending upon its position relative to the White River.[138] All record evidence indicates that the White River acts as a regional drain for groundwater and, as a consequence, groundwater flow in the Upper Brule Aquifer, at least within the License Area, is northerly towards the White River.[139]

Consistent with the EA's characterization of regional groundwater flow, the LRA maintains that flow in the Upper Brule Aquifer was to the northwest prior to mining and that it remained so during the subsequent 20 years of mining operations.[140] This statement is based not only on Crow Butte's current system of more than 200 shallow monitoring wells in the Upper Brule Aquifer (approximately one well every four acres),[141] but also on long-term water level data that was first collected just prior to mining, and then was collected every two weeks during operations for each individual mine unit, including its restoration period.[142]

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[135] Id.

[136] Id. § 3.5.2.2 at 49.

[137] Id. § 3.5.2.1 at 47.

[138] Id.

[139] Ex. NRC-076-R2, NRC Staff's Rebuttal Testimony at 2 (June 8, 2015).

[140] LRA, figs. 2.7-3a to 2.7-3d, at 2-173–79.

[141] Ex. CBR-001 at 36; Ex. CBR-074 at 5.

[142] Ex. CBR-074 at 5.

ii. BC/CPF Levels and Flow Directions

The EA states that the Ore Zone at all mine units is within the BC/CPF Aquifer.[143] The thickness of the BC/CPF Aquifer within the License Area varies from 40 feet to 80 feet with an average thickness of 60 feet.[144] The thickness of the BC/CPF Aquifer decreases to zero approximately one mile northeast of the License Area. The depth to the Ore Zone varies between 400 feet to 900 feet, increasing in the southeastern direction.[145]

Prior to mining, the potentiometric levels (i.e., the imaginary surface that defines the level to which water in a confined aquifer would rise were it pierced by a well) in the BC/CPF Aquifer were above the ground surface in the northern part of the License Area.[146] Comparing recent water levels to the pre-mining water level data in the BC/CPF Aquifer, the NRC Staff's witnesses estimated that drawdown (i.e., lowering of the potentiometric level produced by pumping) within the mine units over 20-plus years of Crow Butte's operations averaged approximately 47 feet.[147] As a result, no present day potentiometric surface level is above the ground surface.[148]

Originally, the groundwater flow direction in the BC/CPF Aquifer was to the northwest away from the License Area.[149] Once Crow Butte initiated mining in 1991,[150] groundwater levels fell due to the inward gradients established during mining operations and restoration as required

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[143] EA § 3.5.2.3.1 at 50–51.

[144] Id.

[145] Id.

[146] Ex. NRC-001-R at 87 (citing SER § 3.1.3.5.6 at 61).

[147] Id.; see also EA § 4.6.2.2.1 at 87–88.

[148] Tr. at 1420.

[149] Ex. NRC-001-R at 41; see also LRA, fig. 2.7-4a, at 2-183.

[150] EA § 1.1 at 14.

by Crow Butte's renewed license (License Condition 10.7) to ensure that none of the mining liquids escaped the License Area.[151] These pumping operations resulted in a variety of new localized flow directions and gradients,[152] as evident from the potentiometric levels established during active ISL operations in 2008 to 2009.[153]

iii. Arikaree Formation

There is no dispute among the parties that the Arikaree Formation is present within the License Area only along the farthest southeastern portion of Mine Unit 11,[154] where it is on a hill and dry.[155] As such there is no aquifer associated with the Arikaree Formation in the License Area.

iv. Pine Ridge Indian Reservation (PRIR) Aquifers

According to the USGS, "[t]he Ogallala and Arikaree [A]quifers are the largest sources of groundwater on the [PRIR] and are used extensively for irrigation and public and domestic water supplies,"[156] while the White River Group (i.e., Chadron and Brule Formations) beneath the PRIR has a permeability that is generally too low for it to serve as a source of groundwater.[157]

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151 Ex. NRC-012, U.S. NRC Materials License SUA-1534 at 8 (Nov. 5, 2014) (License Condition 10.7).

152 See LRA, figs 2.7-4b to 2.7-4d, at 2-185–89.

153 See EA § 3.5.2.2 at 49.

154 LRA, fig. 2.6-1, at 2-99; id., fig. 2.6-9, at 2-121; id., fig. 2.6-11, at 2-125; see also Ex. NRC-001-R at 41, 55; Ex. NRC-102, Scott Summerside, Michael Ponte, Vincent Dreeszen, Stephen Hartung & Joe Szilagyi, Conservation and Survey Division, University of Nebraska-Lincoln, Geology and 1995 Water Table Contours in the Upper Niobrara White Natural Resources District (2001).

155 Tr. at 1170, 2620; see also Ex. NRC-102.

156 Ex. BRD-003 at 1.

157 Ex. NRC-025, Allen J. Heakin, U.S. Geological Survey, Water Quality of Selected Springs and Public-Supply Wells, Pine Ridge Indian Reservation, South Dakota, 1992-97, Water-Resources Investigations Report 99-4063 at 10 (2000).

As we discussed earlier,[158] the EA notes that a groundwater divide occurs along the Pine Ridge Escarpment to the south of the License Area, and that groundwater north of this divide flows in a northerly direction towards the White River.[159]

The parties agreed that the PRIR's water wells (set in the Arikaree Aquifer) that are closest to the License Area are about 50 miles east-northeast of the License Area.[160] The parties also agreed that the Arikaree Aquifer groundwater enters the southern portion of the PRIR from Nebraska and thus this water flows from the southwest (i.e., where the License Area is located) to the northeast in the direction of the PRIR.[161]

b. Hydraulic Parameters in the License Area

i. Vertical Hydraulic Gradient: Upper Brule Aquifer to BC/CPF Aquifer

Crow Butte maintains an inward flow of groundwater in the production zone by pumping water through a waste "bleed stream," that removes more water than it injects during mining, resulting in a drawing down of the potentiometric level in the BC/CPF Aquifer to create a hydraulic cone of depression.[162] Because of this inward gradient caused by the groundwater

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[158] See supra § II.C.2.a.i, Upper Brule Aquifer Levels and Flow Directions at 29–30.

[159] EA § 3.5.2.1 at 47.

[160] We examined Dr. LaGarry about a map of the PRIR (Ex. BRD-017) that shows directions of groundwater flow and on which Dr. LaGarry made annotations denoting the names of the towns with water wells that are set in the Arikaree Aquifer. Ex. BRD-017, Janet M. Carter and Allen J. Heakin, Generalized Potentiometric Surface of the Arikaree Aquifer, Pine Ridge Indian Reservation and Bennett County, South Dakota, U.S. Geological Survey Scientific Investigations Map 2993 (2007); Ex. NRC-095 at 26. Using the distance measuring tool in Google Maps, the NRC Staff's witnesses determined that the closest point of the PRIR area encircled by Dr. LaGarry in BRD-017 is about 50 miles east-northeast of the License Area. Ex. NRC-095 at 26–27.

[161] Ex. OST-001, Statement of Charmaine White Face (a.k.a. Zumila Wobaga) at Ex. 4 (May 5, 2015); Ex. NRC-095 at 27 (citing (1) the elliptical area drawn on Ex. BRD-017; (2) the leftmost arrow within the circled area of Ex. NRC-101; and (3) Ex. NRC-102, which consists of annotated Figures 29 and 30 from the Ex. BRD- 004).

[162] LRA § 2.7.2.1 at 2-193.

drawdown, Crow Butte's witnesses asserted that, by comparing measurements of the potentiometric surface of the BC/CPF Aquifer before mining began (1982–1983) with the measurements at the time the LRA was submitted (2008–2009), it becomes clear that Crow Butte's mining activities have lowered the BC/CPF Aquifer's potentiometric surface 40 to 60 feet across the License Area.[163] These witnesses further maintained that pumping the BC/CPF Aquifer produces strong downward hydraulic gradients within the License Area that ensure containment of the processing liquids within the Ore Zone.[164] As a result, the vertical hydraulic gradient in the permit area is strongly downward.[165] Neither witnesses for the NRC Staff nor Intervenors disputed these facts.

ii. Horizontal Hydraulic Gradient: Upper Brule Aquifer Water Table Elevations

The EA states that a pre-operational (1982–1983) potentiometric surface study for the Brule Formation indicated that, under natural conditions, groundwater flows northwest towards the White River at a gradient of about 0.012.[166] The EA referenced a series of Crow Butte's more recent potentiometric surface measurements from water-level data it collected in 2008 and 2009 that shows similar trends, though with somewhat steeper hydraulic gradients ranging from 0.025 to 0.043.[167]

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[163] Ex. CBR-001 at 15–16, 49; see also LRA § 2.7.2.1 at 2-193; EA § 3.5.2.2 at 49.

[164] Ex. CBR-074 at 5–6; see also EA § 3.5.2.2 at 49.

[165] Ex. CBR-074 at 5.

[166] EA § 3.5.2.2 at 49.

[167] Id.

iii. Horizontal Hydraulic Gradient: BC/CPF Aquifer Potentiometric Surface Elevations

The EA states that pre-operational (1982–1983) groundwater elevation data show that groundwater flow in the BC/CPF was to the north at a gradient of about 0.001.[168] In addition, Crow Butte's witnesses maintained that the most recent data (i.e., after years of mining activities) indicated that local hydraulic gradients in the BC/CPF are highly variable within the permit area,[169] ranging from 0.004 to 0.064 during the 2008 to 2009 time period.[170] Intervenors did not dispute these calculations.

iv. Hydraulic Conductivity/Permeability of the UCU

Based on Crow Butte's hydraulic conductivity values (calculated from consolidation tests on samples of cores from the Red Clay Horizon that ranged from $2.22x10^{-11}$ to $4.46x10^{-11}$ cm/sec.),[171] the EA states that the UCU is a tight formation that isolates the BC/CPF from overlying aquifers with several hundred feet of clay and siltstones.[172]

III. OVERARCHING GEOLOGIC AND HYDROGEOLOGIC ISSUES

As previously mentioned, Intervenors did not always present evidence on a contention-by-contention basis, but instead, challenged the EA's analysis of a variety of related hydrogeologic issues that cut across multiple contentions.[173] The majority of Intervenors' Contentions, specifically Contentions A, C, D, F, 6, and 9, all concern, or are in part dependent on, the factual premise that the EA was deficient insofar as it misinterpreted several geologic

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[168] Id.

[169] Ex. CBR-001 at 25–26.

[170] LRA § 2.7.2.1 at 2-193.

[171] Ex. BRD-002B-R, Crow Butte Resources, Inc., Industrial Ground Water Permit Amendment, Aquifer Test #2 at 2.7-17, -24 to -25, -50 (July 29, 1987).

[172] EA § 3.5.2.3.2 at 51.

[173] See supra § I.C, Intervenor Issues and Admitted Contentions at 12–14.

and hydrogeologic conditions underlying the License Area, and, as such, did not adequately discuss potential pathways through which contaminants could migrate from the License Area to the PRIR. Intervenors criticize the EA for (1) failing to consider possible connections between the BC/CPF Aquifer beneath the License Area and the aquifers underlying the PRIR in South Dakota; (2) incorrectly identifying the structure of the White River Feature; (3) misinterpreting Crow Butte's aquifer pumping tests; (4) failing to demonstrate that the UCU has sufficient integrity to assure containment of the mining liquids within the BC/CPF Aquifer (by ignoring known faulting, fracturing or cracking within the UCU when assessing the containment performance of this strata); (5) inadequately monitoring for, or quantifying, water quality impacts to surface water and groundwater; and (6) failing to consider potential pathways for contaminant migration. Each of these disputed topics is discussed in separate sections below.

Given that these critiques all contribute to Intervenors' overarching premise that the EA did not adequately address potential contaminant pathways for mining contaminants to migrate from the License Area, and that this premise underscores the majority of their contentions, we will resolve these common, disputed facts prior to assessing each of Intervenors' contentions.

A. Presence of the BC/CPF Underlying PRIR and Connection to the Ore Zone

Intervenors raised the possibility of a connection between the BC/CPF in the Ore Zone and the BC/CPF in the PRIR. Herein, we look at the evidence for the BC/CPF to underlie the PRIR and whether that formation could provide a pathway for mining contaminants to directly migrate to the PRIR through the BC/CPF.

1. Parties' Positions on the Presence of the BC/CPF Underlying the PRIR and its Connection to the Ore Zone

Intervenors' witness Dr. LaGarry testified that "the [BC/CPF] occurs at the land surface on the [PRIR] and in the butte tops north of the Black Hills."[174] And, while conceding that the

[174] Tr. at 1074.

BC/CPF in the License Area is deposited as depicted in a USGS report,[175] Dr. LaGarry asserted that this USGS report does not show the complete areal extent of this formation.[176]

Dr. LaGarry used several photographs[177] and other exhibits[178] to identify outcrops of the BC/CPF in Badlands National Park north of the License Area, and opined that the BC/CPF is present in several locations on the PRIR (having been deposited there in historic river valleys or depositional outstreams).[179] It is significant, however, that these exhibits to which Dr. LaGarry referred in this testimony neither define the extent of the BC/CPF beneath the PRIR, nor demonstrate any physical connection between the BC/CPF Aquifer beneath the License Area and any outcrops of the BC/CPF in the PRIR.[180] Essentially, Dr. LaGarry conceded that the BC/CPF Ore Zone being mined by Crow Butte[181] is not contiguous with any BC/CPF that may

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[175] Ex. NRC-023 at 3.

[176] Tr. at 1074.

[177] Ex. INT-080, Supplemental Testimony of Dr. Hannan LaGarry at 5 (Sept. 18, 2015).

[178] See Ex. INT-072, Prajukti Bhattacharyya, Kathryn Converse, John Ejnik, Hannan E. LaGarry & Alyssa L. Riesen, Studying Uranium Contamination Levels in Groundwater from the Pine Ridge Reservation, South Dakota: A Community-University Partnership, 44(6) Geological Soc'y of America Abstracts with Programs at 77 (May 2012); Ex. INT-073, Hannan E. LaGarry, Leigh Anne LaGarry, James Swinehart & Michael B. Leite, Ten Years After: Revised Lithostratigraphy of the Eocene-Oligocene White River Group, Nebraska and South Dakota, 38(7) Geological Soc'y of America Abstracts with Programs at 201 (Oct. 2006); Ex. INT-074, Hannan E. LaGarry and Elisha Yellow Thunder, Surface and Subsurface Distributions of Uranium-Bearing Strata In Northwestern Nebraska and Southwestern South Dakota, Proceedings of the 122nd Ann. Meeting of the Neb. Acad. of Sciences at 91–92 (2012); Ex. INT-075, Hannan E. LaGarry and Leigh Anne LaGarry, Proposed Lithostratigraphic Revision, Redescription, and Redefinition of the White River Group (Eoceneoligocene), South Dakota, 42(3) Geological Society of America Abstracts with Programs at 14 (Apr. 2010); Ex. INT-076, Philip W. Stoffer, Paula Messina, John A. Chamberlain, Jr. & Dennis O. Terry, Jr., The Cretaceous-Tertiary Boundary Interval in Badlands National Park, South Dakota, U.S. Geological Survey Open-File Report 01-56 (2001); Ex. INT-077, Philip W. Stoffer, Geology of Badlands National Park: A Preliminary Report, U.S. Geological Survey Open-File Report 03-35 (2003).

[179] Ex. INT-080 at 5; Tr. at 2575.

[180] See Exs. INT-072–077.

[181] Tr. at 1068; see also Ex. INT-003 at 2–3.

underlie the PRIR.[182] Dr. LaGarry also conceded that the only possible hydraulic connections between the BC/CPF at the License Area and the BC/CPF at the PRIR is via the White River alluvium.[183]

The NRC Staff's witnesses testified that they were aware of only two reported field observations of outcrops of the BC/CPF, and that both are located in Whitehead Creek in northern Sioux County, approximately 12 miles northwest of the city of Crawford, which is far north of the White River alluvium.[184] As a result, it was their opinion that there is no pathway through an outcrop of the BC/CPF for contaminants from mining operations within the License Area to reach the White River alluvium.[185] While Dr. LaGarry did not dispute these two outcrops in Whitehead Creek, he maintained there are others—but did not identify the location of any such outcrops.[186]

While Dr. LaGarry's testimony and the exhibits he sponsored[187] failed to identify specific locations where the BC/CPF exists at or beneath the surface of the PRIR, he did maintain that the outcrops of the BC/CPF in the western area of South Dakota are part of the same deposit as the Ore Zone being mined in the License Area.[188] He also testified that "[a]lthough there is no subsurface data identifying the Chamberlain Pass formation on the reservation, there's ample surface data that does so."[189] At the same time, however, he conceded that "in large part the

[182] Tr. at 2576.

[183] Tr. at 2582.

[184] Ex. NRC-001-R at 20–21.

[185] Id. at 21 (citing Ex. NRC-021 at 7–8).

[186] Tr. at 1076–77.

[187] See Ex. INT-072; see also Ex. INT-080 at 5.

[188] Tr. at 2571–72.

[189] Tr. at 2566.

existence of the Chamberlain Pass formation under the land surface is inferred and interpolated by connecting between surface exposures."[190]

Moreover, Dr. LaGarry admitted it is likely that the BC/CPF in the License Area is not in direct contact with the BC/CPF in the PRIR.[191] Dr. LaGarry's concession was echoed by Crow Butte's witness Mr. Spurlin, who testified that, while the BC/CPF is likely present at the PRIR, this deposit is cut off from the BC/CPF beneath the License Area as a result of the erosion of the White River Group (i.e., the Brule and Chadron Formations) exposing the Pierre Shale of the Chadron Arch that lies between the PRIR and the License Area.[192]

Intervenors' witnesses testified that residents of the PRIR must rely, at least in part, on the BC/CPF Aquifer for their domestic water supply even though this aquifer contains naturally elevated levels of uranium due to historic weathering of the BC/CPF.[193] When queried as to the locations and types of these sources, however, Dr. LaGarry conceded that (1) there had been no comprehensive survey of the groundwater sources for the PRIR population;[194] and (2) naturally-occurring uranium, ubiquitous within BC/CPF outcrops, is the source for much of the uranium contamination of soils, sediments and surface waters in parts of Nebraska and several communities in the PRIR.[195]

The NRC Staff's witness Dr. Striz testified that a USGS groundwater study (Ex. BRD-003) at the PRIR had not identified the BC/CPF in any test hole data at depths down to 2,000

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[190] Tr. at 2574.

[191] Tr. at 2576.

[192] Tr. at 2577–78.

[193] Ex. INT-072 at 1.

[194] Tr. at 2565.

[195] Tr. at 2567–69; see also Ex. INT-074 at 1.

feet.[196] In addition to Dr. LaGarry acknowledging there had been no drilling to define the presence of the BC/CPF within the PRIR,[197] the NRC Staff's witnesses testified that there had been two groundwater studies performed by USGS[198] and that neither identified the BC/CPF in the subsurface geology at the PRIR.[199] Dr. LaGarry countered that there are cross-sections of the geology in and around the License Area that, based on data from 12,500 drill holes, clearly mark the BC/CPF (i.e., therein labeled the Chadron A or Chamberlain Pass Formation) as being present under the entire panhandle of Nebraska.[200]

2. *Board Findings on the Presence of the BC/CPF Underlying PRIR and Connection to the Ore Zone*

Based on the expert testimony presented in this proceeding, we find that the reported outcrops of the BC/CPF on the PRIR indicate it is very likely that the BC/CPF underlies the PRIR in places. Although Intervenors never referenced a map showing the specific location of these outcrops and admitted that it is necessary to infer and interpolate the existence of the BC/CPF under the land surface from the surface exposures, Intervenors' documented photographs of these features (which were not contested by either the NRC Staff or Crow Butte) are sufficient to establish that this formation does exist at least in some locations of the PRIR. While the NRC Staff's witnesses were skeptical of this conclusion (by pointing out that the USGS never identified the BC/CPF on the PRIR in its numerical modeling of groundwater flow in the Ogallala and Arikaree Aquifers),[201] they never challenged the presence of the observed

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[196] Tr. at 2579.

[197] Tr. at 2580–81.

[198] See Ex. BRD-003; Ex. NRC-025.

[199] Ex. NRC-095 at 15.

[200] Tr. at 2580.

[201] Ex. BRD-003.

outcrops nor tried to explain how these outcrops could exist unless the BC/CPF underlies at least part of the PRIR lands.

We also note that the BC/CPF beneath the PRIR is the same deposit as the Ore Zone being mined in the License Area but, as Intervenors conceded, the BC/CPF in the License Area is not directly connected to the BC/CPF that lies beneath the PRIR. We also find the natural weathering of the BC/CPF outcrops is the likely source of uranium contamination of soils, sediments, groundwater, and surface waters within the PRIR.

B. White River Feature: Fault or Fold?

The White River follows a path north of the License Area along a structural feature that has been variously described as either a fault or a fold—on the premise that a fault would be more transmissive than a fold. The evidence supporting a characterization of the White River Feature as a fault vs a fold, as well as the potential transmissivity of the White River as a pathway for the migration of mining contaminants, is discussed immediately below.

1. Parties' Positions on White River Feature

The NRC Staff's witnesses testified that the White River Feature is the only field-documented structural feature near the License Area.[202] The parties dispute whether the White River Feature is a fault or a fold, and thus the extent to which contaminants can migrate through it, given that the fracturing within a fault is likely to be more transmissive than within a fold.

The NRC Staff employed groundwater modeling to support the EA's characterization of the White River Feature.[203] During the hearing, the NRC Staff's witnesses admitted that the

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[202] Ex. NRC-001-R at 34 (citing LRA, fig. 2.6-13, at 2-133; Ex. NRC-028, Crow Butte Resources, Inc., Class III UIC Permit Application, fig. F4-1, at 1 (Jan. 6, 2010)).

[203] SER § 2.4.3.3.1 at 42–43. More specifically, the NRC Staff used Groundwater Modeling System numerical software and a Bayesian maximum likelihood analysis of the model results to ascertain the nature of the White River Feature. The Bayesian maximum likelihood analysis of the model results addressed baseline data, as well as other scenarios to test for varying behavior of the White River Feature, using procedures documented in NUREG/CR-6940. Id.

NRC Staff's groundwater modeling files were never provided to the other parties as part of its mandatory disclosures.[204] Dr. Striz subsequently testified that the NRC Staff was unable to defend some of the assumptions made by the original modeler, who had left the NRC by the time of the hearing.[205] Accordingly, Dr. Stritz recommended that no weight be given to the NRC Staff's modeling effort.[206] We agree. Accordingly, we have not considered the NRC Staff's modeling in evaluating the record evidence as to whether the White River Feature is a fault or a fold. Likewise, we have not considered this modeling in making the related determination as to the transmissive nature of the White River Feature.

In both its initial and its rebuttal testimony, the NRC Staff's witnesses maintained that, even if the modeling were not considered, the EA's conclusions do not need to be altered because the NRC Staff's modeling was only one of a number of bases for its dual conclusion that the White River Feature is not a transmissive fault and that it would not serve as a conduit for transporting contaminants from the License Area to the White River and then to the PRIR.[207]

a. Parties' Positions on Structural Evidence Supporting Fold or Fault

Dr. LaGarry testified on behalf of Intervenors that information set forth in Crow Butte's NTEA license amendment application demonstrates that there is "a fault along the White River

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204 Tr. at 1338–40. Once the NRC Staff provided these groundwater modeling files to the parties during the hearing, we subsequently directed Intervenors to provide a list of questions for the NRC Staff to address regarding inputs and assumptions for modeling the White River Feature. We also directed the NRC Staff to prepare and submit a report responding to those questions. See Ex. NRC-093, NRC Staff Response to Intervenors' Request for Modeling Information (Sept. 8, 2015). As noted in the accompanying text, during the hearing the NRC Staff abandoned any reliance on its modeling and the Bayesian maximum likelihood analysis that was based on this modeling. Id.

205 Tr. at 2587–88.

206 Tr. at 2588, 2590–91; see also Ex. NRC-095 at 20–22.

207 Ex. NRC-001-R at 38–39, 47; Ex. NRC-095 at 22; Ex. NRC-076-R2, NRC Staff's Rebuttal Testimony at 43–44 (June 8, 2015).

that could transport contaminants from the ISL mine to the White River, and from the river directly to Pine Ridge, South Dakota."[208] Dr. LaGarry also opined that if the White River Feature is a fold, the White River would not follow it; however, if the White River Feature is a fault, then not only would the White River follow it, but the White River would also preferentially erode the fault further.[209]

Mr. Wireman's testimony echoed Dr. LaGarry's comments in this regard. He stated that a number of northwest to southeast trending faults have been identified within, and near, the License Area, including the White River Feature (which he opined is a fault).[210] He also referenced several reports indicating that there are fractures within the White River Feature that may increase BC/CPF permeability in some areas.[211] Mr. Wireman also claimed that, in its LRA, Crow Butte reported 200 to 400 feet of offset strata displacement indicative of a fault on the White River Feature.[212] It was Mr. Wireman's opinion that there is a significant likelihood of extensive secondary porosity associated with a fractured fault within the White River Feature and that (1) questions remain as to the nature of the White River fault/fold; (2) there is no rigorous data to support Crow Butte's claim that the White River Feature is a fold in the Pierre Shale; and (3) the 2014 Safety Evaluation Report's (SER) analysis, which characterizes the White River Feature as a fold, is based on too much uncertainty and a lack of empirical data from drilling.[213] Dr. Kreamer further opined that "[t]he EA treats 'fold' features and 'fault'

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[208] Ex. INT-003 at 3.

[209] Tr. at 1174.

[210] Ex. INT-047, Expert Opinion Testimony of Mickel Wireman at 2–3 (Apr. 29, 2015).

[211] Id.

[212] Id. at 3.

[213] Id.

features, such as the White River [F]eature, as mutually exclusive, whereas folds can include many faulted regions."[214]

Crow Butte's witnesses testified that the White River Feature is oriented southwest-northeast generally along the White River drainage.[215] Based on recent close-spaced drilling of over 100 boreholes in conjunction with Crow Butte's NTEA license amendment application, as well as its 3-D modeling performed for NDEQ in support of a Petition for Aquifer Exemption for the NTEA,[216] Crow Butte's witnesses opined that the White River Feature is best interpreted as a fold.[217] This is so, they claim, because the White River Feature, "which at depth offsets the Pierre Formation, is manifested at shallower depths as a northeast trending, subsurface fold . . . within the formations of interest near the License Area."[218] According to the LRA, Crow Butte's "review of more than 130 geophysical logs [and] three-dimensional geologic modeling indicates that the fault associated with the structural feature does not truncate or offset members of the White River Group along a discrete fault surface. Rather, members of the White River Group are broadly folded and are continuous across the structural feature."[219]

The EA reached similar conclusions.[220] In addition, the NRC Staff's witnesses testified that NDEQ's review of Crow Butte's Aquifer Exemption Petition for the NTEA[221] included an

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[214] Ex. INT-046, Expert Opinion Testimony of David K. Kreamer at 3 (Apr. 29, 2015).

[215] Ex. CBR-001 at 23–24.

[216] See generally Ex. CBR-013, Arcadis, Crow Butte Resources, Inc., Petition for Aquifer Exemption, North Trend Expansion Area at 24 (Aug. 2008); Tr. at 1352–53.

[217] Ex. CBR-001 at 23–24.

[218] Id.

[219] LRA § 2.6.2.5 at 2-135.

[220] EA § 3.5.2.3.3 at 51–52; see also Ex. NRC-001-R at 37–39.

[221] Ex. NRC-001-R at 36–37.

evaluation of the White River Feature by an independent panel of geology experts that concluded Crow Butte's interpretation of this feature as a fold was plausible.[222] Intervenors, however, sought to characterize the panel's evaluation in a different light. Specifically, they claimed that, in 2007, NDEQ provided technical comments[223] that allegedly (1) raised several questions disputing Crow Butte's assertion that there is no hydraulic connection among regional aquifers and the White River; and (2) challenged Crow Butte's interpretation of the White River Feature as a fold instead of a fault.[224]

Nevertheless, after receiving Crow Butte's response to these technical comments, NDEQ approved Crow Butte's Aquifer Exemption Petition on April 7, 2011,[225] concluding that Crow Butte's interpretation of this feature as a fold was plausible, and that there was no evidence of faults or contaminant pathways between the BC/CPF Aquifer and the Upper Brule Aquifer—a position supported by the NRC Staff's witnesses.[226] With respect to the potential for the White River Feature to act as a conduit between the aquifers, NDEQ concluded (as did the NRC Staff's witnesses) that the BC/CPF Aquifer underlying the NTEA is hydraulically isolated from the other aquifers based on several lines of evidence, including: (1) Crow Butte's 3-D geological modeling suggesting that any disruption of geologic units—such as structural thinning, structural thickening, missing units, or linear features associated with fault rupture—

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[222] Ex. NRC-095 at 23.

[223] See Ex. INT-011, Letter from the State of Nebraska Department of Environmental Quality to Stephen P. Collings, President, Crow Butte, attach., Technical Review of Aquifer Exemption Petition for North Trend Expansion (Nov. 8, 2007).

[224] See Ex. INT-010, Oglala Sioux Tribe's Request for Hearing and/or Petition to Intervene at 20–21 (July 28, 2008).

[225] Ex. CBR-019, In re the Request of Crow Butte Resources, Inc. for an Aquifer Exemption for Portions of the Chadron Formation In Dawes County, Nebraska at 6 (Neb. Dep't of Envtl. Quality, Apr. 7, 2011) (granting Aquifer Exemption Order).

[226] Ex. NRC-095 at 23.

could plausibly be associated with other geological processes; (2) drilling data from the proposed NTEA demonstrating that "there is no evidence that a fault offsets the geologic contact with the Pierre Shale and overlying White River Group, nor individual members of the White River Group (i.e., Brule and Chadron formations);" (3) agreement among NDEQ's panel of independent geologic experts that Crow Butte's geologic interpretations, including those concerning structural geology, are plausible; (4) the flowing artesian conditions (i.e., groundwater flowing vertically to the surface due to the natural pressure of the aquifer) observed in the proposed NTEA; and (5) the results of a 2006 pumping test performed by Crow Butte.[227]

b. Parties' Positions on Apparent Transmissivity of White River Feature

All parties agreed that, ultimately, the critical issue with respect to the White River Feature is not whether it is a fold or a fault, but rather its actual transmissivity—for that governs whether contaminants can migrate from the mining area to public receptors.[228] Dr. LaGarry stated that Crow Butte's NTEA license amendment application reported a fault along the White River that could transport contaminants from Crow Butte's ISL mine to the White River, and from the White River directly to the PRIR.[229]

The NRC Staff's witnesses, on the other hand, supported their claim that the White River Feature is not transmissive and so does not serve as a conduit for transporting contaminants to the White River and the PRIR, by citing to Crow Butte's Petition for Aquifer Exemption for the NTEA. They asserted that Crow Butte's petition supports the following technical conclusions: (1) the White River Feature does not displace the geologic contact either between the Pierre Shale and the BC/CPF or between members of the Chadron Formation and the Brule formation,

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[227] Ex. CBR-019, attach. C, at 2–8; see also Ex. NRC-001-R at 37–39.

[228] Ex. CBR-001 at 23–25; Ex. NRC-095 at 22; Tr. at 1173, 1187, 1192.

[229] See Ex. INT-003 at 3.

based on Crow Butte's 3-D geologic modeling of more than a hundred geophysical logs;[230] (2) there is a consistent vertical gradient and a large difference in potentiometric groundwater surfaces between the BC/CPF Aquifer and the Upper Brule Aquifer over the area of the White River Feature;[231] (3) aquifer pumping tests in the area demonstrated the integrity of the overlying UCU;[232] and (4) there were distinct geochemical variations between the BC/CPF Aquifer and the Upper Brule Aquifer that are inconsistent with transmissivity within the White River Feature.[233]

Moreover, the NRC Staff's witnesses maintained that even if the White River Feature were transmissive, Crow Butte's mining operation in the License Area would not have a significant impact on the environment during mining operations and restoration activities because (1) on-site conditions preserve confinement of mining liquids within the BC/CPF; and (2) Crow Butte's renewed license requires it to maintain an inward hydraulic gradient within the mining units,[234] which creates a cone of depression that pulls aquifer water into the License Area and away from the White River Feature.[235] The NRC Staff's witnesses opined that this cone of depression has reversed the groundwater flow direction within the BC/CPF Aquifer; originally, the aquifer's groundwater flow was northwest, but after more than 20 years of mining operations, it is southeast (at least in the northwest portion of the License Area nearest the

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[230] Ex. NRC-001-R at 39 (citing Ex. NRC-028, figs. F.3-3a to F.3-3d).

[231] Id. (citing Ex. NRC-028 at G-15 to G-16).

[232] Id. (citing Ex. NRC-028 at G-9 to G-11).

[233] Id. (citing Ex. NRC-028 at G-9).

[234] Ex. NRC-001-R at 38–39.

[235] Id. at 38.

White River Feature), thereby preventing the movement of water through the BC/CPF Aquifer towards the White River.[236]

Furthermore, in light of the fact that the White River Feature is approximately two miles from the northwest boundary of the License Area[237] and the groundwater flow velocity in the BC/CPF Aquifer is estimated to be less than 20 feet per year,[238] the NRC Staff's witnesses opined that, even if contaminants were somehow to migrate from the License Area toward the White River, the time of travel from the License Area boundary to the White River Feature would be several hundred years.[239] In addition to this considerable travel time, the NRC Staff's witnesses identified several naturally-occurring subsurface processes (i.e., advection, dispersion, sorption, and geochemical reactions) that would reduce the concentration of any contaminants of concern and thus further minimize any potential impacts.[240]

Mr. Wireman disputed the NRC Staff's characterization that the White River Feature would have minimal impact on the vertical gradients and on the potentiometric surface of the Upper Brule Aquifer, maintaining that there is insufficient information regarding the effect of the White River Feature on the potentiometric surface of the BC/CPF Aquifer.[241] Mr. Wireman's primary focus in this regard concerned the impact of pumping water from the BC/CPF Aquifer on the area where this aquifer naturally discharges to surface water (although Mr. Wireman was unable to identify where any such discharge occurs, much less the surface water bodies that might be influenced by the pumping of water from the BC/CPF Aquifer at individual mine sites

[236] Ex. NRC-095 at 22.

[237] EA § 3.5.2.3.3 at 51.

[238] Id. § 4.13.6.2.2 at 131.

[239] Ex. NRC-095 at 22–23.

[240] Id.

[241] Tr. at 2600–01.

within the License Area).[242] Mr. Wireman also expressed concern for anyone with a downstream water supply well that is set in the BC/CPF Aquifer because such a well might experience a lower yield from the reduced potentiometric thickness.[243] But, there is no record evidence of any such potentially affected wells around the White River Feature and so there is no indication of the extent, if any, to which this poses a problem.

Dr. Kreamer opined that the impact to the surface water receptors hydraulically connected with the Upper Brule Aquifer is not a water quality issue, but rather a water quantity issue.[244] Although Dr. Kreamer argued that the inward gradient maintained in the BC/CPF Aquifer by Crow Butte's mining and reclamation efforts in the License Area would be very detrimental to well supplies that are in the Upper Brule Aquifer, wetlands, and streams, he was unable to verify whether the level of the Upper Brule Aquifer had dropped as a result of Crow Butte's pumping of water from the BC/CPF Aquifer or whether any water resources had been affected by Crow Butte's operations at the License Area.[245]

Mr. Wireman claimed that, regardless of whether the White River Feature is deemed a fold or a fault, it is likely to have an impact on the potentiometric surface in the BC/CPF because even a folded feature will have increased transmissivity.[246] Mr. Wireman further opined that, due to the long transport times, impacts to these aquifers may not have been detected to date, but once the mining stops and the potentiometric surface rises in the BC/CPF, impacts may be observed similar to those previously experienced at other mine units.[247]

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[242] Tr. at 2600–01.

[243] Tr. at 2600–01.

[244] Tr. at 2601–02.

[245] Tr. at 2601–02.

[246] Tr. at 2605–06.

[247] Tr. at 2605–06.

Dr. Kreamer concurred with Mr. Wireman, maintaining that, because both folds and faults can have high permeability, the exact structure of the White River Feature is largely inconsequential.[248] Although Dr. Kreamer also stressed that Intervenors were not provided with the NRC Staff's travel time calculations,[249] the travel time calculations were discussed in both the EA and the NRC Staff's testimony.[250] In addition, Dr. Kreamer failed to provide any alternative calculations, based on known on-site data.

Moreover, the various claims of Intervenors' witnesses that the White River Feature is a conductive fault likely to transport contaminants to, and impact the quality of, the White River were contradicted by the NRC Staff's initial and rebuttal testimony. Specifically, the NRC Staff's witnesses' testimony supported the EA's conclusion that the White River Feature is a fold with low transmissivity characteristics, independent of any consideration of the NRC Staff's modeling.[251]

2. Board Findings on the Structure of the White River Feature

We find it more likely than not that the White River Feature is a fold rather than a fault. We make this finding primarily on two factors. First, there is no evidence of a geologic displacement that would exist with a fault, either along the contact between the Pierre Shale and the BC/CPF, or along the contact between the BC/CPF and the overlying members of the UCU. The absence of any apparent offset of the geologic layering is based on Crow Butte's field explorations involving 130 geophysical logs of the White River Feature and the surrounding geology that, in turn, formed the basis for Crow Butte's 3-D geological modeling of the White

[248] Tr. at 2606–07.

[249] Tr. at 2606–07.

[250] Ex. NRC-095 at 22–23; see also EA § 4.13.6.2.2 at 130–31.

[251] Ex. NRC-095 at 23–24.

River Feature demonstrating that feature's continuity. The second factor is NDEQ's independent evaluation of the White River Feature, which concluded that Crow Butte's interpretation of the White River Feature as a fold was plausible and that there is no evidence of faults between the BC/CPF Aquifer and the Upper Brule Aquifer.[252]

Having said this, we note that all parties were in agreement that characterizing the White River Feature as a fold or a fault is less important than determining whether it is transmissive. In this regard, Intervenors did not offer evidence supporting their claims that the White River Feature is a conductive fault that either altered the vertical gradients or potentiometric levels in the aquifers or transported sufficient contaminants from the License Area to impact the water quality of the White River. Specifically, Intervenors' witnesses simply asserted that the distortion of the White River Feature (i.e., whether folded or faulted) creates higher permeabilities, which, in turn, may have some effect on the potentiometric surface elevations.[253] But, they presented no field data to support this claim. While Intervenors' witnesses asserted that more study is needed to assess the hydraulic conductivity of the White River Feature,[254] they provided scant evidence in support of this assertion.

By contrast, we find that Crow Butte and the NRC Staff presented several different lines of compelling evidence supporting their position that the White River Feature is not sufficiently transmissive to act as a significant conduit for the migration of contaminated groundwater from the mining operation. This evidence includes: (1) the lack of geologic displacement either along the interface between the Pierre Shale and the BC/CPF or along the interface between members of the Chadron Formation and the Brule Formation; (2) consistency in the vertical gradients; (3) large differences in potentiometric levels between the BC/CPF Aquifer and the

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[252] Id. at 23.

[253] Tr. at 2605–06.

[254] See Tr. at 2605–06.

Upper Brule Aquifer; (4) the demonstrated integrity of the UCU from numerous pumping tests; and (5) geochemical variations in aquifer water quality between the BC/CPF Aquifer and the Upper Brule Aquifer.

Accordingly we find the record evidence supports the NRC Staff's position that, in the event any Crow Butte mining liquids were to escape containment, the White River Feature has not shown (and is unlikely to show) any propensity to act as a permeable conduit for the transport of such contaminants.

Because the NRC Staff abandoned its hydrogeologic modeling of the White River Feature at the hearing, we accord it no weight. Nevertheless, even after disregarding such modeling results, we find that the NRC Staff has taken the hard look required by NEPA and reached a reasonable conclusion that (1) the White River Feature is most likely a fold rather than a fault; and (2) regardless of its characterization as a fold, the White River Feature offers little increased transmissivity to act as conduit for significant contamination transport and adverse receptor impacts.

While the importance of the NRC Staff's hydrologic modeling in defining the structure of the White River Feature is stressed in the EA,[255] our decision effectively amends the EA to eliminate any reliance on its modeling of the White River Feature. Where an adjudicatory hearing tests the adequacy of the NRC Staff's environmental review, a licensing board decision, as the final record of decision under NEPA, can amend the NRC Staff's NEPA documents to "become, in effect, part of the [final NEPA document]."[256] Although there are limits on the extent

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[255] EA § 3.5.2.3.3 at 51–52.

[256] La. Energy Servs., L.P. (Claiborne Enrichment Ctr.), CLI-98-3, 47 NRC 77, 89 (1998); see also Indian Point, CLI-15-6, 81 NRC at 388 ("We therefore affirm the Board's ruling that the environmental record of decision may be supplemented by the hearing and relevant Board and Commission decisions.").

to which a licensing board can amend or cure a NEPA document,[257] as noted above, we find that even putting aside the hydrologic modeling, the NRC Staff still took the requisite hard look at the potential transmissivity of the White River Feature. As a consequence, notwithstanding the significant procedural deficiencies associated with its handling of that modeling in this proceeding,[258] the NRC Staff is not required to amend the EA to eliminate its stated reliance on that modeling.

C. Aquifer Pumping Tests

In accordance with NDEQ Underground Injection Control (UIC) Permit Number NE 0122611 (Ex. CBR-017), Crow Butte conducted four aquifer pumping tests on the BC/CPF Aquifer within the License Area boundary to evaluate the properties of that aquifer and the integrity of the confining layer at the site.[259] These tests were conducted between 1982 and

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[257] See, e.g., Sierra Club v. Marsh, 976 F.2d 763, 770 (1st Cir. 1992). As we stated in our first Partial Initial Decision in this proceeding, "even where the contested hearing's record of decision supplements a deficient factual analysis in an EA or EIS, if the end result raises other questions about the sufficiency of the NRC Staff's analysis that should be explored under NEPA, a remand to the NRC Staff would be required to address all such NEPA concerns." LBP-16-7, 83 NRC at 352.

[258] See supra notes 203–07 and accompanying text.

[259] See Ex. CBR-067, Supplemental Direct Testimony of Crow Butte Resources at 7–8 (Sept. 18, 2015); see also Ex. CBR-017, Nebraska Department of Environmental Quality Authorization for Underground Injection and Mineral Production Wells, Permit Number NE0122611 at 3–4 (Apr. 23, 1990). In addition to these tests, Crow Butte performed six other aquifer pumping tests in conjunction with its NTEA license amendment application. See Ex. CBR-074 at 10; see also Ex. CBR-013 at 36–38; Ex. NRC-028 at G-10 to G-15. While detailed information on these tests is documented in Ex. CBR-001 at 29, these tests have little bearing on our resolution of the contentions in this proceeding (except to show that those tests likewise suggested there is adequate confinement of the BC/CPF in Crow Butte's NTEA, which indicates there is regional competency of the UCU). We also note that nothing in these NTEA tests undermines any of our findings with respect to the testimony and evidence made in this license renewal proceeding, and as such, they play no part in this Partial Initial Decision. Accordingly, these tests will not be discussed further herein.

2002 at four different locations, as Crow Butte was developing particular portions of the License Area.[260]

According to the EA, the data from these tests were evaluated using generally-accepted hydrogeological analysis methods.[261] The NRC Staff's witnesses asserted that "the most important information obtained from these aquifer pumping tests was the assessment of the behavior of the units overlying the [BC/CPF Aquifer] to determine the degree of confinement created by the overlying low permeability layers [i.e., the UCU]."[262]

Data collected and analyzed as part of these aquifer pumping tests included pumping rate, test duration, formation characteristics, transmissivity, hydraulic conductivity (i.e., permeability), storativity (i.e., the volume of available water within an aquifer, expressed as a coefficient), and radius of influence (i.e., the radius defining the area over which drawdown occurs). Crow Butte's aquifer testing (performed in accordance with regulatory requirements as reviewed and approved in advance by NDEQ) suggested there were overlapping areas of influence across the length of the site.[263]

1. Parties' Positions on Aquifer Pumping Tests

a. Parties' Positions on Aquifer Pumping Test Program

Crow Butte's witnesses testified that, not only were Crow Butte's aquifer pumping tests reviewed and approved by NDEQ, but they were consistent with the industry standard

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[260] See LRA, fig. 2.7-8, at 2-203.

[261] EA § 3.5.2.3 at 50–52. Along with the Theis recovery method, these analysis methods included one or more combinations of the following accepted techniques: Jacob's modified non-equilibrium method, the Cooper and Jacob distance-drawdown method, Hantush's method, and the Neuman and Witherspoon method. Id.

[262] Ex. NRC-076-R2 at 66.

[263] See LRA, fig. 2.7-8, at 2-203.

techniques for this type of test.[264] There is no record evidence contradicting Crow Butte's claim that these tests met NDEQ requirements and industry standard techniques.[265]

Although the LRA briefly summarizes Crow Butte's four aquifer pumping tests,[266] it is the individual test reports themselves that (1) contain specific details both about how these tests were performed;[267] and (2) discuss and summarize the key resulting hydraulic characteristics, including hydraulic conductivity, storativity, transmissivity, and the radius of influence.[268] Three to four observation wells were installed in the Ore Zone around the pumping well to monitor drawdown in the BC/CPF Aquifer.[269] The NRC Staff's witnesses testified that all four tests also utilized an observation well in the overlying Upper Brule Aquifer, and that for Test #2, Crow Butte placed an additional piezometer (i.e., a device to monitor water pressure indicative of groundwater levels in an aquifer) in both the UCU and the LCU.[270] None of the observation wells and piezometers in the Upper Brule Aquifer, the UCU, or the LCU showed a response to pumping, indicating that the confining layers act as an impermeable unit.[271]

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[264] Ex. CBR-045 at 20.

[265] See Tr. at 1275.

[266] LRA § 2.7.2.3 at 2-202–14.

[267] Ex. BRD-002A, Crow Butte Resources, Inc., Industrial Ground Water Permit Amendment, Aquifer Test #1 (July 29, 1987); Ex. BRD-002B-R; Ex. BRD-002C, Harlan & Associates, Inc., Ground-Water Pumping Test #3, Data Evaluation Report (Oct. 15, 1996); Ex. CBR-012, Petrotek Engineering Corporation, Ground-Water Pumping Test #4, Data Evaluation Report (Oct. 10, 2002).

[268] LRA, tbl. 2.7-7, at 2-200; Ex. NRC-076-R2 at 37; Ex. CBR-012 at 1.

[269] Tr. at 1265–68.

[270] Ex. NRC-076-R2 at 35–37.

[271] Id.

Because these four aquifer test results demonstrated that the wells' radii of influence overlap (varying from 4,000 to 5,700 feet),[272] the EA states that the results of these tests approximate the hydraulic conditions over most of the License Area.[273] The EA also notes that Crow Butte used the drawdown and recovery data from these tests to estimate the hydrogeological properties of the BC/CPF Aquifer and the UCU using the previously mentioned analysis methods.[274]

In their testimony, Intervenors' witnesses maintained that Crow Butte's "aquifer tests are entirely insufficient and potentially misleading, as typically only one observation well was placed in the overlying Brule Aquifer to determine vertical migration"[275] and "[o]nly two of the aquifer tests performed between 1982 and 2006 included a monitoring well in the [UCU]."[276] Noting the large size of the License Area, Mr. Wireman stated that the aquifer tests were not adequate for characterizing the potential for movement of groundwater from the BC/CPF upward through the UCU, given the heterogeneity of the strata and the extensive fracturing in the rocks that form the UCU.[277] He also testified that there are far too few monitoring wells in the Upper Brule Aquifer to monitor adequately for long-term water level trends in the Upper Brule Aquifer.[278] Specifically, three of the aquifer pumping tests included only one monitoring well in the Upper Brule Aquifer and the fourth included only two Upper Brule Aquifer monitoring wells.[279]

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[272] Ex. NRC-076-R2 at 37.

[273] EA § 3.5.2.3 at 50.

[274] Id.; see supra note 261 and accompanying text.

[275] Ex. INT-069, Rebuttal Statement of Dr. David K. Kreamer at 4 (June 8, 2015).

[276] Ex. INT-070, Rebuttal Statement of Mickel Wireman at 1 (June 8, 2015).

[277] Id.

[278] Ex. INT-081, Supplemental Testimony of Mickel Wireman at 1 (Sept. 16, 2015).

[279] Id.

The NRC Staff's witness, Dr. Striz, countered this, testifying that the number of monitoring wells Crow Butte installed in the License Area was consistent with the standardized aquifer pumping tests that NDEQ had approved.[280] It was her opinion that (1) three to four observation wells in the Ore Zone were sufficient to assess the drawdown of the potentiometric levels from pumping; and (2) one overlying well per pumping test in the Upper Brule Aquifer, placed close to the pumping well, was sufficient because its location was optimal for detecting leakage in the UCU.[281] Furthermore, she observed, Crow Butte supplemented its aquifer pumping tests of the overlying well by conducting consolidation tests to measure the permeability of the overlying UCU aquitard.[282] Dr. Striz also testified that the NRC has based many of its licensing decisions on aquifer pumping testing with a similar configuration to that employed by Crow Butte.[283] In this regard, Crow Butte's witnesses confirmed that Crow Butte performed site-specific testing of cores from the UCU and detected very low permeability,[284] which indicates both that a well in the UCU would not readily respond to an aquifer pumping test and that the recovery of the water levels would be slow.[285]

b. Parties' Positions on Aquifer Pumping Test Analysis Methods

The NRC Staff's witnesses testified that Crow Butte's aquifer pumping test drawdown data were analyzed using a variety of scientifically reliable methods,[286] including the Theis

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[280] Tr. at 1283; see also Ex. CBR-045 at 20.

[281] See Tr. at 1283.

[282] See Tr. at 1283.

[283] Tr. at 1283.

[284] Ex. CBR-045 at 29.

[285] Id. at 31–32; Tr. at 1142–43.

[286] See supra note 261 and accompanying text.

recovery method and standard laboratory consolidation testing.[287] The NRC Staff's witnesses testified that, while Crow Butte used these analytical techniques to evaluate the aquifer pumping tests for the initial planning and design phase of its mining operations, "[o]nce each well field became fully operational, the actual measured data (e.g., flow rates and drawdown) were used to verify and adjust as necessary the extent of the influence of well extraction and injection to maintain an inward gradient."[288]

Intervenors' experts disputed the claims of the NRC Staff. Dr. Kreamer criticized Crow Butte's aquifer pumping test calculations on the grounds that they relied on old data, as well as on outdated research and methods that are inappropriate for analyzing the heterogeneous, anisotropic,[289] non-uniform layering of the geologic strata within the pumping test areas.[290] In Dr. Kreamer's estimation, Crow Butte's misinterpretation of these variable aquifer characteristics led to Crow Butte's failure to recognize the potential vertical flow and the extent of the influence of well pumping and injection during operations.[291] While Dr. Kreamer was critical of the methods that Crow Butte selected to analyze the aquifer pumping tests, he conceded that these methods are common industry-accepted analyses for evaluating the results of such tests.[292]

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[287] Ex. NRC-076-R2 at 33–34; see also LRA § 2.7.2.3 at 2-205.

[288] Ex. NRC-076-R2 at 34.

[289] We use "anisotropic" when referring to an aquifer that has varying hydraulic properties with direction at any given point, e.g., when permeability varies between the horizontal and vertical directions at a point in the aquifer.

[290] Ex. INT-046 at 2.

[291] Id.; see also Ex. INT-079, Supplemental Testimony of Dr. David K. Kreamer at 8 (Sept. 16, 2015).

[292] Tr. at 1299.

Moreover, Dr. Kreamer failed to identify any specific analyses that could be used in lieu of these methodologies.[293]

The NRC Staff's witnesses supported Crow Butte's use of these data analysis methods on the ground that they are widely used and accepted standard methods that have been incorporated into American Society of Testing and Materials standards related to aquifer testing.[294] The NRC Staff's witnesses also disputed Dr. Kreamer's claim that these methods are only reliable for homogeneous, isotropic[295] aquifers, asserting that no hydrogeologic systems are truly homogeneous and isotropic,[296] and that "at some scale all geologic systems are heterogeneous and anisotropic, and application of these 'basic equations' to these systems is done with an understanding of the assumptions inherent to their use."[297]

Furthermore, the NRC Staff's witnesses maintained, while the aquifer pumping tests initially assumed homogeneous, isotropic responses, the actual test results would show whether there were significant deviations from the assumed homogeneity and isotropy which, in turn, would establish the need for the use of more complex analysis methods.[298] Here, the NRC Staff's witnesses opined that, with the exception of a small amount of anisotropy in two of the

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[293] See Tr. at 1299.

[294] Ex. NRC-076-R2 at 33–34; Ex. NRC-080, NRC Staff, List of ASTM Standards for the Analysis of Hydraulic Characteristic of Aquifer by Aquifer Pumping Tests (undated).

[295] We use "homogenous" when referring to an aquifer that has constant hydraulic properties at all locations (e.g., permeability is the same at all distances and depths within the aquifer) and "isotropic" when referring to an aquifer that has constant hydraulic properties in all directions at any given point (e.g., permeability is the same between the horizontal and vertical directions).

[296] Ex. NRC-076-R2 at 34.

[297] Id. at 66.

[298] Tr. at 1284–85.

aquifer pumping tests, the responses obtained were very close to those one would expect for a homogeneous, isotropic aquifer.[299]

c. Parties' Positions on Aquifer Pumping Test Data Interpretation

iii-1. Parties' Position on Crow Butte's Test #1

Crow Butte conducted its first aquifer pumping test in the southeast portion of the License Area in November 1982.[300] In addition to the pumping well, four observation wells were set in the BC/CPF while two observation wells were set in the Upper Brule Aquifer.[301] The pumping well operated for almost 51 hours at 24 gallons per minute (gpm), resulting in a radius of influence of 4,000 feet.[302] Thereafter, the wells were monitored during recovery for nearly 28 hours.[303]

The NRC Staff's witnesses testified that data from the aquifer pumping test report show the two observation wells completed in the Upper Brule Aquifer (PM-6 and PM-7) did not demonstrate any responsive water pressure change due to pumping in the BC/CPF.[304] Moreover, the NRC Staff's witnesses asserted, the drawdown curves of the aquifer pumping test data (i.e., graphs depicting water level decrease with the duration of pumping) indicate that the BC/CPF Aquifer is fully confined.[305]

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[299] See Tr. at 1285–86.

[300] Ex. BRD-002A at 2.7A(1).

[301] Id.

[302] Id.; Ex. CBR-012 at 3.

[303] Ex. BRD-002A at 2.7A(1); Ex. CBR-012 at 3.

[304] Ex. NRC-095 at 9 (citing Ex. BRD-002A at 2.7A(9)).

[305] Id. (citing Ex. BRD-002A at 2.7A(15)).

According to witnesses for Crow Butte and the NRC Staff, the variation from the Theis curves for one observation well (PT-2)[306] indicated either (1) the occurrence of some small leakage squeezed from confining beds during the pumping test (as demonstrated by the "leaky aquifer" analysis);[307] or (2) as shown by the Theis analysis, variations in local transmissivity (caused by an increase in the aquifer thickness or permeability) over the test area gave the false impression of aquifer leakage or of a recharge boundary (i.e., an area or zone of the aquifer with increased groundwater flow).[308] Regardless of the cause of these deviations, Crow Butte's witnesses claimed that by far the most important conclusion to glean from the data is that there were extremely low recharge or leakage rates, which is consistent with a fully-confined aquifer response.[309]

Separate and apart from the significance of the data obtained in the later stages of the aquifer pumping test, Intervenors' witness Dr. Kreamer asserted it was the early drawdown data that was most important—and that this data indicated potential aquifer leakage between the overlying Upper Brule Aquifer and the BC/CPF Aquifer.[310] Dr. Kreamer posited that if the Theis curves are correctly matched with the early-time data (data collected during the time required to account for well bore storage),[311] the results "clearly show a break in the data, moving below the

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306 See Ex. BRD-002A, fig. 2.7A-6, at 2.7A(18).

307 Ex. NRC-095 at 9; Tr. at 2530–31; Ex. CBR-067 at 9; see also LRA § 2.7.2.3 at 2-213; Ex. BRD-002A at 2.7A(8), 2.7A(24)–(29) (detailing the aquifer leakage analysis calculations).

308 Ex. NRC-103, NRC Staff's Supplemental Rebuttal Testimony at 19–20 (Sept. 28, 2015); Ex. CBR-074 at 13; Tr. at 2533–34; see also Ex. BRD-002A at 2.7A(8), 2.7A(13).

309 See Ex. CBR-067 at 9 (stating that ~0.00002 gal/sq. ft. in 51 hours is equivalent to 4×10^{-10} cm/sec).

310 Ex. INT-079 at 3–4.

311 These are shown in red on page four of Ex. INT-079.

[Theis] type-curve for the late data, indicating [a] reduction in the rate of expected drawdown" and signifying "an unexpected water source, or recharge boundary."[312]

Witnesses for both the NRC Staff and Crow Butte disputed Dr. Kreamer's interpretation of the data. They maintained that early time periods should be ignored because early-time drawdown data are negatively influenced by a number of factors not related to the aquifer response to pumping and, therefore, are inappropriate for estimating aquifer behavior.[313] They gave two reasons for this position. First, they argued that theoretical equations rely on the assumption that the well discharge remains constant and that the release of water from the aquifer is immediate and directly proportional to the rate of decline of the pressure.[314] As a result, they claimed there is "initial disagreement between theory and actual flow—and that, as the time of pumping extends, these effects are minimized and closer agreement may be attained."[315] Second, Crow Butte's witnesses testified that wellbore storage can also affect the early-time data, especially for the type of wells that Crow Butte installed, which are large diameter, deep production wells with large water column height.[316] Because the amount of water stored within the wellbore can be substantial, it must be removed before the aquifer can respond properly to the induced drawdown, which further reduces the value of early-time data.[317]

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[312] Id. at 3.

[313] Ex. NRC-103 at 16–17; Ex. CBR-074 at 11 (citing Ex. CBR-081, G. P. Kruseman and N. A. de Ridder, Analysis and Evaluation of Pumping Test Data, International Institute for Land Reclamation and Improvement Publication 47 at 64 (2000)).

[314] Ex. NRC-103 at 16–17 (citing Ex. NRC-110, Kruseman, G.P. and N.A. de Ridder, "Analysis and Evaluation of Pumping Test Data" (2nd Ed.), ILRI Publication 47 (1994) at 2 (excerpt)); Ex. CBR-074 at 11–12.

[315] Ex. NRC-103 at 16–17 (citing Ex. NRC-110 at 2); see also Ex. CBR-081 at 64.

[316] Ex. CBR-074 at 11–12.

[317] Id. at 12.

As a result of these factors, these witnesses opined, measured drawdown in early time is less than matching techniques with Theis curves would predict, thus giving the false impression of aquifer leakage.[318] In this regard, Crow Butte's witnesses testified that it required more than 21 minutes to purge a single casing volume from the pumped well (using a 4½-inch diameter well casing and a 500-foot head).[319] Accordingly, they declared that this substantiates their claim that less weight should be given to the early-time data.[320]

Crow Butte's witnesses also asserted that Dr. Kreamer ignored the fact that Crow Butte's aquifer pumping test report accounted for wellbore storage in assessing the drawdown from the aquifer pumping test data.[321] While Dr. Kreamer conceded that decreased drawdown might occur due to greater aquifer thicknesses, he maintained that the increase in thickness must occur in all parts of the aquifer affected by the pumping test.[322] In response, witnesses for Crow Butte and the NRC Staff maintained that Dr. Kreamer's position (i.e., relying on early-time data, thus failing to account for the effects of wellbore storage) is inconsistent with aquifer analysis guidance advocating the use of later time data.[323]

iii-2. Parties' Positions on Crow Butte's Test #2

During late June and early July 1987, Crow Butte's Test #2 was conducted in the central portion of the License Area just northwest of Crow Butte's Test #1.[324] In addition to the pumping well, three observation wells were set in the BC/CPF Aquifer, while one observation well was

[318] Id.

[319] Tr. at 2539.

[320] Ex. CBR-074 at 12.

[321] Id. at 13 (citing Ex. BRD-002A at 2.7A(8)); Tr. at 2533–34.

[322] Ex. INT-079 at 5.

[323] Ex. CBR-074 at 11; Ex. NRC-103 at 16–17.

[324] Ex. BRD-002B-R at 2.7(15)–(16).

set in the overlying Upper Brule Aquifer and two high sensitivity piezometers (equipped with small, porous tips to improve measurements in low permeability strata) were placed, one each, in the LCU and UCU.[325] The pumping well was operated for about 72 hours at almost 48 gpm, resulting in a radius of influence of 5,000 feet, and it was monitored for close to 72 hours during the recovery after pumping stopped.[326]

Witnesses for both the NRC Staff and Crow Butte opined that Crow Butte's Test #2 demonstrated that the BC/CPF Aquifer is hydraulically isolated from the overlying Upper Brule Aquifer because (1) the overlying UCU piezometer (UCP-1) showed no response to pumping from the BC/CPF Aquifer;[327] (2) the Upper Brule Aquifer monitoring well (BMW-1) showed no response to pumping from the BC/CPF Aquifer;[328] (3) all of the drawdown graphs indicated a fully confined aquifer;[329] and (4) there were no indications of recharge in the recovery graphs.[330]

Dr. Kreamer testified that he conducted additional early-time interpretation of the drawdown relationship for one of the observation wells (COW-3).[331] Based on his interpretation, Dr. Kreamer opined that there was a distinct break point between the early and late drawdown curves at about 30 minutes, and that this can be interpreted as additional vertical flow from the

[325] Id. at 2.7(18)–(23).

[326] Id. at 2.7(28), 2.7(55).

[327] Ex. NRC-095 at 10 (citing Ex. BRD-002B-R, fig. 2.7-21, at 2.7(49)); Ex. CBR-067 at 9–10.

[328] Ex. NRC-095 at 10 (citing BRD-002B-R, fig. 2.7-21, at 2.7(49)); Ex. CBR-067 at 9–10.

[329] Ex. NRC-095 at 10 (citing BRD-002B-R, figs. 2.7-12 to 2.7-14, at 2.7(38)–(40)); see also CBR-074 at 14.

[330] Ex. NRC-095 at 10 (citing BRD-002B-R, figs. 2.7-18 to 2.7-20, at 2.7(44)–(46)); see also CBR-074 at 14.

[331] Ex. BRD-002B-R, fig. 2.7-14, at 2.7(40).

UCU.[332] Furthermore, Dr. Kreamer stated that recovery data for this same well also exhibited this recharge boundary.[333]

The NRC Staff's witnesses disputed Dr. Kreamer's reinterpretation of the data that led him to opine a recharge boundary appeared at the 30 minute break in Crow Butte's Test #2. They disputed Dr. Kreamer's reinterpretation largely by restating the same arguments they made with respect to Test #1, i.e., that early-time data should not be used to estimate aquifer properties.[334] Because deviations not associated with the aquifer characteristics occur during the early time periods, the NRC Staff's witnesses maintained that the generally accepted hydrogeological practice is to look to the middle time data to establish aquifer properties and to the late time data to assess whether recharge boundaries exist.[335]

In addition, the NRC Staff's witnesses testified that if the recharge boundary alleged by Dr. Kreamer had been encountered during the early time of the pumping test, there would only be time for the water to come from the UCU. Were this the case, the resulting drawdown would have been detected in the overlying UCU piezometer (UPC-1) based on its close proximity to the pumping well.[336] In fact, however, no response to pumping was observed at this monitoring point during the pumping test, and the NRC Staff's witnesses maintained that this refuted Dr. Kreamer's hypothesis of leakage through the UCU.[337]

In regards to the inappropriate use of early-time data, Crow Butte's witnesses criticized Dr. Kreamer's claims with respect to Crow Butte's Test #2 for the same reason it criticized his

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[332] Ex. INT-079 at 7.

[333] Id. (citing Ex. BRD-002B-R, fig. 2.7-14, at 2.7(40)).

[334] Ex. NRC-103 at 24–25.

[335] Id. (citing Ex. NRC-111 at 1).

[336] Ex. NRC-103 at 25 (citing Ex. BRD-002B-R, tbl. 2.7.3, at 2.7(21), 2.7(49)).

[337] Id. (citing Ex. BRD-002B-R, fig. 2.7-21, at 2.7(49)).

claims with respect to Crow Butte's Test #1.[338] More specifically, Crow Butte's witnesses testified that his reliance on early-time data during the first 37 minutes for Test #2 was flawed.[339] Crow Butte's witnesses maintained that Dr. Kreamer's assertion that "'a distinct breakpoint at about 30 minutes' represent[s] [a] 'recharge boundary'" is in error because of the cited problems with the use of early-time data collected during the first 37 minutes of the test.[340]

In support of their assertion that wellbore storage can give the false impression of leakage in the early-time period of an aquifer pumping test, Crow Butte's witnesses pointed to a specific figure in a scientific paper authored by Kruseman and de Ridder that they claim demonstrates the effect of wellbore storage on early-time drawdown at observation wells.[341] In particular, Crow Butte's witnesses asserted that a wellbore storage curve in the Kruseman and de Ridder paper bears a striking resemblance to the early-time data that was collected in COW-3 during Crow Butte's Test #2 and that Dr. Kreamer used as justification for his opinion that these test results indicated leakage through the UCU.[342] According to Crow Butte's witnesses, the close match of the COW-3 data with Kruseman and de Ridder's wellbore storage curve further demonstrated that Dr. Kreamer's reliance on early drawdown data is flawed.[343]

As with Crow Butte's Test #1, witnesses for both the NRC Staff and Crow Butte contended that it is likely the UCU and LCU aquitards yielded small amounts of water that were squeezed from storage due to pore pressure changes during the aquifer pumping test.[344] In

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[338] Ex. CBR-074 at 13–15.

[339] Id. at 14–15.

[340] Id. (quoting Ex. INT-079 at 7).

[341] Id. at 12 (citing Ex. CBR-081, fig. 2-15, at 52).

[342] Id.

[343] Id.

[344] Ex. NRC-095 at 10; Ex. CBR-067 at 9.

addition, Crow Butte's witnesses asserted not only that the amounts of water obtained were relatively insignificant, but that it would take more than 2.8 million years for water to move through the UCU.[345]

Crow Butte's witnesses testified that the high sensitivity piezometers in the UCU and LCU detected no change during the aquifer pumping test, and thus provided no data for estimating the hydrologic characteristics of these low permeability units.[346] As an alternative to aquifer pumping tests for determining the vertical hydraulic conductivity of the confining layers, Crow Butte performed consolidation tests on samples of the cores that were taken from the Red Clay Horizon of the Middle and Upper Chadron Formations during the installation of the piezometers.[347] Based on the results of this consolidation testing that is presented in the Crow Butte's Test #2 report, Crow Butte's witnesses maintained that data assessing the hydraulic properties of the UCU indicated the Red Clay Horizon is very impermeable with vertical hydraulic conductivities of less than 1×10^{-10} cm/sec.[348]

Dr. Kreamer and Mr. Wireman criticized Crow Butte's approach in this regard.[349] Specifically, Dr. Kreamer asserted that "ensemble field data were not used to characterize the hydraulic conductivity of these underlying and overlying formations, but the characterization was simply done in the laboratory geotechnical analysis on selected samples from a single borehole."[350] Crow Butte's witnesses responded that, for the same reasons discussed above, it

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[345] Ex. CBR-067 at 9; see also Ex. BRD-002B-R at 2.7(50).

[346] Ex. CBR-067 at 9.

[347] Ex. CBR-045 at 31–32; see also Tr. at 1283.

[348] See Ex. CBR-001 at 14–15; Ex. CBR-045 at 31–32.

[349] Ex. INT-047 at 4–5; Ex. INT-079 at 8.

[350] Ex. INT-079 at 5, 8.

is not possible to obtain hydraulic properties in tight confinement layers from an aquifer pumping test.[351]

iii-3. Parties' Positions on Crow Butte's Test #3

During September 1996, Crow Butte's Test #3 was conducted in the northwest portion of the License Area.[352] The pumping well operated for 55 hours at 51.2 gpm to create a radius of influence of 5,700 feet.[353] Thereafter, it was monitored for nearly 44 hours during recovery.[354] In addition to the pumping well, three observation wells were set in the BC/CPF Aquifer, while one observation well was set in the overlying Upper Brule Aquifer.[355]

Witnesses for the NRC Staff testified that the information in Crow Butte's Test #3 report demonstrated that the BC/CPF Aquifer is hydraulically isolated from the overlying Upper Brule Aquifer because (1) the water level in the Upper Brule Aquifer monitoring well (BOW96.1) did not change as a result of pumping the BC/CPF Aquifer;[356] (2) all of the drawdown graphs for the observation wells indicated that the BC/CPF is a fully confined aquifer;[357] and (3) there were no indications of recharge in the recovery graphs.[358]

While Dr. Kreamer did not dispute the interpretation of the drawdown curves for Crow Butte's Test #3, he nevertheless asserted that "[t]he possibility of secondary porosity and fractures in the strata overlying the [BC/CPF] was not even considered [by Crow Butte or the

[351] Ex. CBR-045 at 31–32.

[352] Ex. BRD-002C at 2.

[353] Id. at 5–6.

[354] Id. at 5.

[355] Id. at 1, 4; see also Ex. CBR-067 at 8.

[356] Ex. NRC-095 at 10–11.

[357] Id. (citing Ex. BRD-002C, app. C).

[358] Id.

NRC Staff]."[359] But Dr. Kreamer did not point to any specific data indicating where leakage through fractures was observed in the results of this aquifer test. In other respects, he provided the same criticism he raised with respect to Crow Butte's Tests #1 and #2—i.e., that there is an inadequate number of observation wells in the Upper Brule Aquifer, that additional testing is needed, and that there is a lack of long-term testing.[360]

iii-4. Parties' Positions on Crow Butte's Test #4

During August 2002, Aquifer Pumping Test #4 was conducted in the southeastern portion of the License Area.[361] Crow Butte installed five new wells (CPW2002, COW2002, CM9-04, CM9-13, and CM9-14) in the BC/CPF Aquifer prior to initiating this test.[362] CPW2002 was installed specifically for use as the pumping well, while the others served as observation wells in the BC/CPF.[363] One new observation well (SM9-10) was installed in the monitoring zone within the Brule Formation.[364] The pumping well was operated for almost 65 hours at 51 gpm creating a radius of influence of 5,500 feet.[365] Thereafter, it was monitored for nearly 96 hours during recovery.[366]

Witnesses for the NRC Staff and Crow Butte testified that the results of Crow Butte's Test #4 (Ex. CBR-012) demonstrated that the BC/CPF Aquifer is hydraulically isolated from the Upper Brule Aquifer for the following reasons: (1) no drawdown was observed in the well

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[359] Ex. INT-079 at 9.

[360] Id. at 9–10.

[361] Ex. CBR-012 at 1, 9.

[362] Id. at 4.

[363] Id.

[364] Id., fig. 3.

[365] Id. at 6, 9.

[366] Id. at 6.

installed in the Brule Formation (SM9-10);[367] (2) the data, plotted on drawdown graphs, indicated a fully confined aquifer;[368] and (3) there were no indications of recharge in the data plotted on recovery graphs.[369]

Dr. Kreamer, however, testified that there was "a recharge boundary in the data (indicated potential vertical leakage)" from Crow Butte Test #4 in the form of a variance in the drawdown plot for CM9-14.[370] Dr. Kreamer's interpretation of the data is based on the observed variant responses in the straight line graph of time vs. drawdown at about 700 minutes.[371]

While there were some variances in the data plotted on drawdown graphs, the NRC Staff's witnesses testified such variances were transient and did not reflect a recharge boundary.[372] Disputing Dr. Kreamer's interpretation, Mr. Back for the NRC Staff testified that, for the data to indicate a recharge boundary, the plot of time vs. drawdown would continue to deviate from the straight line plot with increasing time, i.e., the plot would continue to deviate and never return to the straight line again.[373] Ultimately, Dr. Kreamer agreed with Mr. Back that the plot would continue to deviate from the straight line drawdown curve when a recharge boundary had been encountered.[374]

Crow Butte's witnesses also testified that the drawdown rates were likely affected by pumping from operations at adjacent wellfields with overlapping radii of influence, which, in turn,

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[367] Ex. NRC-095 at 11.

[368] Id.

[369] Id.

[370] Ex. INT-079 at 1–2; see also Tr. at 1276.

[371] Tr. at 1276.

[372] Tr. at 1303–13; Ex. NRC-095 at 11.

[373] Tr. at 1304–05; Ex. NRC-103 at 10–11.

[374] Tr. at 1307–08.

produced the variances observed in the drawdown curves.[375] As Crow Butte's witness Mr. Lewis testified, pumping in adjacent mine units was turned off at the point in the test when the variances in the drawdown curve were observed and the subject data returned to expected values.[376] Thus, according to Crow Butte and the NRC Staff, the Test #4 curve does not indicate recharge of the aquifer.[377]

d. Summary of Aquifer Pumping Test Results

Crow Butte's witnesses testified that, in all four of the aquifer pumping tests, there was no drawdown in the observation wells set in the overlying Upper Brule Aquifer, and that this demonstrates the impermeability of the UCU.[378] In regards to the analytical methods used to evaluate the tests, Crow Butte collected actual drawdown data from wells in the BC/CPF Aquifer,[379] then analyzed that data using industry-accepted methods.[380] And the NRC Staff's witnesses maintained that, in every instance, the accepted methods indicated that the pumping test data overestimated the actual drawdown, and, as a result, provide a conservative estimate of the aquifer drawdown at any consumptive use rate during operations and restorations.[381]

Crow Butte's witnesses also emphasized that, in Crow Butte's Test #1, which utilized two observation wells set in the Upper Brule Aquifer, no drawdown occurred in either

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[375] Tr. at 1306; see also Ex. CBR-012 at 10–11.

[376] Tr. at 1306.

[377] Tr. at 1304–06; Ex. NRC-095 at 11; Ex. NRC-103 at 11; Ex. CBR-067 at 9–10.

[378] Ex. CBR-045 at 31–32.

[379] See Ex. NRC-087, Crow Butte Resources, Drawdown Predictions and 2009 Measured Values (undated); Tr. at 2561.

[380] EA § 3.5.2.3 at 50; Ex. CBR-045 at 20.

[381] Ex. NRC-076-R2 at 67.

observation well.[382] Likewise, in Crow Butte's Test #2, which included a piezometer set in the lower portion of the UCU, there was no measurable drawdown observed—signifying that the UCU is a significant hydraulic barrier.[383] Finally, in the remaining two Aquifer Pumping Tests (#3 and #4), both of which utilized an observation well in the Brule Formation, no drawdown was observed.[384]

The report for Crow Butte's Test #1 states (1) that the leakage rate through the UCU would be less than 0.00002 gal/sq. ft. in 51 hours (i.e., 4×10^{-10} cm/sec.); and (2) that it would take more than 12,000 years for water to move through just a 15-foot thick section of the Red Clay Horizon that directly overlies the BC/CPF.[385] The report for Crow Butte's Test #2 states (1) that neither the overlying confining layer piezometer nor the overlying aquifer monitor well showed any response to the pumping from the BC/CPF Aquifer during the test; and (2) that it would take more than 2.8 million years for a molecule of water to move through the entire UCU.[386] The report for Crow Butte's Test #3 concludes (1) that there is integrity of the UCU above the mining zone; and (2) that there is no evidence of confining layer leakage.[387] Finally, the report for Crow Butte's Test #4 concludes (1) that there is integrity of the UCU above the Ore Zone; (2) that the BC/CPF exhibits a hydrologic response consistent with a relatively homogeneous and isotropic aquifer within the southern portion of the License Area; and (3) that there was no evidence of confining layer leakage.[388]

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[382] Ex. CBR-045 at 32 n.2.

[383] Id.

[384] Id.

[385] See Ex. BRD-002A at 2.7(28)–(29); see also Ex. CBR-067 at 9.

[386] See Ex. BRD-002B-R at 2.7(53)–(54); see also Ex. CBR-067 at 9–10.

[387] Ex. BRD-002C at 6, 8.

[388] See Ex. CBR-012 at 7, 12–13; Ex. CBR-067 at 10.

The NRC Staff's witnesses testified that the LRA's "test data (e.g., laboratory tests of core samples, confining unit piezometer responses, and drawdown analysis of the [BC/CPF Aquifer]) indicated an extremely small recharge from the extensive stress applied to the confining unit during the aquifer pumping tests."[389] They further testified that "all four aquifer pumping tests . . . showed that no leakage occurs through the 200 to 500 feet thick overlying confining unit and that no communication exists between the [BC/CPF Aquifer] and the overlying [Upper] Brule [A]quifer."[390]

2. Board Findings on Aquifer Pumping Testing

We find that Crow Butte conducted four aquifer pumping tests in the License Area (during 1982, 1987, 1996, and 2002) using well casing sealed into the BC/CPF, pumping rates that varied from 24 gpm to 51 gpm, and pumping durations extending from 51 to 72 hours that created radii of influence from 4,000 to 5,700 feet. These tests were conducted in an effort to ensure that the Ore Zone of the BC/CPF is hydraulically isolated from the Upper Brule Aquifer by the surrounding aquitards, which consist of the Pierre Shale underlying the Ore Zone (i.e., the LCU) and the Middle/Upper Chadron and Lower Brule Formations (i.e., the UCU) overlying the BC/CPF. As a secondary goal, these tests sought to enable Crow Butte to estimate the aquifer parameters needed to predict the flow rates and drawdown in the BC/CPF Aquifer during long-term pumping associated with operations and restoration.

All four pumping tests indicated that there is no hydraulic connection between the Upper Brule Aquifer and the BC/CPF Aquifer. Overall, there is strong evidence (1) that the Upper Brule Aquifer is hydraulically isolated from the Ore Zone of the BC/CPF; and (2) that a competent UCU exists in the License Area (with all Brule wells demonstrating no drawdown),

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[389] Ex. NRC-076-R2 at 38.

[390] Id.

which indicates that groundwater flow pathways between the production zone and overlying aquifer are not present.

Dr. Kreamer attempted to discredit Crow Butte's aquifer pumping tests using early-time drawdown data that he opined was indicative of potential aquifer leakage.[391] But we find that relying upon early-time drawdown data is inconsistent with aquifer testing guidance, and that the use of later-time drawdown data is superior for estimating aquifer parameters and detecting leakage.[392]

We also find that Crow Butte analyzed this aquifer pumping test data by using well-established and professionally accepted methods that have been incorporated into the American Society of Testing and Materials standards. We further find that, even though these test methods are designed for homogenous, isotropic, non-leaky strata, Crow Butte recognized these shortcomings for the subject aquifers and was prepared to make appropriate allowances for the use of more complex algorithms if there were any deviations in these aquifer characteristics.

Nevertheless, we find that none of the results indicated sufficient deviations to necessitate the use of more complex models. While two of the aquifer pumping tests suggested a small amount of leakage and anisotropy, this conclusion was only inferred from Aquifer Pumping Test #1 as a result of the "leaky aquifer" analysis performed at the NRC Staff's request. We also find that the other analyses, including the two-stage Theis aquifer curve matching method, concluded that leakage was not evident and that the deviation from the ideal

[391] Ex. INT-079 at 3–4.

[392] See Ex. CBR-074 at 11; Ex. NRC-103 at 16–17.

confined aquifer drawdown curve in late time was solely due to changes in local transmissivity.[393]

While Intervenors' witnesses claimed that Crow Butte's calculations for estimating the rate of leakage are "inappropriate,"[394] they did not provide an independent estimate for the rate of leakage, nor did they suggest an alternative, superior method. We find that Crow Butte's estimated rates of leakage were reasonably calculated, and are so low as to be considered negligible and within the range expected for a fully confined aquifer.

Accordingly, we find that all four pumping tests are consistent with other lines of evidence discussed in the next section of this Partial Initial Decision, which finds that there is no significant hydraulic connection between the Upper Brule Aquifer and BC/CPF Aquifer. We also find that Crow Butte's four aquifer pumping tests demonstrated that it properly plugged and abandoned its exploration, development, and pilot test holes that were drilled on-site, ensuring they cannot serve as a secondary conduit between these aquifers. Likewise, we find that Crow Butte's analysis of the pumping test data established that the Upper Brule Aquifer is isolated and that there is adequate confinement of the BC/CPF Aquifer.

D. Integrity of the UCU

We now turn to questions raised by Intervenors relating to the integrity of the UCU, which is needed to assure containment of mining contaminants within the BC/CPF.

1. Parties' Positions on Integrity of the UCU

Intervenors' witnesses disputed whether the UCU will restrict communication between the BC/CPF Aquifer and the Upper Brule Aquifer, based on three major considerations: (1) the presence of lineaments regionally, and specifically in the License Area, that may be indicative of bedrock fracturing; (2) the existence of secondary porosity, and the associated increase in

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[393] See Ex. CBR-074 at 13; Tr. at 2533–34.

[394] Ex. INT-079 at 6.

permeability of the UCU; and (3) the detection of changes in the groundwater levels in the Upper Brule Aquifer when Crow Butte conducts mining operations by pumping in the BC/CPF. We address the parties' positions on these topics immediately below.

a. Parties' Positions on Lineaments

Based mostly on the presence of lineaments in the region and fractures in outcrops outside of the License Area, Intervenors' witnesses asserted that contaminants can pass through the UCU via faults, fractures, joints, and cracks in the consolidated strata.[395]

Dr. LaGarry defined lineaments as any unexplained, straight-line topographic feature observed in remotely sensed imagery.[396] While initially stating that these lines represent fracturing that may compromise the containment properties of the UCU,[397] Dr. LaGarry clarified that there is no certainty that an unexplained linear feature is a fracture, as opposed to some other type of straight line image—a conflict that can only be resolved through on-site ground investigation.[398] And, as Dr. LaGarry stated, even though they are obvious when viewed from Earth's orbit, lineaments indicating fracturing are difficult to observe when covered by surficial deposits (as is the case with the UCU).[399]

In his testimony, Dr. LaGarry asserted that multiple sets of parallel lineaments, oriented generally northwest-southeast and southwest-northeast, were mapped in 1994 throughout

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[395] Ex. INT-043, Hannan E. LaGarry, Ph.D., Additional Testimony Regarding Lineaments, Joints, and Faults as Contaminant Pathways Near Crawford, Nebraska (Crow Butte Resources ISL Facility) at 3–4 (undated); Tr. at 1212–13, 1225.

[396] Ex. INT-043 at 2; Tr. at 1175.

[397] Tr. at 1173–75.

[398] Tr. at 1177–78.

[399] Ex. INT-013, Hannan E. LaGarry, Ph.D., Supplemental Expert Opinion Regarding the Renewal of ISL Uranium Mining (Crow Butte Resources) Near Crawford, Nebraska at 3 (undated).

northwestern Nebraska, including the License Area.[400] But, as Dr. LaGarry acknowledged, these lineaments do not necessarily represent fracturing because extensive fieldwork is required to check each lineament.[401] Dr. LaGarry also noted that a 2011 study field-checked and analyzed lineaments south of Chadron in a 20 square-kilometer area of northwestern Nebraska, and concluded that, in this survey area, lineaments representing fracturing were identified on the ground.[402] At the same time, however, Dr. LaGarry recognized that this 2011 study was conducted more than 20 miles northeast of the License Area, and its applicability to the issues in this proceeding is uncertain.[403] Dr. LaGarry also described a poster presentation that reviewed detailed fieldwork to support his claims that fracturing existed at the License Area.[404] While Dr. LaGarry described these studies as an effort to define the regional structure of the geology in northwestern Nebraska and southwestern South Dakota,[405] the NRC Staff's witnesses disputed Dr. LaGarry's claim, asserting that, because the fieldwork in this study was limited to locations distant from the License Area, it failed to establish the existence of fractures at this site.[406]

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[400] Ex. INT-043 at 2–3 (citing Ex. INT-055, Robert F. Diffendal, Jr., Geomorphic and structural features of the Alliance 1° × 2° Quadrangle, western Nebraska, discernible from synthetic-aperture radar imagery and digital shaded-relief maps, 30(2) U. of Wyo. Contributions to Geology 137–47 (1994)); Tr. at 1177.

[401] Ex. INT-043 at 4.

[402] Id. at 2–3 (citing Ex. INT-056, Jennifer L. Balmat, Chadron State College, Subtle Structures of the Pine Ridge Region, Northwestern Nebraska at 53 (June 21, 2011)).

[403] Ex. NRC-076-R2 at 24–25; Tr. at 1176–77.

[404] Ex. INT-043 at 3–4 (citing Ex. INT-060, Harmon Maher Jr. and Robert D. Shuster, Significance of an ESE Fracture Direction in Tertiary Strata of South Dakota and Nebraska, 44(7) Geological Society of America Abstracts with Programs 547 (2012)); Tr. at 1176–77, 1181.

[405] Ex. INT-043 at 3.

[406] Ex. NRC-076-R2 at 24–26.

In addition, Crow Butte's witness Mr. Beins disputed Dr. LaGarry's claim on a separate ground—that the composition of the rock layers in the License Area would largely prevent fractures:

> While we at Crow Butte realize that there may be some joints and fractures in the Brule portion, the upper Brule Formation and everything, we don't feel that those fractures extend at depth down into the lower Brule and into the Chadron Formation. And so, because of the plasticity or the plastic nature of those sediments, any fracture that is present there, if there were to be movement, is likely to seal itself off. The clays that we're talking about have a high percentage of montmorillonite clay in it. As those become wet, they tend to swell.[407]

The NRC Staff's witnesses also noted that the identified lineaments in the 2011 study had not been confirmed with the fieldwork that is required to determine whether the lineaments are in fact fractures.[408] Dr. LaGarry agreed that these lineaments had not been confirmed on the ground[409] and that "[s]uch a determination would require extensive fieldwork to check each lineament."[410]

In an attempt to denote these lineaments, Dr. LaGarry personally drew red lines on a water resources map (Ex. INT-043, fig. 2)[411] that suggest there is a "kink" in the shape of the Ore Zone within the License Area.[412] Referring to this annotated map, Dr. LaGarry testified that the "area marked as the potential ore body is a generally NW-SE trending lineament."[413] Dr. LaGarry also asserted that the presence of fractures at the License Area is supported by a 1989

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[407] Tr. at 1100–01.

[408] Ex. NRC-076-R2 at 27–28.

[409] Tr. at 1181.

[410] Ex. INT-043 at 2.

[411] Id., fig. 2, at 5. Dr. LaGarry stated that he added the figure number, title, and red lines to an original map from Wyoming Fuels Company (Crow Butte's predecessor at the site). Tr. at 1199–1200.

[412] Tr. at 1199–1202.

[413] Ex. INT-043 at 4.

letter to the NRC from an exploration geologist (Ex. INT-009) that claimed Crow Butte had recovered uranium in the License Area within formation fractures, not within a roll-front deposit (which is formed by the precipitation of dissolved uranium in groundwater as it moves through the aquifer), and that the extraction of uranium from the fractures opened up pathways through which contaminants could migrate.[414]

The NRC Staff's witnesses disputed Dr. LaGarry's claims that Crow Butte's Ore Zone occurs in a fracture oriented along a lineament. To the contrary, they asserted that a report entitled "Relationship Between Groundwater Flow and Uranium Mineralization in the Chadron Formation, Northwest Nebraska" (Ex. NRC-030) establishes Crow Butte's "uranium trend has been unequivocally described as a roll-front deposit."[415] The NRC Staff's witnesses also testified that "the orientation of the ore body is a function of its roll-front depositional history."[416]

Furthermore, the NRC Staff's witnesses claimed that Dr. LaGarry provided no technical support establishing that his red lines on the annotated water resources map either represent actual fractures or correspond to the lineaments identified in the License Area.[417] In addition, they asserted that Dr. LaGarry failed to use the available hard data provided by Crow Butte (e.g., aquifer pumping test results, borehole geophysical logs, and over 20 years of operational and monitoring data) to field-verify whether those red lines correspond to potential fractures.[418] To the same effect, Crow Butte's witnesses maintained that "nearly 11,000 drill holes completed

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[414] Id. (citing Ex. INT-009, Letter from John Petersen to Gary Konwinski, Uranium Recovery Field Office, NRC (Apr. 4, 1989)).

[415] Ex. NRC-001-R at 42.

[416] Ex. NRC-076-R2 at 27.

[417] Id. at 27–28.

[418] Id.

across the permit area, aquifer tests, and other evidence do not support the presence of a fault or faults in the [License Area]."[419]

b. Parties' Positions on Secondary Porosity/Permeability from Fracturing

While none of the parties disputed the confining properties of the LCU,[420] Intervenors alleged that fractures within the UCU have the potential to transmit contaminants from the BC/CPF Aquifer to the Upper Brule Aquifer,[421] and, from there, to the White River alluvium.[422] Dr. LaGarry testified that his "concerns regarding the Crow Butte [R]esources ISL uranium mine are the lack of confinement resulting from secondary porosity in the form of faults and joints,"[423] adding that secondary porosity could allow constituents to migrate up from the Ore Zone into the Upper Brule Formation and, ultimately, to the land surface.[424] In this instance, Dr. LaGarry opined that lixiviant could be transmitted from the Ore Zone to the land surface by upward flow through areas of secondary porosity,[425] and that secondary porosity in the Brule Formation could transmit water up to 1,500 feet per day through faults and cracks, and ultimately, towards the PRIR.[426]

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[419] Ex. CBR-045 at 13.

[420] Tr. at 1028.

[421] Ex. INT-013 at 3; Ex. INT-046 at 2–3; Ex. INT-047 at 2, 5; Tr. at 1120–22, 1173–74.

[422] Ex. INT-003 at 3.

[423] Ex. INT-013 at 2.

[424] Id.

[425] Ex. INT-013 at 6.

[426] Id. No Intervenor witness provided specific identification of fracturing in the License Area. Dr. LaGarry testified at the August 2015 hearing that this was because the License Area is privately-controlled and, as a consequence, he had not been afforded access to the site to attempt such identification. Tr. at 1185.

Based on these claimed observations of outcrops of the BC/CPF and the overlying Middle Chadron (i.e., the lower unit of the UCU) more than ten miles northwest of the License Area,[427] Dr. LaGarry asserted that the secondary porosity of geologic strata due to fractures "is common in northwestern Nebraska,"[428] and that these fractures, generally oriented northwest to southeast and southwest to northeast, are a result of the uplift of the Black Hills of South Dakota.[429] Dr. LaGarry also opined that many of these fractures extend for tens of miles and that the alluvium deposited by rivers follows "fault zones because fractured rock erodes more easily."[430] He also testified that detailed fieldwork in northwestern Nebraska and in adjacent South Dakota supports his assertions that faults and joints are ubiquitous throughout the region.[431]

As noted earlier,[432] Dr. LaGarry further opined that "the nature of the sedimentary rocks in this region is such that they may be loosely consolidated, poorly indurated [i.e., hardened], and in places one can work them with one's hands," resulting in these formations being described as "semi-consolidated."[433] Dr. LaGarry added that it is entirely possible that the portions that were once consolidated are no longer so because, subsequent to the deposit being formed, local earthquakes could have fractured these zones.[434]

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[427] Ex. NRC-021 at 3; Tr. at 1076–77.

[428] Ex. INT-003 at 3.

[429] Ex. INT-013 at 2.

[430] Id. at 3.

[431] Ex. INT-043 at 3–4.

[432] See supra notes 52–53 and accompanying text.

[433] Tr. at 1035.

[434] Tr. at 1067.

Dr. Kreamer, who supported Dr. LaGarry's testimony, claimed that Crow Butte may have erred in assuming that the sand or sandstone in the ore-bearing body has no secondary porosity.[435] Providing additional support of Dr. LaGarry's opinion, Mr. Wireman testified that the presence of the fracturing surrounding the License Area suggests the significant likelihood of extensive secondary porosity in the portion of the licensing area where Crow Butte conducts its mining operations.[436] Mr. Wireman further testified that the EA did not adequately characterize the secondary permeability of the UCU in order to quantify this value.[437] Mr. Wireman suggested that such a quantification of the hydraulic properties of the low-permeability UCU could be accomplished by using specialized coring techniques to assess the direction of fracturing, followed by a series of pumping tests in the UCU to measure directly the hydrologic parameters. At the same time, however, Mr. Wireman conceded that not only is oriented core testing expensive, but it is unlikely to be successful in soft rock such as that which makes up the UCU at the License Area.[438]

According to the EA, the License Area is located within a triangular-shaped structural feature known as Crawford Basin.[439] The EA's only mention of secondary porosity is a reference to the fracturing of the overlying Upper Brule Aquifer—which allows it to serve as a usable water source outside the License Area.[440] Nevertheless, the NRC Staff's witnesses testified that they "found no evidence of faults or fractures at the [License Area] which could act as permeable pathways between the [BC/CPF Aquifer] and the White River [a]lluvium or the

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[435] Ex. INT-069 at 3.

[436] Ex. INT-047 at 3.

[437] Id.

[438] Tr. at 1122–24.

[439] EA § 3.4.2 at 40.

[440] Id. § 3.5.2.1 at 47–48.

overlying [Upper] Brule [A]quifer,"[441] thereby ensuring the integrity of the UCU within the License Area. Moreover, the EA and the SER state that there is vertical hydrological confinement of the BC/CPF Aquifer in the License Area, as established by the site-specific and reproducible nature of five separate groups of physical evidence collected from this site,[442] which are described below.

(1) Hydrological Characteristics of Confining Units – EA § 3.5.2.3.2 describes the presence of thick, low-permeability clay and mudstone layers of the Upper Chadron and the lower portions of the Brule Formations that isolate the BC/CPF Aquifer from the overlying Upper Brule Aquifer.[443]

(2) Aquifer Pumping Tests – EA § 3.5.2.3.1 states that Crow Butte conducted four separate aquifer pumping tests covering the entire License Area between 1982 and 2002 in an attempt to establish the integrity of the confining layers over the BC/CPF Aquifer and that, in the estimation of the NRC Staff, these tests showed a lack of drawdown in the Upper Brule Aquifer and demonstrated that there is no hydrological connection between the overlying Upper Brule Aquifer and the BC/CPF Aquifer.[444]

(3) Potentiometric Surfaces – EA § 4.6.2.2.1 compares historical groundwater surfaces, beginning with the commencement of Crow Butte's mining activities. This comparison indicates

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[441] Ex. NRC-001-R at 22.

[442] Id. at 29–31. While reliance on the NRC Staff's groundwater modeling that had been performed to assess the confinement of the BC/CPF Aquifer within the License Area was abandoned by the NRC Staff's witnesses during the hearing, they claimed that this modeling was not essential to the EA's conclusion here. See supra notes 203–07 and accompanying text.

[443] EA § 3.5.2.3.2 at 51; Ex. NRC-001 at 29.

[444] EA § 3.5.2.3.1 at 50–51; LRA, fig. 2.7-8, at 2-203.

that there has been little change in the potentiometric elevations in the Upper Brule Aquifer, while the potentiometric surface of the BC/CPF Aquifer has decreased by about 47 feet.[445]

(4) Aquifer Water Quality – EA § 4.13.6.2 and SER § 2.4.3.2.2, which refer to water quality data in LRA Table 2.2-9, depict distinct differences in geochemistry between the wells screened in the Upper Brule Aquifer and those screened in the BC/CPF Aquifer, indicating that the two aquifers are hydraulically isolated.[446] The EA also notes that groundwater quality monitoring data from private wells in the Upper Brule and BC/CPF aquifers have consistently shown that neither aquifer exceeded background levels for radiological constituents.[447]

(5) Operational and Monitoring Data – EA § 3.5.2.3.2 and SER § 5.7.9.3.2 both state that, over the course of Crow Butte's 20 years of mining operations, Crow Butte has monitored both groundwater and surface water and that the resulting data have not shown Crow Butte's mining operations to have contaminated the surrounding or overlying aquifers.[448] They further state that, instead, these results demonstrate the continued isolation of the BC/CPF Aquifer over the period of Crow Butte's mining operations given that (a) the only vertical excursions detected to date were associated with well installation issues, rather than from a lack of integrity of the confining layers;[449] and (b) monitoring results from private Upper Brule Aquifer wells, located within one mile of the License Area, exhibited no discernible trends and remained at preoperational levels.[450]

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[445] EA § 4.6.2.2.1 at 87–88; see also SER § 3.1.3.5.6 at 61.

[446] EA § 4.13.6.2 at 128; SER § 2.4.3.2.2 at 41; see also LRA, tbl. 2.2-9, at 2-28.

[447] EA § 4.6.2.2.6 at 94.

[448] Id. § 3.5.2.3.2 at 51; SER § 5.7.9.3.2 at 143.

[449] EA § 3.5.2.3.2 at 51; SER § 5.7.9.3.2 at 143; see also infra § III.E.1.a, Parties' Positions on Operational Groundwater Impacts from Excursions at 102–109; § III.E.2.a, Board's Findings on Operational Groundwater Impacts from Excursions at 111–113.

[450] Ex. NRC-001-R at 31; EA § 4.6.2.2.6 at 94.

Witnesses for both Crow Butte and the NRC Staff conceded three regional studies (employing observations of surface outcrops) identified in Dr. LaGarry's testimony indicated that fracturing and secondary porosity may be present in the Brule Formation throughout the region.[451] Nevertheless, they asserted such fracturing is insignificant with respect to the containment characteristics of the UCU within the License Area[452] because (1) none of the three studies were conducted within the License Area; and (2) there is no "measured, reproducible site data" demonstrating the existence of significant fractures that connect different strata.[453] While we address in detail below the probative value of this evidence,[454] it is sufficient at this point to note that there is adequate evidence to support the claims of the NRC Staff and Crow Butte that fractures within the UCU (if any) in the License Area are not sufficiently transmissive to impact the water quality of the overlying Upper Brule Aquifer.

Crow Butte's witnesses agreed it is likely that secondary porosity is present in the Brule Formation throughout the region, but they maintained that the field data it has collected from within the License Area strongly suggests the License Area has both hydraulic isolation and a competent UCU.[455] As a result, Crow Butte's witnesses opined that fracturing of the UCU, if any, has not resulted in significant groundwater flow pathways between the BC/CPF Aquifer and any overlying aquifers.[456] Accordingly, they concluded that "while faults and joints may exist at a regional level, there is no evidence of the existence of faults or fractures at the [License Area]

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[451] Ex. NRC-001-R at 34; Ex. CBR-045 at 7.

[452] Ex. NRC-001-R at 34; Ex. CBR-045 at 7.

[453] Ex. NRC-001-R at 34.

[454] See infra § IV.C.1, Hydraulic Communication between the BC/CPF Aquifer and Upper Aquifers at 161–66.

[455] Ex. CBR-045 at 6–7.

[456] Id. at 7.

that affect confinement or transmit mining liquids."[457] Crow Butte's witnesses also asserted that if any minor fractures were to appear, they would close up quickly (i.e., be essentially self-sealing) as a result of overburden pressure from the weight of overlying strata.[458]

As previously discussed,[459] witnesses for both Crow Butte and the NRC Staff have characterized the UCU as containing significant swelling, low-permeability, montmorillonite clays that are not brittle and are "self-healing" so that they would not tend to undergo any permanent changes in secondary porosity under seismic ground motions.[460] This is based on particle size distribution analyses of the UCU (indicating mostly silt and clay-sized fractions) and on observations made during pervasive geophysical logging (indicating very thick sequences of predominantly fine-grained materials). Accordingly, Crow Butte's witnesses asserted that the UCU is significantly less permeable than the BC/CPF and, given its substantial thickness, is essentially impermeable, absent preferential flow paths (e.g., fractures).[461] Dr. LaGarry, however, disputed this characterization of the UCU, testifying that where the Chadron Formation portion of the UCU outcrops approximately 15 miles northwest of the License Area, he observed slickensides (i.e., a smoothly polished surface caused by frictional movement between rocks along the two sides of faults)—indicating that these fractures have not yet healed.[462]

Even were Dr. LaGarry correct that there are isolated faults or joints in the vicinity of the License Area, the NRC Staff's witnesses testified there is enough swelling of the UCU's 200 to 500 feet thick saturated bentonitic and montmorillonite clays to prevent any isolated fractures

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[457] Id.

[458] Id. at 6–7.

[459] See supra § II.B.3.b, Composition of the UCU at 21–25.

[460] Ex. CBR-001 at 14–15; see also Ex. NRC-001 at 111.

[461] Ex. CBR-001 at 14–15.

[462] Tr. at 1076, 1180.

from forming a continuous pathway,[463] and accordingly, there would be insufficient secondary porosity to allow the vertical transmission of constituents out of the Ore Zone.[464] In this regard, the NRC Staff's witnesses also highlighted a point made earlier[465]—that the UCU is continuous over the License Area, based on Crow Butte's cross-sectional survey data.[466]

Finally, the NRC Staff's witnesses reiterated that, even were it possible for constituents to migrate to other aquifers, Crow Butte is required to "maintain an overall inward gradient in all mine units," until restoration is complete,[467] thereby creating a cone of depression in the potentiometric level that draws groundwater toward the interior of the wellfield.[468] This required inward gradient must have sufficient strength to prevent the movement of mined liquids outside of the License Area.[469] Furthermore, this inward gradient must continue to be maintained until the mine unit is restored either to background maximum contaminant levels, or to an alternative concentration limit, whichever is higher.[470]

To the same effect, Crow Butte's witnesses opined that "the presence of a fault or joint does not necessarily mean there is a hydraulic connection created. Faults and joints may be barriers to groundwater flow, or neutral (i.e., do not significantly affect groundwater flow), depending on the degree of offset and character of the material that fills the fault/joint."[471] Along

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[463] Ex. NRC-001-R at 35.

[464] Id.; Ex. NRC-076-R2 at 39.

[465] See supra § II.B.3.a, Extent of the UCU at 20–21.

[466] Ex. NRC-076-R2 at 39.

[467] Ex. NRC-012 at 8 (License Condition 10.7).

[468] EA § 4.6.2.2.1 at 88; Ex. NRC-001-R at 21.

[469] Ex. NRC-076-R2 at 72.

[470] Tr. at 2596.

[471] Ex. CBR-045 at 5.

the same lines, there is no dispute among the parties that, as applied to a specific feature, the central concern is not the mere presence of cracks in the formation, but rather the transmissivity of the fractured strata.[472] Moreover, Dr. LaGarry conceded that, even if the UCU were fractured to some extent, the degree to which such a fracture serves as a preferential pathway can only be confirmed by direct observation.[473] Meanwhile, Crow Butte's witnesses maintained their data and experience with the License Area indicate that (1) there is no continuous permeable pathway between aquifers within the License Area;[474] and (2) processing liquids and other mobilized constituents from Crow Butte's mining operations are confined by the UCU of the Middle and Upper Chadron Formation and by the Lower Brule Formation.[475]

c. Parties' Positions on Brule Aquifer Water Levels During Mining

Intervenors' witness Dr. Kreamer testified that there are numerous monitoring wells showing a drawdown in the Upper Brule Aquifer as a result of Crow Butte's pumping of the Ore Zone in the BC/CPF Aquifer.[476] There is no record evidence, however, that the water level in even one of these monitoring wells had been lowered as a direct result of Crow Butte's mining activities. Specifically, Crow Butte's witnesses disputed Dr. Kreamer's water level drawdown claim by presenting monitoring well data taken bi-weekly from over 200 wells during the operation and restoration of each Crow Butte mine unit.[477] These data, first presented in the LRA itself, indicate that the potentiometric surface of the BC/CPF Aquifer ranges from approximately 3,690 to 3,750 feet, while the water surface in the Upper Brule Aquifer ranges

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[472] Ex. CBR-001 at 23–25; Ex. NRC-095 at 22; Tr. at 1187, 1192.

[473] Tr. at 1179.

[474] Ex. CBR-045 at 6–7.

[475] Id. at 6.

[476] Ex. INT-079 at 10.

[477] Ex. CBR-001 at 15–17.

from approximately 3,830 to 3,970 feet, i.e., an average difference in potentiometric levels in excess of 100 feet.[478] Crow Butte's witnesses opined that this large difference in potentiometric levels demonstrates the two aquifers are hydraulically isolated from each other because, for significant hydrologic communication to be present, the potentiometric levels in the two aquifers would be expected to be much closer in elevation.[479]

Crow Butte's witnesses also maintained that the data Crow Butte collected from the License Area over the past 20-plus years established that water levels in the Upper Brule Aquifer were not lowered due to inadequate confinement of the BC/CPF Aquifer.[480] To support this assertion, they point to hydrographs (i.e., plots of water levels over time) for ten wells (which were set forth in Ex. CBR-063 to Ex. CBR-065) spaced across the License Area (as shown on Ex. CBR-066) that, according to Crow Butte's witnesses, demonstrated constant water table elevation for the Upper Brule Aquifer over Crow Butte's 20 years of operation in the License Area.[481]

For instance, Crow Butte offered hydrographs for SM7-17 and SM7-22[482] (i.e., Upper Brule Aquifer monitoring wells near to and overlying the active mining area for Mine Unit 7, which first began operating in 1999) that encompass the period from 1999 to the 2015.[483] Crow Butte's witnesses argued these hydrographs support their opinion that little variation exists in

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[478] Id. at 16 (citing LRA, tbls. 2.7-5 to 2.7-6, at 2-197–99; id., figs. 2.7-3d to 2.7-4d, at 2-179–89).

[479] Ex. CBR-001 at 16.

[480] Ex. CBR-067 at 6; Ex. CBR-074 at 5.

[481] Ex. CBR-067 at 6; Ex. CBR-074 at 5.

[482] Ex. CBR-063-R, Cameco Resources, Inc., Crow Butte Operation, Water Level of SM 7-17 (undated); Ex. CBR-064-R, Cameco Resources, Inc., Crow Butte Operation, Water Level of SM at 7-22 (undated).

[483] Ex. NRC-105, Map of Crow Butte License Boundary and Mine Units (undated); LRA, tbl. 1.7-1, at 1-13.

the water levels in the Upper Brule Aquifer,[484] with average elevations of 3,850 feet for SM7-17, and 3,844 feet for SM7-22.[485] It was Dr. Kreamer's opinion that Crow Butte's hydrographs were not definitive because there could have been rapid declines in the potentiometric levels before 1999.[486] Specifically, Dr. Kreamer asserted that there is an early critical period for which Crow Butte produced no data, i.e., between 1991 (when mining activities began in Mine Unit 1) and 1999 (when Crow Butte's first hydrograph data was apparently recorded in Mine Unit 7).[487] Dr. Kreamer opined, as did Mr. Wireman, that there may have been a drawdown of 40 feet or more in the Upper Brule Aquifer before the period monitored by the hydrographs.[488]

Witnesses for both Crow Butte and the NRC Staff disputed this, asserting that operations in Mine Unit 7 did not start until 1999, and that these hydrographs do in fact date from the first time pumping was activated for this mine unit.[489] As such, they assert, these hydrographs demonstrate that water levels in the Upper Brule Aquifer have not been affected by Crow Butte's pumping in the Ore Zone—which commenced with the start of production and has continued for decades thereafter.[490] In addition, Intervenors could offer no explanation for how the large volume of water that would be required to lower the water table in the unconfined Upper Brule Aquifer by 40 feet (or more) could have moved through at least 100 feet of the UCU's low permeability aquitard and then recharged the lowered potentiometric level of the BC/CPF during the first few years of mining—particularly in light of the apparent absence of any

[484] See generally Ex. CBR-063-R; Ex. CBR-064-R.

[485] See generally Ex. CBR-063-R; Ex. CBR-064-R.

[486] Ex. INT-079 at 10–11.

[487] Id.

[488] Tr. at 1786–88; Ex. INT-081 at 2.

[489] Ex. NRC-103 at 4–5; Ex. CBR-074 at 6.

[490] Ex. NRC-103 at 4–5; Ex. CBR-074 at 6.

suggestion of drawdown during the subsequent 16 years of Crow Butte's mining in the License Area.

Crow Butte's witnesses further testified that, were these two aquifers hydraulically connected, additional drawdown in wells within another mine unit's radius of influence would be expected to occur as new mining areas came online.[491] Instead, they claim, the relatively narrow band of water level readings (i.e., only a few feet of change in either direction) indicates that any variations are likely due to temporal weather patterns in the area rather than to Crow Butte's mining operations.[492] In accord with this testimony of Crow Butte's witnesses, the EA states there is no evidence that water levels in the overlying Upper Brule Aquifer have been impacted by mining activities in the BC/CPF.[493]

Intervenors' witnesses also attempted to attribute the gradually rising water levels in the Upper Brule Aquifer to Crow Butte's termination of its pumping operations in areas that are hydraulically connected to the Ore Zone within the BC/CPF Aquifer.[494] For instance, Mr. Wireman opined that the increase in water level in wells SM7-17 and SM7-22[495] (which occurred between 2008 and 2012) could be a result of stopping or reducing mining operations in the vicinity of these two wells, and thus is another indication that pumping in the Ore Zone within the BC/CPF Aquifer affects the water level in the Upper Brule Aquifer.[496] Dr. Kreamer supported Mr. Wiremen's opinion on this point.[497]

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[491] Ex. CBR-067 at 5.

[492] Id.

[493] EA § 4.13.6.2.2 at 131.

[494] Ex. INT-082-R, Rebuttal Statement of Dr. David K. Kreamer at 1–2 (Sept. 28, 2015).

[495] Ex. CBR-063-R; Ex. CBR-064-R.

[496] Ex. INT-081 at 3.

[497] Ex. INT-079 at 10–11.

Crow Butte's witnesses disputed this, however, testifying that, because the mine units (Mine Units 7 and 9) associated with these wells are still in operation, they could not be implicated in this apparent rise in water level.[498] Similarly, the NRC Staff's witnesses asserted that if Mr. Wireman were correct that the effects of mining activities are reflected in the hydrographs, then these water level graphs would have shown an increased drawdown at the beginning of the mining activities—which, they assert, was not the case.[499]

Dr. Kreamer also claimed that the Upper Brule Aquifer water levels in SM08-006[500] showed steady or rising levels of two feet in the period of November 2013 through March 2014, and that this rise cannot be correlated with weather conditions.[501] Crow Butte's witness Mr. Lewis testified that it can take months, or even years, for rainfall to percolate through the soil (much of which is clay) into the underlying aquifer, especially given the distance from the recharge area for the Upper Brule Aquifer to the License Area and the low permeability clay content in some portions of this formation.[502] As such, Mr. Lewis stated that an immediate response to those precipitation events is unlikely due to the significant lag between a rainfall event and changes in the underlying water table.[503] Therefore, Mr. Lewis maintained that it would be incorrect to rule out the lack of correlation with weather conditions as contributing to rising water levels in the Upper Brule Aquifer.[504]

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[498] Tr. at 1091–92.

[499] Ex. NRC-103 at 5 (citing Ex. CBR-063-R; Ex. CBR-064-R).

[500] Ex. BRD-010L, Letter from Larry Teahon, Safety, Health, Environment, and Quality Manager, Crow Butte, to Document Control Desk, NRC (May 23, 2014), attach., Water Level of SM08-006, at 4 (May 21, 2014).

[501] Ex. INT-082-R at 1–2.

[502] Tr. at 2482–83.

[503] Tr. at 2482–83.

[504] Tr. at 2482–84.

To indicate mining impacts on the Upper Brule Aquifer, Dr. Kreamer and Mr. Wireman compared the pre-mining Upper Brule Aquifer water level of Well #11 (Ex. BRD-008A)[505] with the post-mining level of Well #11 by interpolating contour mapping of estimated 2008 water levels (Ex. BRD-008B). From this, they opined that the Upper Brule Aquifer experienced up to 40 feet of drawdown, which they attributed to a lack of confinement.[506] Witnesses for Crow Butte disputed this interpretation of the data, noting that (1) the pre-mining values for the Upper Brule Aquifer are based on a limited data set from private wells surrounding the License Area; and (2) there is minimal information regarding the depth and construction of some of the subject wells.[507] Crow Butte's witnesses further testified that, because deeper screened private wells can have water levels that are significantly different from water levels measured in shallow wells, the differences in water levels that Intervenors noted should not be misinterpreted as representing significant changes in potentiometric head (i.e., the vertical distance that a groundwater level will rise above a selected elevation) over time when compared with more recent water levels from shallow wells screened in consistent locations.[508] Crow Butte's witnesses concluded that Crow Butte's bi-weekly readings are far more reliable for a consistent comparison of water levels at a particular point over time.[509]

The NRC Staff's witnesses also disputed Dr. Kreamer's and Mr. Wireman's interpretation of Well #11 water level readings by asserting that the pre-mining data for Well #11

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[505] Ex. BRD-008A is an annotated version of LRA, fig. 2.7-3a, at 2-173. See Ex. BRD-008A, Crow Butte Resources, Inc., Annotated Figure 2.7-3a, Regional Water Level Map Brule Formation 1982–1983 (undated).

[506] Tr. at 1786–88.

[507] Ex. CBR-067 at 6.

[508] Id.

[509] Id.

(set forth in Table 2.7-5 of the LRA),[510] consists of 12 water level measurements collected between January and December 1982, and that those measurements vary only between 3,830 and 3,834 feet.[511] From this, the NRC Staff's witnesses opined that the water level of 3,883.7 feet assigned to Well #11 (shown in Figure 2.7-3a of Ex. BRD-008A) is almost certainly a transposition error (i.e., the correct value is likely 3,838.7 feet, which would be an elevation consistent with water level readings throughout the 11 years of data presented in LRA Table 2.7-5).[512] The NRC Staff's witnesses stated that their hypothesis of a transposition error for Well #11 is further supported by the average hydrograph reading for SM7-22[513] (i.e., the well closest to Well #11), which is about 3,844 feet (i.e., nearly identical to the likely transposed, water level of 3,838.7 feet for Well #11).[514]

Even though there is sparse pre-mining data, the NRC Staff's witnesses compared Crow Butte's data for two other well pairs to test whether the Upper Brule Aquifer has been impacted by mining activities.[515] The first well pair concerns Well #27 (water level: 3,808.2 feet)[516] and nearby Well #5-30 (water level: 3,806.3 feet), which closely matches the 2008 contour intervals in this same area.[517] The second well pair concerns PM-6 and PM-7. For this well pair, the

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[510] LRA, tbl. 2.7-5, at 2-197.

[511] Ex. NRC-095 at 3.

[512] Id.

[513] See Ex. CBR-064.

[514] Ex. NRC-095 at 3 (citing Ex. BRD-008B, Crow Butte Resources, Inc., Annotated Figure 2.7-3b, Current License Area Water Level Map – Brule Formation (2008)).

[515] Id.

[516] Ex. NRC-096-R, Crow Butte Resources, Inc., Annotated Figure 2.7-3a, Regional Water Level Map Brule Formation 1982–1983 (undated) & Annotated Figure 2.7-3b, Current License Area Water Level Map – Brule Formation (2008) at 1 (Well #27 is indicated by the green box on page 1 of this exhibit).

[517] Id. at 2 (Well #5-30 is indicated by the green box on page 2 of Ex. NRC-096-R).

NRC Staff's witnesses compared the pre-mining water levels recorded in each well for Crow Butte's first pumping test.[518] They noted that these 1983 values (i.e., 3,843.5 feet for PM-6 and 3,845.9 feet for PM-7)[519] were very similar to the 2008 elevations measured in the same area.[520] In addition, the NRC Staff's witnesses opined that Crow Butte's mining had not affected the Upper Brule Aquifer[521] because its water level measured in 2008[522] at the location for well BMW-1[523] was very similar to the pre-mining level measured immediately before Crow Butte initiated Aquifer Test #2 in 1987.[524] In the opinion of the NRC Staff's witnesses, these data demonstrate that Crow Butte's mining activities have not impacted water levels in the Upper Brule Aquifer and that this aquifer is hydraulically isolated from the Ore Zone in the BC/CPF Aquifer within the License Area.[525]

In his testimony, Mr. Wireman claimed that groundwater levels in the Upper Brule Aquifer have not been adequately monitored to determine if there is a long-term trend of water levels declining as a result of lowering the potentiometric surface of the underlying BC/CPF Aquifer.[526] Crow Butte's witnesses disputed Mr. Wireman's allegations, claiming that, from the time it commenced mining operations in the License Area, Crow Butte has maintained more

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[518] See Ex. NRC-103 at 3.

[519] Ex. BRD-002A at 2.7A(5).

[520] See Ex. NRC-096-R at 2 (relevant area indicated by magenta circle, which is the NRC Staff's annotation of Ex. BRD-008B); see also Ex. NRC-095 at 30.

[521] Ex. NRC-103 at 3.

[522] Ex. NRC-104, Crow Butte Resources, Inc., Annotated Figure 2.7-3a, Regional Water Level Map Brule Formation 1982–1983 at 2 (undated).

[523] Id.

[524] See Ex. BRD-002B-R.

[525] Ex. NRC-095 at 5; Ex. NRC-103 at 3.

[526] Ex. INT-081 at 1.

than 200 shallow monitoring wells in the Upper Brule Aquifer[527] and has collected water level data every two weeks from each such well.[528] Moreover, in accordance with its NDEQ Class III UIC permit, Crow Butte has collected groundwater monitoring data before it commenced mining, during its mining operations, and during its restoration of each mine unit.[529] While Mr. Wireman maintained that there have been far too few monitoring wells measured to detect long-term water level trends in the Upper Brule Aquifer,[530] he did not explain why Crow Butte's 200 wells have been insufficient, nor did he point to any other specific inadequacies in Crow Butte's program.

2. Board Findings on the Integrity of the UCU

In regards to the integrity of the UCU, we make findings on the three major topics raised by Intervenors: (1) whether lineaments are associated with the fracturing of the UCU; (2) whether secondary porosity and increased communication through the UCU are associated with fracturing; and (3) whether changes in the groundwater levels in the Upper Brule Aquifer are associated with pumping from mining operations, and concomitantly, whether this is an indicator of degraded confinement provided by the UCU.

a. Board Findings on Lineaments

Intervenors' evidence regarding mapped lineaments within the License Area was not contested by witnesses for Crow Butte or the NRC Staff, and we accept it as establishing that lineaments exist the region that encompasses the License Area. The issue posed by this contention, however, is not whether these lineaments exist, but rather whether such lineaments were caused by a fracture and whether those lineaments are transmissive. In this regard, there

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[527] Ex. CBR-074 at 5.

[528] Id.

[529] Ex. CBR-001 at 34–35.

[530] Ex. INT-081 at 1.

is no credible record evidence that that these mapped lineaments are transmissive—as fracturing is only one of the many potential reasons for the presence of these straight-lined features. As Dr. LaGarry agreed, his aerial photographic interpretation technique is not a conclusive indication of fracturing in the License Area because it was not accompanied either by field-verification through visual observation of stratigraphic outcrops or by geologic explorations.[531] Accordingly, we find that whether lineaments within the License Area are a result of geologic fracturing and whether these fractures are transmissive will be inferred by the actual confinement characteristics of the UCU, which is discussed in the immediately succeeding section.

b. Board Findings on Secondary Porosity/Permeability from Fracturing

We find that there is no record evidence of fractures in the UCU within the License Area that are sufficiently significant to impair the confinement properties of the UCU. Intervenors offered evidence of such fracturing only in outcrops distant from the License Area. In contradistinction to this, we find that the borehole analyses by Crow Butte establish the absence of transmissive fractures in the UCU within the License Area.

In addition, we find that there is sufficient evidence to demonstrate that the UCU provides adequate confinement of the BC/CPF within the License Area. This evidence includes our evaluation of (1) the results of Crow Butte's aquifer pumping tests;[532] (2) geophysical data, geological descriptions, particle size distribution testing, soil mineralogy, and soil core permeability testing from UCU samples obtained from the boreholes made for installation of the piezometers in the UCU and LCU during pumping test #2;[533] and (3) geochemical data, hydraulic gradients, and operations data from the network of monitoring wells installed by Crow

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531 Ex. INT-043 at 2; Tr. at 1175-79.

532 Supra § III.C.2, Board Findings on Aquifer Pumping Tests at 73–75.

533 Ex. BRD-002B-R at 2.7-17, 2.7-24.

Butte. As a result, we find that the geochemical data indicates the groundwater in the Upper Brule Aquifer and the BC/CPF Aquifer are different. Likewise, we find that the groundwater potentiometric data indicates that there is hydraulic isolation of the BC/CPF from the Upper Brule Formation. Additionally, we find that, during Crow Butte's mining and restoration operations, vertical groundwater gradients are downward, thus preventing the migration of groundwater from the BC/CPF Aquifer upward into the Upper Brule Aquifer.[534] We find that this overwhelming evidence also includes (1) the presence of a thick layer of low permeability clay/claystone within the UCU; (2) the lack of drawdown in the Upper Brule Aquifer during pumping tests; (3) historic and current differences in the potentiometric surface behaviors/responses of the BC/CPF and the Upper Brule aquifers; (4) unique stable signatures of water quality between the BC/CPF and the Upper Brule Aquifer; and (5) lack of data to suggest there has been any impact on the Upper Brule Aquifer water quality that would be associated with leakage from the BC/CPF, despite over 20 years of monitoring data from Crow Butte's excursion monitoring wells and from nearby private wells.[535]

We find that Intervenors' claims are largely suppositions based on regional geology with no specific indications from on-site data to support their interpretation that fracturing caused any lineaments that may be present within the License Area. We further find that Intervenors failed to counter record evidence offered by the NRC Staff and Crow Butte that demonstrated the absence of such features at the License Area. In contrast, based on the NRC Staff's and Crow Butte's description of the cuttings and geophysical surveys, which Intervenors did not dispute, we find that, even if such cracks are present, either the plastic, non-lithified strata would tend to heal by the nature of the swelling clays or any openings that briefly arose would quickly close

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[534] Ex. CBR-045 at 21–22; Tr. at 1236–38.

[535] Ex. NRC-001-R at 28.

due to the high vertical stresses from the weight of 130 to 480 feet of overburden layers.[536] Accordingly, we find that the geologic conditions in the License Area support the lack of transmissive fractures in the UCU there.

Intervenors' witnesses also testified that "the nature of the sedimentary rocks in this region is such that they may be loosely consolidated, poorly indurated, and in places one can work them with one's hands," and are not composed of brittle material that is susceptible to fracturing.[537] Where this soil-like condition exists, the Board finds it is unlikely that the UCU is sufficiently fractured to transmit significant quantities of liquids that could produce adverse impacts to groundwater quality. In those zones where the UCU is harder, and hence sufficiently brittle to fracture, it is still unlikely that large quantities of liquid could be transmitted because, as mentioned, the applied stress from the overburden material and the high content of active clays present in the strata would help heal any such fractures.

c. Board Findings on Brule Aquifer Water Levels during Mining

While Crow Butte's 1983 water level contour map for the Upper Brule Aquifer was based on relatively sparse pre-operational data,[538] we find that there now is sufficient water level data covering the mining and restoration periods in the License Area to justify the EA's conclusion that Crow Butte's mining operations within the License Area have not caused a lowering of the potentiometric levels in the Upper Brule Aquifer.[539]

In particular, Crow Butte has maintained over 200 monitoring wells in the Upper Brule Aquifer and has monitored them every two weeks while wells in each of its mine units are

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[536] EA § 3.4.1.6 at 39; Ex. CBR-001 at 21.

[537] Tr. at 1035.

[538] See LRA, fig. 2.7-3a, at 2-173.

[539] EA § 4.6.2.2.1 at 88; id. § 4.13.6.2.2 at 130; id. § 4.13.6.2.3 at 132

operating.[540] This plethora of available water level data shows that there has been little drawdown in the Upper Brule Aquifer from the time mining operations began at the License Area.[541] We find that the data from these monitoring wells demonstrates Crow Butte's mining and restoration operations are not having an effect on the water levels of the Upper Brule Aquifer because there has been no sustained downward trend in water levels in the Upper Brule Aquifer that can be correlated to Crow Butte's drawdown of the underlying BC/CPF Aquifer. While Intervenors have called for more wells, and we do not dispute that additional monitoring wells might yield useful information about long-term water level trends in the Brule Aquifer, there is no record evidence establishing that that the absence of such additional monitoring wells renders the EA's water-level findings deficient.

Insofar as Intervenors' witnesses presented data to suggest there had been some lowering of the Upper Brule Aquifer water levels during the past 20-plus years, none of that data is necessarily tied to Crow Butte's mining operations in the License Area. For instance, Mr. Wireman claimed that since Crow Butte began mining operations, there had been a 40-foot drop in the Brule water levels.[542] Upon closer examination, however, it becomes clear that Mr. Wireman's claim was based on one data point that was almost certainly the result of a transposition error[543]—an explanation that Intervenors conceded was a reasonable possibility.[544] Similarly, while Dr. Kreamer asserted that numerous wells showed drawdown in the Upper Brule Aquifer in the period beginning with Crow Butte's preoperational levels in 1982 up through its

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[540] Ex. CBR-001 at 36; Ex. CBR-074 at 5.

[541] Ex. CBR-067 at 6; Ex. CBR-074 at 5; see also EA § 3.5.2.3.1 at 50–51; LRA, fig. 2.7-8, at 2-203.

[542] Tr. at 1798.

[543] Tr. at 1983–94.

[544] Tr. at 2437–38.

operational levels in 2008,[545] Intervenors' witness did not supply any plausible analysis either that an actual drawdown exists or that Crow Butte's mining operations in the License Area have caused or contributed to any such drawdown in these wells.[546] We also find that Intervenors' witnesses' interpolations of contour maps presented in conjunction with their testimony are insufficiently precise for reasonably estimating drawdown by comparing water levels at selected time intervals. Instead, we find that a far more accurate method of measuring drawdown (and hence, of demonstrating upper aquifer behavior) is to use the actual levels that Crow Butte recorded in individual monitoring wells. And, we find that the actual recorded levels of the individual wells confirms the EA's assertion that there has been no drawdown in the Upper Brule Aquifer due to Crow Butte's pumping from the BC/CPF Aquifer during its mining operations.

In summary, we find there is no credible evidence that the water levels in the Upper Brule Aquifer have dropped significantly during the more than 20 years of Crow Butte's mining operations at the License Area, much less that such mining operations have impacted those water levels.

E. Operational Groundwater Quality Impacts

Groundwater impacts can occur from spills and leaks seeping into the ground, from vertical and horizontal excursions of mining liquids, and from excessive consumptive use of aquifer resources.[547] Crow Butte's groundwater monitoring includes excursion monitoring for each mine unit. It also includes regional monitoring to ensure that Crow Butte's mining operations do not adversely impact private groundwater use surrounding the License Area.[548]

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[545] Ex. INT-079 at 10.

[546] Tr. at 2557.

[547] EA § 4.6.2.2 at 87.

[548] Id. § 4.6.2.2.4 at 91; id. § 4.6.2.2.6 at 94.

We discuss immediately below the impacts from excursions, including the monitoring, controls, and corrective measures that Crow Butte has implemented to minimize potential impacts to private groundwater wells. In subsequent sections of this Partial Initial Decision, we address the potential impacts from spills and leaks on surface water features (in conjunction with our resolution of Contention C),[549] as well as the potential impacts on aquifer water levels and water quality from consumptive use (in our resolution of Contentions 6 and 9).[550]

1. Parties' Positions on Operational Groundwater Impacts

a. Parties' Positions on Operational Groundwater Impacts from Excursions

i-1. Excursion Control and Monitoring

During mining operations, excursions of lixiviant and processing liquids may occur either vertically from breaches in the UCU or horizontally from processing liquids escaping the mine unit wellfields. The EA as well as the NRC Staff's witnesses' testimony, maintains that, because the UCU separating the BC/CPF Aquifer and the Upper Brule Aquifer is composed of a thick competent sequence of low permeability clays, mudstones, and siltstones, the integrity of the UCU[551] mitigates the possibility of vertical migration up through the UCU.[552]

As for horizontal excursions, Crow Butte's witnesses testified that its mining operations include the development of inward gradients to help assure that all mining liquids are collected and pumped to Crow Butte's on-site processing plant.[553] To verify field performance during

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[549] See infra § IV.B.2.a, Board Findings on Operational Surface Water Impacts and Monitoring at 154–57.

[550] See infra § IV.E.2, Board Findings on Short-Term NEPA Impacts from Consumptive Groundwater Use During Restoration at 186–87; § IV.F.2, Board Findings on Failure to Address Groundwater Restoration Mitigation Measures at 197–201.

[551] We have previously discussed the integrity of the UCU at supra § III.D, Integrity of the UCU at 75–100.

[552] Ex. NRC-001-R at 22 (citing EA § 3.5.2.3.2 at 51).

[553] Ex. CBR-001 at 41–42.

operation, Crow Butte has established a wellfield monitoring program to detect and correct an excursion, as required by License Condition 11.5.[554]

Based on the potential for groundwater impacts from excursions of mining liquids beyond the operating wellfield within the License Area, whether horizontally within the BC/CPF or vertically into the Upper Brule Aquifer, Crow Butte's witnesses stated that Crow Butte developed a groundwater monitoring program to identify potential impacts to groundwater resources, not only in the License Area, but also in the 19 private wells that are within a one-mile radius of the perimeter of the License Area.[555] This groundwater monitoring program was designed to (1) establish the baseline water quality of monitoring wells prior to mining at each unit; (2) detect excursions of lixiviant either horizontally or vertically outside of the Ore Zone within the License Area; and (3) determine when the BC/CPF Aquifer (which includes the Ore Zone) has been adequately restored following mining.[556]

Crow Butte's witnesses testified that, in order to limit the potential for these inadvertent releases, Crow Butte monitored for several parameters: production, injection rates, injection volumes, wellhead pressure, water levels, and water quality.[557] They also testified that Crow Butte's mining operation employs an injection well and production well pattern that creates local flow toward the production wells with relatively little flow across the mined area or toward the

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[554] EA § 4.6.2.2.4 at 91; Ex. NRC-012 at 12 (License Condition 11.5).

[555] Ex. CBR-001 at 34; see also EA § 4.6.2.2.6 at 94. We note that the required radial distance for private well sampling varied from one kilometer (as described in Crow Butte's testimony, Ex. CBR-001 at 42; Tr. at 1685, and in SER § 5.7.9.3.3 at 147), to one mile (as described in the EA § 4.6.2.2.6 at 94). But, as our decision does not hinge on either distance, this discrepancy need not be resolved here.

[556] Ex. CBR-001 at 34–35; EA § 4.6.2.2.6 at 94.

[557] Ex. CBR-001 at 36.

ring of monitoring wells that surround the mining operation.[558] Specifically, they asserted that there is a greater volume of liquids (i.e., "bleed" water consisting of leach solution and native groundwater) extracted from the mine unit than the volume of leach solution that is injected into the Ore Zone.[559] This, in turn, they asserted, creates a typical bleed water of 0.5 to 1.5 percent during production, which causes an inflow of groundwater into the production area and prevents loss of the leach solution.[560]

Crow Butte's witnesses further testified that, in order to detect the migration of mining solutions from the production area, Crow Butte encircled each production zone with monitoring wells that are screened across the entire interval of the ore-bearing BC/CPF Aquifer and in the first overlying aquifer above each wellfield segment (i.e., the Upper Brule Aquifer).[561] Crow Butte's Class III UIC permit[562] requires that each production zone's monitoring wells that are set in the BC/CPF Aquifer must be spaced no more than 300 feet from a mine unit, and with no more than 400 feet between the wells, so as to detect horizontal excursions.[563] For detecting vertical excursions into the Upper Brule Aquifer, shallow monitoring wells were installed in this aquifer—one well for every four acres of each mine unit.[564] Sampling of these wells is done on a bi-weekly basis for excursion indicators that include chloride, total alkalinity, and conductivity.[565] To the extent that Crow Butte's sampling indicates an increase in the

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[558] Id. at 41.

[559] Id. at 36–37.

[560] Id.

[561] Id. at 41–42; Tr. at 1030.

[562] Ex. CBR-001 at 35 (citing Ex. CBR-017).

[563] Ex. CBR-017 at 16.

[564] EA § 4.6.2.2.4 at 91–92; Ex. CBR-001 at 36; Ex. CBR-074 at 5.

[565] EA § 4.6.2.2.4 at 91.

concentrations of these constituents, witnesses for both Crow Butte and the NRC Staff asserted that these parameters provide an early warning of the movement of process liquids away from the wellfield and enable Crow Butte to initiate corrective actions to draw process liquids back into the wellfields prior to any lixiviant leaving the mine area.[566]

The NRC's upper control limits (UCLs) for chloride, conductivity, and total alkalinity are set at 20 percent above the maximum baseline concentration for each of these indicator parameters (unless the baseline average is below 50 milligrams per liter (mg/L), in which case Crow Butte can use alternative methods).[567] During routine sampling, if two of the three constituents exceed the UCLs in a given monitoring well, or if one constituent exceeds the UCL by more than 20 percent, that well must be resampled within 48 hours and analyzed again.[568] If the second sample does not exceed the UCLs, a third sample is taken within 48 hours, and if the limit continues to be exceeded, Crow Butte is obligated to implement corrective actions.[569] In conjunction with our resolution of Contention A, we address whether these three excursion indicators are adequate, or whether Crow Butte should also be required to test for uranium. For now, we simply note that Crow Butte's witnesses claimed Crow Butte's past experience at ISL mining facilities has shown that using these three excursion indicators with this monitoring system is effective in detecting leachate migration.[570]

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[566] Ex. NRC-076-R2 at 5–6; Ex. CBR-001 at 37.

[567] Ex. CBR-001 at 37.

[568] Id. at 37–40. In their testimony, witnesses for the NRC Staff discussed in greater detail the requirements for a monitoring well ring's location (License Condition 10.4) and for Crow Butte's bi-weekly sampling and other excursion monitoring procedures (LRA § 5.8.8.2). See Ex. NRC-001-R at 5–6.

[569] Ex. CBR-001 at 39–40.

[570] Id. at 41.

i-2. Excursion Corrective Actions

The NRC Staff's witnesses testified that, in the event one or more of Crow Butte's UCLs are exceeded, License Condition 11.5 requires Crow Butte to place that well on excursion status, to notify the NRC, to begin corrective action, and to increase the sampling frequency for the indicator parameters at the excursion well (from bi-weekly to once every seven days) to ensure that the excursion is expeditiously corrected.[571] Crow Butte is required to take a number of additional corrective actions including (1) completing a preliminary investigation to determine the probable cause of the excursion; (2) adjusting production and/or injection rates in the vicinity of the monitoring well to increase inward groundwater flow toward the production zone; (3) pumping individual wells to enhance recovery of mining solutions; and (4) suspending injection of lixiviant into the wellfield area adjacent to the monitoring well.[572] The NRC Staff considers an excursion concluded when the parameters drop below the target concentration levels for three consecutive weekly samples.[573] It is undisputed that Crow Butte's excursion monitoring program currently consists of bi-weekly sampling at 333 wells and weekly sampling at any wells that are on excursion status.[574]

i-3 Crow Butte's Documented Excursions

The NRC Staff's witnesses testified that, between 1995 and 2010, Crow Butte reported that 13 of its perimeter monitoring wells had been placed on excursion status (indicating horizontal excursions), and that it had experienced 16 vertical excursion status events in 12

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[571] Ex. NRC-001-R at 8–9 (citing EA § 4.6.2.2.4 at 91).

[572] Ex. CBR-001 at 40.

[573] Ex. NRC-012 at 12 (License Condition 11.5).

[574] SER § 5.7.9.3.2 at 142–43.

monitoring wells in the overlying aquifer.[575] The NRC Staff's witnesses stated that none of these excursions is known to have impacted the surrounding groundwater quality.[576]

Crow Butte attributed all but 1 of the 16 vertical excursion events in the overlying aquifer to natural fluctuations in water quality coincident with precipitation events.[577] Crow Butte's witnesses stated that the only exception involved a spill (though not an excursion) that Crow Butte corrected and remediated, asserting that Crow Butte has never had a vertical excursion of mining solution.[578] The EA states that all of Crow Butte's excursion events in the Upper Brule Aquifer were resolved within 90 days and without the need for corrective actions.[579] The NRC Staff's witnesses testified that "[a]ll of these excursions were corrected and no long term impacts were determined to have occurred,"[580] and that Crow Butte's "historical record of excursions demonstrates that adjustments in pumping and injection rates have successfully corrected excursions within the [License Area]."[581] The EA states that the NRC Staff agreed with Crow Butte that (1) excursions for monitoring wells in the Upper Brule Aquifer did not appear to result from the migration of lixiviant from the BC/CPF Aquifer; and (2) these excursions coincided with precipitation events.[582] To date, Crow Butte has not been required to take corrective actions for these wells.[583]

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[575] Ex. NRC-001-R at 10.

[576] Ex. NRC-001-R at 10–11, 13 (citing EA, tbl. 4-3, at 93; SER § 5.7.9.3.2 at 142).

[577] EA § 4.6.2.2.4 at 92.

[578] Ex. CBR-001 at 41.

[579] EA § 4.6.2.2.4 at 92.

[580] Ex. NRC-001-R at 20.

[581] Id. at 21.

[582] EA § 4.6.2.2.4 at 92.

[583] Id.

The NRC Staff's witnesses testified that Crow Butte's corrective actions for horizontal excursion monitored by the perimeter ring wells primarily consisted of adjusting extraction and injection rates near the excursion well to capture any outward flow.[584] These corrective actions were adequate in controlling the excursions in a timely manner for 9 of the 13 perimeter wells.[585] For three wells (PR-8, PR-15, and IJ-13) located in Mine Unit 1 (an inactive restored mine unit that is surrounded by subsequently activated mine units), the EA states that Crow Butte's corrective action proved less effective.[586] Crow Butte attributed the lower efficacy to the combined operation of bordering mine units, which caused liquids to be drawn into Mine Unit 1.[587] As for a fourth well (CM5-11), Crow Butte attributed its less effective corrective actions here to inefficiencies in corrective pumping due to differences in completion intervals of the perimeter well and the nearest production wells.[588] The EA concludes that Crow Butte's explanation for these well excursions is acceptable.[589]

Significantly, the EA states that none of these excursions impacted the surrounding groundwater quality.[590] Likewise, the SER states that, at the completion of operations, the groundwater in all mine units (which includes any groundwater contaminated at the mine unit monitoring wells) must be restored to applicable standards.[591]

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[584] Ex. NRC-001-R at 13.

[585] EA § 4.6.2.2.4 at 92.

[586] Id.; SER § 5.7.9.3.2 at 142–43.

[587] EA § 4.6.2.2.4 at 92; SER § 5.7.9.3.2 at 142–43.

[588] EA § 4.6.2.2.4 at 92; SER § 5.7.9.3.2 at 142–43.

[589] EA § 4.6.2.2.4 at 92; SER § 5.7.9.3.2 at 142–43.

[590] EA § 4.6.2.2.4 at 92.

[591] SER § 5.7.9.3.2 at 143.

With the exception of the one spill that was corrected and remediated, the EA questions whether the vertical excursion events in Mine Units 6 and 8 were caused by spills or by unintended releases of production liquids that then moved with groundwater pulses during precipitation events, thus affecting the water quality of the Upper Brule Aquifer.[592] The NRC Staff's witnesses testified that, because the continued number of vertical excursions in the Upper Brule Aquifer could not conclusively be attributed to natural fluctuations, the NRC Staff added a condition in Crow Butte's renewed license requiring Crow Butte to assess whether there is any impact to groundwater quality.[593] That condition requires Crow Butte to sample for natural uranium (in addition to the standard three indicator parameters) in Mine Units 6 and 8 whenever an overlying monitoring well in these units is placed on excursion status for more than 60 days.[594]

Even though some uncertainty remains as to the precise cause of the excursions at Mine Units 6 and 8, the EA concludes that the long-term impacts on groundwater from all excursions within the License Area will be SMALL.[595] This conclusion is based on the analysis of groundwater quality impacts from excursions in the prior license period and Crow Butte's continued obligations for excursion monitoring to detect and take corrective action to eliminate any excursions.[596]

b. Parties' Positions on Operational Groundwater Impacts to Private Wells

The EA states that Crow Butte "is required in its license to monitor ground water quality at water supply wells located within 1 mile [1.6 km] of a wellfield as part of the environmental

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[592] EA § 4.6.2.2.4 at 92 (citing SER § 5.7.9.4 at 149).

[593] Ex. NRC-012 at 14 (License Condition 11.12).

[594] Id.; see also Tr. at 1638 (correcting EA by dropping the requirement for radium testing).

[595] EA § 4.6.2.2.4 at 92.

[596] Id.

monitoring program" and that Crow Butte's program "monitored ground water quality at 19 water supply wells."[597] To establish baseline values, Crow Butte sampled these private water supply wells prior to starting its mining operations. While most of these water supply wells are placed in the Upper Brule Aquifer, one well is placed in the BC/CPF Aquifer.[598]

EA § 4.6.2.2.6 states that a review of groundwater monitoring data from private wells shows water quality has remained consistent with radiological background levels.[599] Additionally, the NRC Staff's witnesses testified that this data set did not indicate that mining liquid has migrated beyond the individual mine sites within the License Area.[600] The EA concludes there were no discernible trends in the monitoring data, which would indicate that there have not been any impacts from Crow Butte's mining operations.[601] Likewise, the EA states that these observed levels are both consistent with background levels and below established Federal groundwater quality standards.[602] In addition, with respect to those wells that Crow Butte screened in the Upper Brule Aquifer,[603] its data indicate that vertical excursions, spills, and leaks, as well as Crow Butte's facility operations, have not had an impact on the Upper Brule Aquifer.[604]

Intervenors' witness Mr. Wireman asserted that, because drawdown of an aquifer has the potential to affect the yield from other wells, there should be a BC/CPF monitoring well

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[597] Id. § 4.6.2.2.6 at 94 (citing Ex. NRC-012 at 14 (License Condition 11.13)).

[598] Ex. NRC-001-R at 20; SER § 5.7.9.3.3 at 147.

[599] EA § 4.6.2.2.6 at 94.

[600] Ex. NRC-001-R at 20.

[601] EA § 4.6.2.2.6 at 94.

[602] Id.

[603] SER § 5.7.9.3.3 at 147.

[604] Ex. NRC-001-R at 20.

located near Chadron to monitor the extent of any lowering of the potentiometric surface and that this data should be reported in the EA.[605] Crow Butte's witnesses disagreed, claiming that regional monitoring data is not conducted by Crow Butte, but rather by the Nebraska Water Resources District.[606] Moreover, they continued, the placement of BC/CPF regional monitoring wells near Chadron are not appropriate because the BC/CPF Aquifer is not present east of the License Area as it pinches out near the eastern boundary of the License Area and, as such, is not continuous from the License Area to Chadron.[607] The NRC Staff's witnesses agreed with this characterization, testifying that "[t]he city of Chadron is separated from the License Area by a distance of almost 20 miles. . . . [T]he [BC/CPF Aquifer] pinches out and is not present beyond about 5 miles north and east of Crawford, between the CBR [License Area] and the city of Chadron. Therefore, it is not possible or necessary to place a monitoring well in this aquifer near the city of Chadron."[608]

2. Board Findings on Operational Groundwater Impacts

a. Board Findings on Operational Groundwater Impacts from Excursions

Turning first to groundwater impacts from excursions, we find that the record evidence established that there were 333 wells monitored for excursions. Of these, 13 perimeter monitoring wells in the BC/CPF were placed on excursion status (indicating horizontal excursions), and 16 vertical excursion events were identified in 12 monitoring wells placed in the Upper Brule Aquifer.

We further find that, for the horizontal excursions detected by the perimeter monitoring wells in the BC/CPF, in most instances Crow Butte quickly detected each perimeter excursion

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[605] Ex. INT-047 at 6.

[606] Ex. CBR-045 at 34.

[607] Id.

[608] Ex. NRC-076-R2 at 65 (citing Ex. NRC-023).

and successfully controlled them by increasing pumping in the immediate vicinity of the excursion. We also find that, while there were four instances in which this process did not control the horizontal excursion in a timely manner, in no case did any excursion threaten the water quality of an underground source of drinking water. Further, Crow Butte is required to restore these wells to applicable standards during restoration.

As for the vertical excursion status events, we find that all but one were due to natural seasonal fluctuations in groundwater quality of the Upper Brule Aquifer,[609] and that the other vertical excursion status event was not actually an excursion, but rather was a spill that Crow Butte corrected and remediated.[610] Even though the NRC Staff's witnesses questioned whether natural seasonal fluctuations in groundwater quality of the Upper Brule Aquifer caused the vertical excursions, we find that there is no record evidence that the migration of lixiviant from the BC/CPF Aquifer caused these vertical excursion events. Rather, we find that these excursion events coincided with precipitation events, and that no corrective actions by Crow Butte have been required to date. We further find that Crow Butte's renewed license contains conditions (requiring additional testing for natural uranium when an overlying excursion monitoring well in Mine Unit 6 or Mine Unit 8 is placed on excursion status) that will ensure that Crow Butte addresses the cause of any such varying water quality data.[611]

For both vertical and horizontal excursions, we also find that the EA correctly concludes that Crow Butte satisfactorily addressed its excursions and that no long-term impacts have appeared to date. As a result, based on the EA's analysis of groundwater quality impacts from excursions in the prior license period and on Crow Butte's license condition requiring it to undertake excursion monitoring to detect and take corrective action to resolve any excursion,

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[609] Ex. CBR-001 at 40–41.

[610] Id.

[611] Ex. NRC-012 at 10 (License Condition 11.1).

we find that the EA correctly concludes that the long-term impacts on groundwater from excursions will be SMALL.

Despite the fact that excursions have occurred at the Crow Butte facility, we find that there is no evidence that those excursions resulted in the transport of contaminants outside of the License Area. This finding is supported by operational monitoring data collected during Crow Butte's mining operations that span more than 20 years. The total effect of: (1) the close proximity of the monitoring wells, (2) the low flow rate from the well field, and (3) the use of bleed water that removes more liquid from the aquifer than is reinjected, make it unlikely that there will be an undetected excursion.

b. Board Findings on Operational Groundwater Impacts to Private Wells

In regards to overall impacts on private wells from excursions, we find that the water quality monitoring data from private wells shows the groundwater contamination has not exceeded radiological background levels.[612] This data, in conjunction with the fact that all but one of the private wells are placed in the Upper Brule Aquifer,[613] also demonstrates that vertical excursions, spills, leaks and Crow Butte operations in general, have not adversely impacted the Upper Brule Aquifer.

F. Pathways for Contaminant Migration

Intervenors' witnesses opined that there were several pathways by which contaminated water could migrate from the License Area and ultimately impact drinking water wells on the PRIR, which are located approximately 50 miles northeast of the License Area. In his initial testimony, Dr. LaGarry stated that the primary pathway for contaminant migration would be

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[612] EA § 4.6.2.2.6 at 94.

[613] See SER § 5.7.9.3.3 at 147.

through fractures along the White River alluvium.[614] At the hearing, however, Dr. LaGarry raised the additional possibility that there is a northwest flow from the License Area to discharge points at BC/CPF outcrops in South Dakota, which could then flow southeast to the PRIR.[615] A third pathway, suggested in the testimony of Ms. Charmaine White Face, posits that mining contaminants could travel northeastward from the License Area to drinking water wells on the PRIR that draw from the Arikaree Formation.[616] Each of these three suggested pathways is analyzed below.

1. First Pathway: License Area to White River Feature to White River Alluvium

a. Parties' Positions on First Pathway: License Area to White River Feature to White River Alluvium

Dr. LaGarry testified that "the White River and its alluvium or a complex network of intersecting joints and faults were the most likely ways for contaminants to migrate from the Crow Butte Resources License Area to the [PRIR],"[617] and that "faults could potentially connect the uranium-bearing [BC/CPF] to the [White River alluvium], and connect the uranium-bearing [BC/CPF] to the overlying secondary porosity of the Brule Formation."[618] Based on this characterization, Dr. LaGarry maintained that Crow Butte's mining contaminants that reach the White River could be transmitted into areas where the alluvium intersects faults downstream from the city of Crawford.[619] Moreover, Dr. LaGarry continued, once such mining contaminants reached the White River alluvium, every rain event thereafter would push those contaminants a

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[614] Ex. INT-003 at 3.

[615] Tr. at 2582.

[616] Ex. OST-001 at 3–4.

[617] Ex. INT-080 at 6.

[618] Ex. INT-003 at 3.

[619] Id.

little bit further downstream.[620] Dr. LaGarry noted that, in the case of the White River, downstream is to the north-northeast and leads directly onto the PRIR.[621]

Although Dr. LaGarry posited that the White River alluvium could serve as a potential contaminant pathway, he was not able to identify instances in which uranium or other contaminants originating in individual mine sites within the License Area were actually found to be present in the White River alluvium. Crow Butte countered that it's sampling of English and Spring Creeks within the License Area (both of which are tributaries of the White River), as well as offsite sampling of the White River downstream of the License Area by NDEQ and the South Dakota Department of Environment and Natural Resources (SDDENR),[622] supports the position of both Crow Butte and the NRC Staff that Crow Butte's mining operations have not adversely affected the water quality of the White River.

While that data suggests the White River has not been impacted to date, Dr. LaGarry asserted that Crow Butte's mining contaminants have the potential to reach the White River alluvium via three mechanisms: (1) surface spills at the Crow Butte facility; (2) waters transmitted through the BC/CPF Aquifer where it is exposed at the land surface; and (3) water migrating through fractures in the UCU. And as noted above, Dr. LaGarry opined that if contaminants originating in the License Area were to enter the White River alluvium, they could

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[620] Id.

[621] Id. at 3–4.

[622] Ex. NRC-001-R at 25 (citing Ex. NRC-022, South Dakota Department of Environment and Natural Resources, The 2014 South Dakota Integrated Report for Surface Water Quality Assessment at 143 (Mar. 2014)); Ex. NRC-095 at 24; Ex. CBR-001 at 46.

migrate downstream in a north-northeast direction with every rain event and ultimately reach the PRIR.[623] We discuss each of these potential sources for alluvium contamination below.

i-1. Parties' Positions on Migration of Surface Spills and Leaks along the First Pathway

Initially, we note that witnesses for Intervenors, Crow Butte, and the NRC Staff all agreed that the groundwater flow in the Upper Brule Aquifer is to the northwest, towards the White River and its alluvium.[624] Moreover, Intervenors' and the NRC Staff's witnesses also agreed it is at least theoretically possible that uncontained spills and leaks could be transported through surface waters or could migrate over a distance of two miles through the shallow Upper Brule Aquifer.[625] Their agreement ends there, however. In particular, the NRC Staff's witnesses opined it is implausible that contaminants from uncontained spills and leaks could impact the White River alluvium because natural processes (e.g., dilution, sorption, precipitation) would so limit any potential impacts as to render them negligible.[626]

Spills and leaks from the License Area that could impact surface waters or shallow aquifers include leaks from exposed or buried piping, well casing failures, leaks or overflows from evaporation ponds, and vertical excursions. The EA states that, in order to prevent surface water impacts, Crow Butte implemented its Spill Prevention, Control, and Countermeasure (SPCC) Plan.[627] That SPCC Plan contains a number of controls, including dikes and berms to prevent spilled process solutions from entering surface water features.[628] As discussed later in

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[623] Ex. INT-003 at 3.

[624] Tr. at 2465–67.

[625] Tr. at 2582–83; Ex. NRC-001-R at 17.

[626] Ex. NRC-001-R at 17.

[627] EA § 4.6.1.2 at 83.

[628] <u>Id.</u>

this Partial Initial Decision,[629] Crow Butte's SPCC Plan also includes procedures for investigating and reporting spills and leaks, spill response, and cleanup measures.[630] Based on these measures, the EA concludes that the impact from any such spills and leaks will be SMALL.[631]

i-2. Parties' Positions on BC/CPF Aquifer Outcrops for First Pathway

Dr. LaGarry suggested this first pathway might have another potential source for migration of Crow Butte's mining contaminants: excursions reaching the White River through the BC/CPF Aquifer where it is exposed at the surface.[632] In this scenario, production liquids would migrate away from the License Area through the BC/CPF Aquifer to areas where that aquifer outcrops approximately 12 to 15 miles north of Crawford.[633] But Dr. LaGarry's testimony did not identify any places where the BC/CPF is exposed at the surface in the License Area or where it connects to alluvium along White Clay Creek, Squaw Creek, English Creek or the White River.

In disputing Dr. LaGarry's characterization, the NRC Staff's witnesses testified that "[a]s demonstrated in the cross sections provided in Figures 2.6-4 through 2.6-11 of the LRA, the [BC/CPF Aquifer] does not outcrop anywhere in the [License Area] or in the proposed NTEA site northwest of the [License Area]."[634] They also testified that these cross sections indicate the

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629 See infra § IV.B.1.c, Parties' Position on Spill Prevention, Control, and Countermeasure Plan at 150–52; § IV.B.2.a, Board Findings on Operational Surface Water Impacts and Monitoring at 160–61.

630 EA § 4.6.1.2 at 83.

631 Id. § 4.6.1.2 at 85; see infra § IV.B.1.b, Parties' Positions on Origins of Spills and Leaks at 143–45; § IV.B.1.e, Parties' Positions on Operational Groundwater Impacts from Spills and Leaks at 149–53; § IV.B.2.a, Board Findings on Operational Surface Water Impacts and Monitoring at 154–57; § IV.B.2.b, Board Findings on Operational Groundwater Impacts from Surface Spills and Leaks at 157–60.

632 Ex. INT-003 at 3.

633 Tr. at 1076.

634 Ex. NRC-001-R at 20–21 (citing LRA, fig. 2.6-4 to 2.6-11, at 2-111–25).

BC/CPF Aquifer is located 200 to 700 feet below the ground surface (Dr. LaGarry agrees that this depth is correct).[635] In addition, the NRC Staff's witnesses maintained that the only outcrops of the BC/CPF Aquifer are located near Horn, Nebraska, which is approximately 12 miles northwest of both the city of Crawford and of the White River alluvium.[636] As a result, it was the NRC Staff's witnesses' opinion that there is no plausible pathway through an outcrop of the BC/CPF Aquifer within or near the License Area to the White River alluvium.[637]

As another measure to help prevent processing liquids from migrating offsite through the BC/CPF Aquifer, Crow Butte's renewed license (License Condition 10.7) requires Crow Butte to maintain an inward hydraulic gradient in each mine unit until restoration of it is complete[638] (which as we noted earlier, draws groundwater toward the interior of each mine unit within the License Area).[639] In addition, its renewed license (License Condition 11.5) requires Crow Butte to monitor a ring of perimeter wells screened in the BC/CPF Aquifer to detect horizontal excursions and, if any such excursions are detected, to adjust its extraction and injection rates in the mining wellfield to draw liquids back in.[640] In their testimony, the NRC Staff's witnesses indicated that this procedure successfully corrected Crow Butte's excursions during its previous mining operations within the License Area.[641]

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[635] Id.; Tr. at 1075.

[636] Ex. NRC-001-R at 20–21; Tr. at 1076.

[637] Ex. NRC-001-R at 21

[638] Ex. NRC-012 at 8 (License Condition 10.7).

[639] EA § 4.6.2.2.1 at 87–88; Ex. NRC-001-R at 21.

[640] Ex. NRC-012 at 12 (License Condition 11.5).

[641] Ex. NRC-001-R at 20.

Crow Butte's witnesses testified that, based on the cross-sections in the LRA showing potentiometric surfaces, there is currently no artesian flow in the License Area.[642] Dr. LaGarry did not dispute this point during the hearing.[643] This absence of artesian flow is also supported by the potentiometric surface of the Upper Brule Aquifer being significantly higher than that of the BC/CPF Aquifer throughout the License Area.[644] Thus, even were this pathway to arise, these higher water levels of the Upper Brule Aquifer would preclude upward flow from the BC/CPF Aquifer within the License Area.[645]

Crow Butte's witnesses estimated that "[b]ased on our experience, as well as on groundwater modeling of the site, the movement of fluids at the edges of the operating wellfields typically ranges from 5 to15 feet per month."[646] Even if migration were to occur, the NRC Staff's witnesses testified that, at this rate, it would take hundreds of years for water from the Ore Zone to reach the White River Feature, and many more hundreds of years for it to reach the outcrops of the BC/CPF that are located to the north.[647]

i-3. Parties' Positions on Fractures in the UCU for First Pathway

Dr. LaGarry's third potential source for contaminant migration involved fractures in the UCU that he asserted are ubiquitous in the region,[648] and that would permit both vertical flow up to the Upper Brule Aquifer and then horizontal flow along the groundwater gradient

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[642] Tr. at 1047–48.

[643] Tr. at 1049.

[644] Ex. CBR-062, Crow Butte Resources, Inc., Current License Area Potentiometric Surface – Basal Chadron Sandstone, fig. 2.7-4d (2009); see also LRA, fig. 2.7-4d, at 2-189.

[645] Tr. at 1435–36, 2477.

[646] Ex. CBR-001 at 38–39.

[647] Ex. NRC-095 at 22–23.

[648] Ex. INT-013 at 3.

northeastward towards the PRIR[649] (in a fashion similar to the one suggested by Ms. White Face, discussed below).[650] In support of this characterization, Dr. LaGarry noted that, in 2007, Chadron Creek went dry for the first time in its known history.[651] Thereafter, a study was conducted of the creek's water flow rates, and it suggested that, even though normal amounts of water were flowing from the springs, this water was disappearing into deeper alluviums or into fractures in the rock.[652] From this, Dr. LaGarry opined that faults in the License Area may be transmitting contaminated liquids between and around monitoring wells, which, in turn, would enable water containing these contaminants to enter the White River, which would then be taken directly to the PRIR.[653]

While the NRC Staff's witnesses did not dispute Dr. LaGarry's suggestion that there are fractures and joints in northwestern Nebraska, they noted that there is no site-specific data indicating the presence of significant faults, fractures, or joints connecting the confining layers within the License Area.[654]

b. Board Findings on the First Pathway: License Area to White River Feature to White River Alluvium

Based on the record evidence, we find there is no basis to conclude that contaminants from the License Area (from spills, leaks, discharges from BC/CPF outcrops, or migration through fractures) could reach the White River Feature or the White River alluvium through this pathway. Intervenors have not demonstrated a reasonable likelihood of a hydraulic connection between the BC/CPF Aquifer and the White River environment (i.e., the White River Feature,

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[649] Ex. INT-003 at 3.

[650] Infra § III.F.2, Second Pathway: Northeasterly Flow to the PRIR at 123–31.

[651] Ex. INT-003 at 1.

[652] Id.

[653] Tr. at 2583–84.

[654] Ex. NRC-001-R at 34.

White River alluvium, or the White River itself). This finding is supported by record evidence demonstrating that the UCU is not sufficiently fractured in the License Area to enable such communication between the BC/CPF Aquifer and the White River alluvium.

But, even if the UCU were fractured, Crow Butte's renewed license requires it to maintain an inward hydraulic gradient and to monitor for, and correct, excursions. Given that Crow Butte has demonstrated it can timely identify and correct excursions, we also find that it is unlikely for contaminants to reach the White River environment by this pathway, especially since there is no evidence of outcrops of the BC/CPF Aquifer anywhere near the White River in the vicinity of the License Area. We further find there is no evidence that contaminants from Crow Butte's mining operations have impacted the White River water quality, based on both Crow Butte's on-site sampling of English and Spring Creeks, and the off-site monitoring of the White River by NDEQ and SDDENR.

As described in the EA, and as reflected in testimony during the hearing,[655] there is adequate record evidence establishing that Crow Butte has implemented appropriate controls and procedures for investigating and responding to spills and leaks, including its SPCC Plan, and that it has satisfactorily mitigated the impacts of any spills experienced to date. The EA discusses both the comprehensive engineering and the administrative controls of Crow Butte's SPCC Plan.[656] Likewise, the EA states that sampling of surface waters and sediments within the License Area, as well as of the nearby offsite private water wells, yielded no evidence of contamination.[657]

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[655] Tr. at 1529–42, 1548–50, 1555–62, 1565–66, 1619–23, 1810–15; see also infra § IV.B.1.c, Parties' Positions on Spill Prevention, Control, and Countermeasure Plan at 145–46; § IV.B.2.a, Board Findings on Operational Surface Water Impacts at 154–57.

[657] See EA § 4.6.1.2 at 83–85; id. § 4.13.6.12 at 127; id. § 4.13.6.2.2 at 130–31.

While Dr. LaGarry claimed that artesian flow could transmit contaminated water to the land surface and then into the White River alluvium, we find that, due to Crow Butte's inward gradients maintained during mining and restoration activities, there is no evidence of any such artesian conditions in the License Area. We further find that, even if such a pathway existed, because the potentiometric surface of the Upper Brule Aquifer is significantly higher than that of the BC/CPF Aquifer throughout the License Area, there can be no upward flow.[658] For these reasons, we find that artesian flow from the BC/CPF is not a credible pathway for potential contaminants from the License Area to reach surface waters. Although Dr. LaGarry also noted that, in 2007, Chadron Creek went dry for the first time in history, the difficulty with this explanation is that: (1) the point at which Chadron Creek went dry lies more than 25 miles from the License Area; and (2) Dr. LaGarry could provide no meaningful support either for the presence of similar fractured flow in the License Area or for how any such fractured flow is connected to the BC/CPF Aquifer.[659]

In summary, we find that, other than the White River Feature,[660] there is no evidence of specific, field-verified fractures or folds in the License Area. We agree with Intervenors that faults are common in the region, and certainly do not rule out the presence of isolated small faults or fractures in either the Lower Brule Formation or the Upper and Middle Chadron Formations within the License Area. Nonetheless, based on the undisputed evidence of confinement of the BC/CPF Aquifer, we find it highly unlikely that the License Area contains a fault or a connected pathway of faults in the UCU, that is capable of transmitting contaminants

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[658] Tr. at 1435–36, 2477.

[659] Tr. at 2583–84; see also EA § 3.6.1 at 54; Ex. INT-013 at 3.

[660] We have previously found that the White River Feature is most likely a fault, and is unlikely to show any propensity to act as a permeable conduit for the transport of contaminants from the License Area to the PRIR. See supra § III.B.2, Board Findings on the Structure of the White River Feature at 50–53.

from the License Area to the White River Feature or its alluvium, much less to the surface waters of the White River. Although Intervenors' witnesses posited that the White River alluvium could serve as a potential contaminant pathway, there is no record evidence establishing that uranium, or any other contaminant from the License Area, is in fact present in the White River alluvium.

2. Second Pathway: Northeasterly Flow to the PRIR

a. Parties' Positions on Second Pathway: Northeasterly Flow to the PRIR

i-1 Parties' Positions on Northeasterly Flow for Second Pathway

Intervenors' witness, Charmaine White Face, testified that radioactivity detected on the PRIR in wells set in the Arikaree Aquifer originated from Crow Butte's mining activities on the License Area.[661] She opined that contaminants from Crow Butte's mining operations traveled northeasterly through fractures in individual mine sites within the License Area as a result of the hydraulic pull of wells that are installed in the Arikaree Formation on the PRIR.[662] Dr. LaGarry also supported this potential pathway suggested by Ms. White Face, stating that once such contaminants reached any unspecified fractures, they could migrate with the groundwater northeastwardly towards the PRIR.[663] Dr. LaGarry further opined that uranium could be drawn upwards into parts of the High Plains Aquifer (e.g., the Ogallala and Arikaree Aquifers) by high capacity irrigation wells.[664]

In support of her position, Ms. White Face testified that "the direction of flow within the Arikaree [A]quifer, and the number of excursions from the Crow Butte Resources operation, the

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[661] Ex. OST-001 at 3–4.

[662] Id.

[663] Ex. INT-003 at 3–4.

[664] Id.

secondary porosity, and the physical pull from the wells" on the PRIR led her to conclude that Crow Butte is the source of the radioactive contaminants present in the Arikaree Aquifer.[665] The NRC Staff's witnesses disputed the plausibility of this pathway, pointing out that the PRIR wells closest to Crow Butte's mining operation are about 50 miles from the nearest boundary of the License Area.[666] Ms. White Face agreed that the closest well to the License Area is in Oglala, which is about 50 miles distant.[667] She also agreed that the other wells where radionuclides have been detected are in towns on the PRIR that lie 20 to 60 miles further east or north of Oglala.[668]

Given these distances, Crow Butte's witness, Mr. Lewis, testified that it is physically implausible that uranium in the water detected beneath the PRIR could have originated at the License Area.[669] In his opinion, mine water cannot migrate during operations because (1) the inward gradients maintained during operations and restoration would not allow water to leave the License Area and migrate to the PRIR; and (2) after operations and restoration cease, the groundwater being mined will be restored to ensure the concentrations of contaminants do not exceed regulatory limits.[670] Second, Mr. Lewis testified that, because Crow Butte has only been operating for 25 years at the License Area, it is not physically possible for a release of uranium from Crow Butte's facility to reach the PRIR, given the distance involved (as noted, all parties agreed the distance between the License Area and the closest well on the PRIR is about 50

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[665] Ex. OST-001 at 8.

[666] Ex. NRC-076-R2 at 47.

[667] Tr. at 1515–16.

[668] Tr. at 1515–16.

[669] Tr. at 1822–23.

[670] Tr. at 1822–23.

miles) with “the natural rates of flow in the groundwater system [of about] 20 feet per year.”[671] Mr. Lewis also testified that there are physical processes at work that would retard any transmission and reduce the concentration of radioactive contaminants (i.e., dispersion, attenuation, and chemical dilution).[672] Additionally, the BC/CPF Aquifer must be fully restored before Crow Butte is allowed to halt its inward gradients, and so it would only be at that point in time that natural groundwater transport away from the mine could take place. As a consequence, he asserted, it is inconceivable that contamination from the License Area could have reached the PRIR by this point in time.[673]

Testimony from the NRC Staff’s witnesses largely supported Mr. Lewis’s opinion and emphasized that Crow Butte’s renewed license requires it to operate and restore the subject aquifer under an inward hydraulic gradient.[674] They further opined that there is no continuous pathway between the BC/CPF Aquifer at the License Area and the drinking water aquifers at the PRIR.[675]

Witnesses for both the NRC Staff and Crow Butte maintained that the BC/CPF Aquifer pinches out a few miles northeast of Crawford, which effectively means there are at least 25 miles of aquitard (i.e., surficial Pierre Shale) between the edge of the BC/CPF Aquifer and the southwestern boundary of the PRIR.[676] In this regard, the parties agreed that all the geologic strata, including the BC/CPF, have been eroded down to the underlying Pierre Shale from a few miles east of the current License Area, and extending northeastward to several miles north of

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[671] Tr. at 1823.

[672] Tr. at 1823.

[673] Tr. at 1822–23.

[674] Ex. NRC-001-R at 31–33.

[675] Id.

[676] Id.; Ex. NRC-076-R2 at 65; Ex. NRC-095 at 16–17; Ex. CBR-045 at 34.

Nebraska's border with South Dakota. As a result of this erosion, the Pierre Shale is exposed at the ground surface between the License Area and the PRIR in what is called the Chadron Arch.[677] The NRC Staff's witnesses asserted that the presence of this aquitard at the surface effectively prevents any direct northeasterly transmission from the BC/CPF Aquifer at the License Area to the drinking water aquifers on the PRIR.[678] In fact, during the hearing, Dr. LaGarry conceded that he could not provide data supporting a northeasterly pathway between the License Area and the PRIR through the BC/CPF Aquifer.[679]

i-2 Parties' Positions on Groundwater Flow Through the Arikaree Aquifer for Second Pathway

Witnesses for both Crow Butte and the NRC Staff dispute Ms. White Face's claims that the radioactivity in wells set in the Arikaree Aquifer on the PRIR comes from Crow Butte's mining activities.[680] The NRC Staff's witnesses testified that the Arikaree Aquifer does not exist on-site within the License Area and that the Arikaree Formation is only present in the far south end of the License Area as a dry elevated outcrop that is upgradient of Crow Butte's mining operations.[681] The NRC Staff's witnesses concluded that, based on the absence of either the Ogallala Aquifer or the Arikaree Aquifer (both of which serve as drinking water sources for the PRIR) within the License Area, there cannot be any hydraulic connection between the BC/CPF Aquifer and these aquifers.[682]

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[677] Tr. at 1220, 2577–78; see also Ex. NRC-097, M.J. Ellis and D.G. Adolphson, Geologic map showing water-analysis diagrams and locations of wells, springs, and test holes, Hydrogeology of the Pine Ridge Indian Reservation, South Dakota, U.S. Geological Survey Hydrologic Atlas HA-357 (1971).

[678] Ex. NRC-095 at 17.

[679] Tr. at 2576.

[680] Ex. NRC-076-R2 at 46; Ex. CBR-067 at 13–14.

[681] Tr. at 1156–57; Ex. NRC-076-R2 at 46.

[682] Ex. NRC-001-R at 41.

According to the NRC Staff's witnesses, this lack of a direct viable pathway through the Arikaree formation at the southeast portion of the License Area to the southern border of the PRIR is confirmed by the fact that all groundwater flow in the overlying aquifers in and around the License Area discharges to the White River.[683] While the NRC Staff's witnesses acknowledged that groundwater in the Arikaree Aquifer enters the PRIR from Nebraska, they maintained that the low permeability of the Chadron Arch acts as an effective barrier to groundwater flow between Crow Butte's mining operations within the License Area and the south end of the PRIR along the southern border of South Dakota.[684] In addition, the NRC Staff's witnesses testified that, in order for Ms. White Face's suggested second pathway to exist, it would be necessary for water to travel cross-gradient for about 50 miles—not to mention crossing over a groundwater mound—just to reach the South Dakota-Nebraska border, which, in their opinion, is an engineering impossibility.[685] Ultimately, Dr. LaGarry agreed with the NRC Staff's witnesses' assessment, stating that "it's very unlikely that there's a direct lateral route from the License Area to the [PRIR]."[686]

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683 Ex. NRC-095 at 26–28 (citing to Ex. NRC-102 at 2).

684 Id. at 27. During the hearing, an NRC Staff's witness denoted this groundwater mound on a map of the area, Ex. BRD-004, Nebraska Department of Natural Resources, Report on Hydrologically Connected Ground Water and Surface Water in the Upper Niobrara-White Natural Resources District, figs. 29, 30, (Oct. 2004), and indicated that it lies to the immediate south of an area encompassing the Arikaree Aquifer. Tr. at 2620–22. The annotated version of Ex. BRD-004, figs. 29, 30 is Ex. NRC-102.

685 Ex. NRC-095 at 27–29.

686 Tr. at 2622.

i-3 Parties' Positions on Radiologic Impacts to PRIR Drinking Water from Second Pathway

Ms. White Face testified that test results from five wells placed in the Arikaree Aquifer on the PRIR show elevated levels of uranium.[687] Ms. White Face attributes these elevated levels to Crow Butte's mining operations within the License Area.[688]

In their testimony, the NRC Staff's witnesses disputed this claim by pointing to a USGS publication[689] indicating that, while the Ogallala and Arikaree Aquifers are "the largest sources of groundwater on the [PRIR] and are used extensively for irrigation and public and domestic water supplies,"[690] these aquifers are wholly separate and distinct from the Middle/Upper Chadron and Lower Brule Formations of the White River Group underlying the PRIR, and these formations are generally too impermeable to serve as a source or movement of groundwater.[691]

In addition, the NRC Staff presented evidence that "[v]olcanic ash within the aquifers is the primary source of elevated uranium levels in the region's groundwater."[692] Consistent with the NRC Staff's position, and undercutting Ms. White Face's claims, Intervenors' witnesses submitted studies (partly performed by Dr. LaGarry) stating that naturally elevated uranium levels in the BC/CPF Aquifer on the PRIR are "due to devitrified [crystallized] volcanic glass

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687 Ex. OST-001 at 3–7.

688 Id.

689 Ex. NRC-001-R at 33 (citing Ex. NRC-025; Ex. BRD-003); Ex. NRC-095 at 15–16.

690 Ex. NRC-026, Kyle W. Davis, Larry D. Putnam & Anneka R. LaBelle, U.S. Geological Survey, Conceptual and Numerical Models of Groundwater Flow in the Ogallala and Arikaree Aquifers, Pine Ridge Indian Reservation Area, South Dakota, Water Years 1980–2009, Scientific Investigations Report 2014–5241 at 2 (Feb. 2015).

691 Ex. NRC-025, tbl. 1, at 7.

692 Ex. NRC-098, Cathrine J. Botzum, John, W. Ejnik, Kathryn Converse, Hannan E. LaGarry & Prajukti Bhattacharyya, Uranium Contamination in Drinking Water in Pine Ridge Reservation, Southwestern South Dakota, 43(5) Geological Society of America Abstracts with Programs 125 at 1 (Oct. 2011).

within the aquifer,"[693] and that outcrops of the BC/CPF are likely sources of natural uranium contamination of soils, sediments, surface waters, and groundwater in several communities on the PRIR.[694] The NRC Staff's witnesses' position in this regard was further buttressed by Dr. LaGarry's concession during the hearing he had no data to suggest that contaminants detected at the PRIR came from Crow Butte's mining operations within the License Area.[695]

As noted above, Ms. White Face's claims that the PRIR's pumping of its five deep wells in the Arikaree Aquifer may have accelerated the draw of lixiviant (with dissolved radionuclides) from Crow Butte's mining operations within the License Area all the way to the aquifer underlying the PRIR.[696] In disputing this assertion, the NRC Staff's witnesses responded that: (1) Crow Butte does not pump lixiviant into the Arikaree Aquifer;[697] and (2) the Arikaree Formation is present only in the far southeast corner of the License Area, where it is dry.[698]

Ms. White Face also testified that five well samples showed concentration ratios of Uranium (U)-234/U-238 of approximately two to one, a much higher ratio than associated with naturally-occurring concentration percentages, i.e., U-234 (0.005 percent) to U-238 (99.27 percent).[699] From this, Ms. White Face opined that the higher ratio of U-234 to U-238 indicates that the radioisotopes detected in the wells on the PRIR originated at the License Area. Specifically, Ms. White Face maintains that the concentrations detected in the five well samples

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[693] Ex. INT-072 at 1.

[694] Ex. INT-074 at 1.

[695] Tr. at 1489.

[696] Ex. OST-001 at 4.

[697] Ex. NRC-076-R2 at 47.

[698] Ex. NRC-001-R at 55.

[699] Ex. OST-001 at 5–6.

reflect the extraction effects of Crow Butte's ISL mining operations within the License Area, i.e., dissolving U-238 and the decay products of U-238.[700]

In disputing this claim, the NRC Staff's witnesses testified that U-238 is transformed to U-234 only through radioactive decay—and is not influenced by chemical reactions associated with Crow Butte's ISL process.[701] The NRC Staff's witnesses also maintained that Ms. White Face had incorrectly compared the activity ratios of U-234/U-238 rather than the natural concentration (mass) ratios of those isotopes,[702] and that this is inappropriate because the two isotopes have different measured levels of activity (related to their half-lives),[703] i.e., the half-life of U-234 is more than four orders of magnitude shorter than that of U-238.[704] The NRC Staff's witnesses further testified that, because the natural activity ratio of U-234/U-238 typically ranges between one and three in groundwater, the measured U-234/U-238 activity ratios in the Arikaree Aquifer well tests are within the range one would expect to find in naturally-occurring groundwater.[705]

As an additional reason for her opinion that the radionuclides detected in the five drinking water wells on the PRIR are attributable to Crow Butte's mining activities within the License Area, Ms. White Face pointed to the presence of Thorium (Th)-234 (i.e., the first decay product in the natural U-238 decay series) in the PRIR drinking water wells because the

[700] Id.

[701] Ex. NRC-076-R2 at 49.

[702] Id. The Board takes official notice under 10 C.F.R. § 2.337(f) that these ratios are based on different physical properties. Activity is based on measurements of decays per unit time, while natural concentration is based on measurements of mass.

[703] Id.

[704] Ex. NRC-082, M.C. Rhodes, K.G. Keil, W.T. Frederick, J.S. Leithner, J.M. Peterson & M.M. MacDonell, Utilizing Isotopic Uranium Ratios in Ground-water Evaluations at [Niagara Falls Storage Site], tbl. I, at 2 (undated).

[705] Ex. NRC-076-R2 at 49 (citing Ex. NRC-082 at 2, 3).

"naturally occurring thorium has been unnaturally displaced so that it is in the drinking water" on the PRIR.[706] To reach this conclusion, however, it was necessary for Ms. White Face to assume that Th-234 traveled from the License Area to the PRIR—but neither she nor any other witness for Intervenors could offer any data to explain how such a pathway was plausible. Moreover, the NRC Staff's witnesses testified that, "given the short half-life of Th-234 (24 days), it is highly unlikely measurable amounts of Th-234 could travel in ground water approximately 50 miles from the [License Area] to the wells at the [PRIR], even if a pathway existed."[707]

b. Board Findings on Second Pathway: Northeasterly Flow to the PRIR

Based on the testimony summarized above, we find there is no credible northeasterly underground pathway from the BC/CPF Aquifer to either the Arikaree Aquifer or the Ogallala Aquifer that underlie the PRIR. We also find that it is more likely than not that elevated levels of uranium in wells completed in the High Plains Aquifer on the PRIR are caused by naturally-occurring uranium derived from outcrops of the BC/CPF near or on the PRIR, and are not the result of Crow Butte's mining operations within the License Area. In addition, based on the glacial flow of groundwater in this area, we find it is not reasonable that a release of uranium from Crow Butte's mining operations could have traversed a distance of about 50 miles from the License Area to the water wells inside the PRIR closest to the License Area, given that Crow Butte's mining operations within the License Area have only been ongoing for 25 years.[708] Finally, the Board finds that the activity ratios of U-234 to U-238 detected in the subject well waters on the PRIR are within the range one would expect to find in naturally-occurring groundwater, and that the short half-life of Th-234 detected in the PRIR drinking water indicates

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[706] Ex. OST-001 at 6.

[707] Ex. NRC-076-R2 at 50.

[708] Tr. at 1032–33, 1822–23.

the presence of naturally-occurring uranium inside or at least in the immediate vicinity of the PRIR, as opposed to any uranium that might have originated on the License Area.

3. Third Pathway: Northwesterly Flow from License Area to BC/CPF Outcrops to the PRIR

a. Parties' Positions on Third Pathway: Northwesterly Flow from License Area to BC/CPF Outcrops to the PRIR

In conjunction with Intervenors' original petition in this proceeding, Dr. LaGarry opined that contaminated water from the License Area could migrate through fractures and then travel along the groundwater gradient northeastward towards the PRIR,[709] in a fashion similar to that suggested by Ms. White Face.[710] Seven years later, Dr. LaGarry conceded in his testimony at the hearing that the NRC Staff was correct in its assessment that: (1) there is no plausible direct lateral route northeast from the License Area to the PRIR,[711] and (2) it is extremely unlikely there could be any lateral migration of contaminated water from the License Area around, over, or through the Chadron Arch onto the PRIR.[712] At the same time, however, Dr. LaGarry continued to assert that "once contaminants through cracks, or spills, or [other pathways] found their way into the White River, then they would be flushed diagonally across the [PRIR], and in short order could get from there into people's wells, or into the sediments."[713]

Dr. LaGarry later refined this assertion by opining that the likely hydraulic connection between the License Area and the PRIR would be a northwest flow from the License Area into the White River alluvium and the White River itself, which, in turn, would be followed by a northeast flow through the White River alluvium to connect either with the BC/CPF outcrops,

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[709] Ex. INT-003 at 3.

[710] Tr. at 2582–83; Ex. OST-001 at 3–4.

[711] Tr. at 2622.

[712] Tr. at 2582.

[713] Tr. at 2583.

with the BC/CPF Aquifer, and/or with the Arikaree and Ogallala Aquifers that underlie the PRIR.[714]

Crow Butte's witness, Mr. Spurlin, agreed that the BC/CPF is likely present in the region that encompasses the PRIR in South Dakota, but he also maintained that the BC/CPF is not connected to the same formation that exists in the License Area because of the presence of the low permeability Pierre Shale that lies between these two regions.[715] As a result, there is no evidence of a hydraulic pathway connecting the BC/CPF underlying the License Area with BC/CPF that may underlie the PRIR.

While maintaining that the BC/CPF exists in some locations under the PRIR,[716] Dr. LaGarry agreed that the BC/CPF underlying the License Area is not contiguous with any BC/CPF that may underlie the PRIR.[717] He also agreed that the BC/CPF underlying the License Area could only be hydraulically connected to the PRIR aquifers by the White River alluvium because "lateral migration of contaminated water from the License Area somehow around, or over, or through the Chadron Arch onto the PRIR is extremely unlikely."[718] Nevertheless, for this third pathway to be a plausible one, Dr. LaGarry testified that the White River alluvium must cross the PRIR from southwest to northeast and come in contact with virtually every geological unit available at the land surface including the BC/CPF and the Arikaree Formation.[719]

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[714] Tr. at 1075–76, 2582.

[715] Tr. at 2577.

[716] Ex. INT-080 at 4–6; Tr. at 2566, 2572–75.

[717] Tr. at 2576.

[718] Tr. at 2582.

[719] Tr. at 1487.

b. Board Findings on Third Pathway: Northwesterly Flow from License Area to BC/CPF Outcrops to the PRIR

As with the other pathways suggested by Intervenors' witnesses, we find that there is no credible record evidence that Dr. LaGarry's proposed northwesterly flow from the License Area is a viable pathway for contaminants to migrate from the License Area to the PRIR. We are convinced of this by the record evidence for three distinct reasons: (1) migration from the License Area is unlikely because of the confining nature of the UCU and the inward gradients Crow Butte maintains as part of its mining and restoration operations within the License Area; (2) a release of uranium from Crow Butte's mining operations within the License Area could not reasonably traverse a distance of about 50 miles to the Arikaree or Ogallala Aquifers that underlie the PRIR; and (3) given the obstacles preventing migration and the slow groundwater movement in the region, any such contaminants could not reasonably be detected at the PRIR because Crow Butte has only been operating its mines at the License Area for roughly 25 years.

With these various overarching issues explained and resolved, we now turn to our ruling regarding the validity of Intervenors' contentions.

IV. CONTENTIONS

A. Contention A – Well Monitoring Frequency and Excursion Indicators

As admitted, this contention was previously narrowed to challenge (1) whether Crow Butte's bi-weekly testing of monitoring wells is sufficient to identify the potential impacts of non-radiological contaminants, and (2) whether uranium should be routinely used as an excursion indicator.[720]

[720] CLI-09-9, 69 NRC at 346–47; see also LBP-08-24, 68 NRC at 718.

1. *Parties' Positons on Contention A: Well Monitoring Frequency and Excursion Indicators*

   a. *Parties' Positions on Bi-weekly Testing of Monitoring Wells*

Witnesses for both Crow Butte and the NRC Staff testified that Condition 11.5 of Crow Butte's renewed license requires it to sample and test all perimeter and aquifer monitoring wells at least once every 14 days.[721] Crow Butte's witnesses added that whenever a well goes on excursion status[722] Crow Butte must increase its sampling frequency to weekly until the well goes off excursion status.[723] In addition, Crow Butte's witnesses testified that NDEQ requires Crow Butte to demonstrate compliance with these excursion indicators for an additional three weeks in order to provide further assurance that subsurface conditions are stabilized.[724]

We note initially that there is no disagreement among the parties that Crow Butte's monitoring wells were installed within 300 feet of each individual mine unit and that Crow Butte monitors these wells on a bi-weekly basis. But, Intervenors assert this system is insufficient because leaks could go undetected in the event that a scheduled test does not coincide with a leak.[725] Crow Butte's witnesses disputed this, arguing that bi-weekly testing provides enough time to detect a potential excursion and to take corrective action before any mining liquids can leave the License Area.[726] Additionally, they testified that Crow Butte's groundwater modeling establishes that its horizontal flow rates are approximately 5 feet to 15 feet per month at the

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[721] Ex. NRC-001-R at 10; Tr. at 1597; see also Ex. NRC-012 at 12 (License Condition 11.5).

[722] Ex. CBR-001 at 39–40.

[723] Tr. at 1597; see also Ex. NRC-012 at 12 (License Condition 11.5).

[724] Tr. at 1597.

[725] Tribe Petition at 7.

[726] Ex. CBR-001 at 38–39.

edges of the operating wellfields.[727] Accordingly, Crow Butte's witnesses asserted that, with bi-weekly testing, there is more than sufficient time to detect a potential excursion and to take corrective action prior to any migration of mining liquids beyond the License Area.[728]

Crow Butte's witnesses also maintained that whenever Crow Butte experiences an increased concentration above background levels for one or more indicator parameter, this serves as a sufficient early warning for Crow Butte to take any necessary preemptive action, e.g., altering the pumping rate to reduce the rate of groundwater movement and to reverse the flow direction back toward the wellfield before UCLs are exceeded.[729]

The NRC Staff's witnesses testified that Crow Butte's bi-weekly monitoring is consistent with the Standard Review Plan for In Situ Leach Uranium Extraction License Applications (NUREG-1569), which states that "an acceptable excursion monitoring program should indicate that all monitor wells will be sampled for excursion indicators at least every 2 weeks during *in situ* leach operations."[730] They further noted that this bi-weekly sampling requirement has been in place since Crow Butte's initial license was granted in 1989 and that it was previously described in both the EA for that initial licensing action and the EA for the 1998 license renewal.[731] Moreover, the EA for the licensing action at issue here states that Crow Butte has

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[727] See id. (citing Ex. CBR-020, Letter from Robert Lewis, Principal Hydrogeologist, WorleyParsons, to David Moody, Restoration Manager, Crow Butte Operations, Response to NDEQ Excursion Monitoring Issues at 3 (Aug. 26, 2010)).

[728] Id. at 39.

[729] Id. at 38–39; see also Ex. NRC-012 at 12 (License Condition 11.5).

[730] Ex. NRC-001-R at 10 (quoting Ex. NRC-013, Office of Nuclear Material Safety and Safeguards, Standard Review Plan for In Situ Leach Uranium Extraction License Applications, NUREG-1569 at 5-43 (June 2003) [hereinafter Ex. NRC-013, NUREG-1569]).

[731] Id. (citing NRC-015 Final Environmental Assessment for Crow Butte ISR Project at 1–2 (1989) (excerpt); Ex. CBR-044, Office of Nuclear Material Safety and Safeguards, Division of Waste Management, Environmental Assessment for Renewal of Source Material License No. SUA-1534 § 3.7.1 at 35–36 (Feb. 1998) [hereinafter 1998 EA]).

detected excursion events at the License Area with bi-weekly testing and has managed those events with subsequent corrective actions that prevented any measurable impact to groundwater beyond the License Area.[732]

b. Parties' Positions on Uranium as an Excursion Indicator

Intervenors' witnesses opined that, in addition to testing for chloride, conductivity, and total alkalinity, Crow Butte should also be required to test for uranium during excursion monitoring.[733] Crow Butte's witnesses disputed whether there was any need for uranium to be added as an excursion indicator and testified that testing for chloride is preferable to testing for uranium because (1) chloride is introduced into the lixiviant from the ion exchange process (i.e., uranium is exchanged for chloride on the ion exchange resin); (2) chloride is highly mobile in groundwater and will show up quickly in a monitoring well if lixiviant escapes the wellfield; and (3) chloride is easy to detect due to its low background levels in the native groundwater.[734] Similarly, they asserted, conductivity is a better excursion indicator than uranium because it provides an excellent general picture of overall groundwater quality.[735] Finally, Crow Butte's witnesses maintain that total alkalinity is a better excursion indicator than uranium because a major constituent added to the lixiviant during mining is bicarbonate, and during an excursion event, the presence of bicarbonate in groundwater would be reflected in an increase in total alkalinity concentrations.[736]

While there is no dispute among the parties that uranium is mobilized during mining, Crow Butte's witnesses testified that uranium—unlike chlorides, conductivity, and total

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[732] EA § 4.6.2.2.6 at 94.

[733] Tr. at 1603–04; see also Ex. INT-070 at 2.

[734] Ex. CBR-001 at 37–38 (citing LRA § 5.8.8.2 at 5-123).

[735] Id.

[736] Id.

alkalinity—is a poor leading indicator of excursions because the reducing conditions (i.e., adsorption and precipitation) in the aquifer often slow the rate of uranium transport through the aquifer.[737] Turning to the specific on-site conditions at the License Area, Crow Butte's witnesses opined that, in a given period of time, the total distance uranium could be expected to travel would be no more than 15 percent (and perhaps as low as 0.5 percent) of the distance traveled by an excursion indicator such as chloride.[738]

The NRC Staff's witnesses' testimony was largely consistent with the testimony of Crow Butte's witnesses. They stated that three separate NRC guidance documents discourage the use of uranium as an excursion indicator.[739] The NRC Staff's witness, Mr. Lancaster, testified that NUREG-1569 aligns with Crow Butte's experience that uranium is not a particularly effective excursion indicator because it may be retarded by the reducing conditions in the aquifer.[740] Another of the NRC Staff's witnesses, Mr. Fuhrmann, testified that, while in some conditions uranium could move as fast as the groundwater does in an aquifer, it is likely that other excursion indicators, such as chloride or alkalinity, would also be traveling at the same rate.[741] As such, he concluded, there is no added benefit from testing for uranium because the other excursion indicators would also be present.[742]

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737 Id. at 38.

738 Id. (citing Ex. CBR-020 at 3).

739 Ex. NRC-001-R at 12–13 (citing Ex. NRC-017, Division of Fuel Cycle Safety and Safeguards, Office of Nuclear Material Safety and Safeguards, A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees, NUREG/CR-6733 at 4-38 (Sept. 2001) [hereinafter Ex. NRC-017, NUREG/CR-6733]; Ex. NRC-018, Office of Nuclear Regulatory Research, Methods of Minimizing Ground-Water Contamination from In Situ Leach Uranium Mining, NUREG/CS-3709 at 5 (Mar. 1985) [hereinafter Ex. NRC-018, NUREG/CS-3709]; Ex. NRC-013, NUREG-1569 at 5-41).

740 Tr. at 1604.

741 Tr. at 1607.

742 Tr. at 1607.

The NRC Staff's witnesses also emphasized that it is not as if Crow Butte does not test any of its monitoring well samples for uranium because, as a result of its previous excursions, Crow Butte is required to sample for uranium whenever a well in two mine units (Mine Units 6 and 8) is placed on excursion status.[743] Also, in connection with Crow Butte's effluent and environmental monitoring program,[744] the EA states that Crow Butte is required to conduct quarterly sampling for uranium and radium in any private water supply wells located within one mile of an individual mining wellfield.[745] Annually, Crow Butte also samples for uranium, radium-226, Th-230, and lead-210 in sediments at locations both upstream and downstream from creeks in the License Area.[746]

Dr. Kreamer opined that Crow Butte should introduce conservative tracers into the mining units.[747] He asserted that this intentional release of conservative tracers can be used to characterize flow in fractured rock settings and to identify clearly subsurface flow paths in assessing of the influence of ISL on groundwater.[748]

2. Board Findings on Contention A: Well Monitoring Frequency and Excursion Indicators

We find that the record evidence supports the adequacy of Crow Butte's bi-weekly sampling. We further find that there is no record evidence compelling Crow Butte to sample for uranium in addition to the three excursion indicators, i.e., chloride, conductivity, and total alkalinity.

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[743] See Ex. NRC-001-R at 8–9, 14; EA § 4.6.2.2.4 at 91–92; Tr. at 1632, 1638; Ex. NRC-012 at 14 (License Condition 11.12).

[744] Ex. NRC-012 at 14 (License Condition 11.13).

[745] EA § 4.6.2.2.6 at 94.

[746] Id. § 4.6.1.2 at 83.

[747] Ex. INT-046 at 5.

[748] Id.

Turning first to bi-weekly sampling frequency, we find that Intervenors presented no evidence that would necessitate Crow Butte increasing its sampling frequency for monitoring wells. In contrast, we find that Crow Butte presented convincing evidence that justified the current bi-weekly sampling interval based on: (1) the short travel distance of groundwater flow in the License Area during a two week period; (2) Crow Butte's experience with early detection using the three excursion indicators of chloride, conductivity, and total alkalinity as well as with its subsequent corrective measures, both of which have successfully limited the migration of radionuclides when excursions were detected; and (3) Crow Butte's obligation, under its renewed license, to increase its sampling frequency from bi-weekly to weekly after an excursion is detected.

Although Intervenors' witnesses asserted that Crow Butte should be required routinely to test its samples for uranium[749] (in addition to the three excursion indicators),[750] we find that there is no record evidence that the addition of uranium as a standard excursion indicator would provide any significant information beyond that obtained from using only chloride, conductivity, and total alkalinity. Given the retardation uranium would likely encounter in the License Area's subsurface environment, we find that it is not reasonable to require testing for uranium. Furthermore, three of the NRC Staff's guidance documents discourage using uranium as an initial excursion indicator.[751] And, while Intervenors' recommendation to introduce conservative tracers into the mine field could be scientifically sound, neither Dr. Kreamer nor Mr. Wireman

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[749] Tr. at 1603–04; see also Ex. INT-070 at 2.

[750] Ex. NRC-001-R at 10–11.

[751] Ex. NRC-001-R at 12–13 (citing Ex. NRC-017, NUREG/CR-6733 at 4-38; Ex. NRC-018, NUREG/CS-3709 at 5; Ex. NRC-013, NUREG-1569 at 5-41).

could explain why chloride, conductivity, and total alkalinity do not already serve the same function as would these tracers.[752]

B. Contention C – Impacts on Surface Water

In Contention C, Intervenors argue that the NRC Staff's "characterization that the impact [on] surface waters from an accident is 'minimal since there are no nearby surface water features,' does not accurately address the potential for environmental harm to the White River."[753]

This contention asserts that impacts to surface waters from Crow Butte's mining operations (and specifically from spills and leaks) are anything but small due to the potential for the White River alluvium to receive contaminants from three distinct sources: (1) surface spills in the License Area; (2) water transmitted through the BC/CPF; and (3) fractures in the strata that make up the UCU.[754] As originally admitted, we found that Contention C presented a genuine dispute as to "whether these aquifers are interconnected and so could be the potential pathway for contaminant migration to surface waters."[755] With the publication of the EA, Contention C migrated to encompass whether the EA took a "hard look" at potential water quality impacts to

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[752] While affirming the effectiveness of chloride, alkalinity, and electrical conductivity (as well as a fourth parameter, sulfate, not deemed necessary here) as effective excursion indicators relative to the proposed ISL facility at issue in the recent Strata proceeding, the Licensing Board in that case also noted there may be site-specific aquifer geochemical conditions that could render uranium a better excursion indicator. See Strata Energy, Inc. (Ross In Situ Recovery Uranium Project), LBP-15-3, 81 NRC 65, 150 (2015), petition for review denied, CLI-16-13, 83 NRC 566, 601 (2016). We note, however, that, as was the case in the Strata proceeding, no evidence was presented in this proceeding to suggest that the prevailing site-specific geochemical conditions in the License Area would make uranium a more effective excursion detector than chloride, alkalinity, and electrical conductivity.

[753] LBP-15-11, 81 NRC 401, 451, app. A (2015).

[754] Ex. INT-003 at 3.

[755] LBP-08-24, 68 NRC at 725.

surface waters from spills and leaks, and particularly to the White River, as part of its environmental review.[756]

1. Parties' Positions on Potential Impacts to Surface Water Resources

Crow Butte conducts both surface and groundwater quality monitoring at the License Area. Surface water impacts are primarily attributable to spills and leaks, which are managed by Crow Butte's SPCC Plan, and which are monitored via surface water quality sampling. We address below the parties' positions on the surface water resources exposed to mining impacts, the types of surface and subsurface spills and leaks, the adequacy of Crow Butte's SPCC Plan, and the effectiveness of Crow Butte's monitoring and control programs in protecting surface water and groundwater resources.

a. Parties' Positions on Surface Water Resources

As we noted earlier, the EA states that the Crow Butte facility lies within the watersheds of White Clay Creek, Squaw Creek, and English Creek, which are all small southern tributaries of the White River.[757] Squaw Creek and English Creek flow from southeast to northwest within the License Area, while White Clay Creek, on the west side of the facility, is located outside of the License Area, but also flows to the northwest.[758] All three streams converge and enter the White River approximately three miles north of the License Area and two miles downstream from the city of Crawford.[759] There are also eight surface water impoundments within or near the License Area, which primarily are used for livestock watering.[760] Of these eight

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[756] LBP-15-11, 81 NRC at 410, at 451, app. A.

[757] See supra § II.C.1, Surface and Subsurface Water Resources at 28–29; see also EA § 3.5.1 at 45.

[758] Ex. NRC-001-R at 16 (citing LRA, fig. 2.2-3, at 2-25).

[759] Id.

[760] Id. (citing EA § 3.5.1 at 45, LRA § 2.7.1.3 at 2-163).

impoundments, four lie within the License Area on Squaw and English Creeks.[761] While the parties do not dispute this inventory of surface water features in the License Area, Intervenors' witnesses claimed that the drawdown of impoundment water levels (observed from a comparison of Google maps from 1993 to 2010) can be attributed to Crow Butte's mining operations within the License Area.[762]

b. Parties' Positions on Origins of Spills and Leaks

In their prefiled testimony, Intervenors' witnesses claimed that "identified spills are not well addressed by [Crow Butte],"[763] and that sediments in stream flows can become a possible pathway for the lateral surface movement of spills or leaks.[764] Dr. Kreamer opined that contaminants from Crow Butte's surface spills and leaks will be transmitted through faulted regions or discharged through surface expressions of the BC/CPF Aquifer and, as a result, have the potential to reach and infiltrate the White River alluvium.[765]

EA §§ 4.6.1.2 and 4.6.2.2.2 discuss the impacts of surface spills and leaks on surface waters.[766] In expanding on this discussion, the NRC Staff's witnesses testified that there are two primary pathways for contaminants from spills or leaks within the License Area to reach the White River alluvium.[767] The first pathway would involve contaminants being released from a surface spill (e.g., pond leaks, piping ruptures, transportation accidents) and then entering the

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[761] EA § 3.5.1 at 45; LRA § 2.7.1.3, fig. 2.7-1, at 2-159; id. § 2.7.1.3 at 2-163.

[762] Tr. at 1458.

[763] Ex. INT-046 at 5.

[764] Ex. INT-069 at 2.

[765] Ex. INT-046 at 3.

[766] EA § 4.6.1.2 at 82–85; id. § 4.6.2.2.2 at 88–90.

[767] Ex. NRC-001-R at 17.

streams (i.e., English and Squaw Creeks) that flow through the License Area.[768] If this were to occur, surface runoff during subsequent rain events would transport contaminants from the License Area downstream to the White River.[769] The second pathway would involve subsurface releases from spills, leaks, or excursions that could result in vertical migration (i.e., the unintended flow of process liquids into the Upper Brule Aquifer).[770] Thereafter, such contaminants could migrate underground until they reached one of the on-site streams (i.e., English and Squaw Creeks) or the White River alluvium.[771]

Crow Butte's witnesses suggested that, to the extent that such spills and leaks have occurred, they have proven to be relatively minor.[772] Specifically, Crow Butte's witnesses testified that "[t]he most common form of surface release from in-situ mining operations occurs from breaks, leaks, or separations within the piping that transfers mining fluids between the process plant and the wellfield," and that "[t]hese are generally small releases due to engineering controls that detect pressure changes in the piping systems and alert the plant operators through system alarms."[773] In addition to surficial spills of processing wastewater, the EA states that leaks can also come from abandoned boreholes and well casings, as well as from wastewater evaporation ponds.[774]

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[768] Id.

[769] Id.

[770] Id.

[771] See id. at 17, 19–20.

[772] Ex. CBR-001 at 44.

[773] Id.

[774] EA § 4.6.2.2.2 at 88–89; id. § 4.6.2.2.3 at 90–91.

c. Parties' Positions on Spill Prevention, Control, and Countermeasure Plan

The EA states that, to prevent surface water impacts, Crow Butte has promptly investigated and mitigated the impacts from spills and leaks,[775] and has an SPCC Plan that prescribes procedures for reporting accidental discharges, spill response, and cleanup measures.[776]

In addition, Crow Butte's witnesses testified that Crow Butte's measures to protect surface water quality include the installation of protective berms and dams around Squaw Creek and English Creek to minimize the potential impact to those on-site creeks from any surface spill of the materials that Crow Butte uses in mining, processing, or restoration activities.[777] They further testified that "[t]hese berms and dams are routinely maintained and inspected to ensure their integrity and protect the surface water in the permit area.[778] Crow Butte also has installed instrumentation to detect wet berms, wet valve stations, and wet wellhouses."[779]

The EA states that, in order to prevent pipeline leaks, Crow Butte's piping (made of PVC, high density polyethylene with butt welded joints, or their equivalent),[780] is leak-tested prior to the initiation of mining operations as well as following any repairs or maintenance.[781] According to the SER, Crow Butte maintains continuous real-time monitoring and control of flow rates and trunk line pressures.[782] The SER also states that Crow Butte installed alarms, sensors and

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[775] EA § 4.6.1.2 at 83.

[776] Id.

[777] Ex. CBR-001 at 45.

[778] Id.

[779] Id.; see also EA § 4.6.1.2 at 83.

[780] LRA § 5.8.1.3 at 5-29.

[781] EA § 4.6.2.2.2 at 88.

[782] SER § 3.1.3.4 at 56; see also EA § 4.6.2.2.2 at 88.

other instrumentation to monitor the status of its ISL system and to alert its mining employees to any leaks or spills.[783]

Crow Butte's witnesses maintained that Crow Butte's spill control programs have been very effective at limiting surface releases from mining operations.[784] Specifically, they testified that, in over 20 years of mining operations on the License Area, Crow Butte has experienced 358 spills, ranging from 1 to 40,000 gallons.[785] Of these 358 spills, only three were reportable to NDEQ.[786] Moreover, Crow Butte's witnesses testified that none of these spills was reportable to the NRC Staff under 10 C.F.R. Part 20 criteria.[787] In addition, they maintained that Crow Butte analyzes all spills for root causes and contributing factors.[788]

d. Parties' Positions on Surface Water Monitoring Program and Results

The EA states that Crow Butte performed pre-operational water quality sampling and has continuously (i.e., since it initiated mining operations on the License Area 20 years ago) conducted quarterly surface water sampling for natural uranium at upstream and downstream locations on English Creek and Squaw Creek, as well as at surface impoundments within the wellfields.[789] Crow Butte's witnesses testified that Crow Butte's quarterly sampling of English Creek and Squaw Creek are representative of the surface water quality within the License

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[783] SER § 3.1.3.4 at 56.

[784] Tr. at 1558.

[785] Tr. at 1558.

[786] Tr. at 1557.

[787] Ex. CBR-001 at 45; Tr. at 1555.

[788] Ex. CBR-001 at 45; Tr. at 1555–56.

[789] EA § 4.6.1.2 at 83; <u>see also</u> LRA § 5.8.7.2 at 5-77. License Condition 11.13 governs Crow Butte's effluent and environmental monitoring program. Ex. NRC-012 at 14 (License Condition 11.13).

Area.[790] They further testified that these sample results show Crow Butte's operations have not impacted the water quality of either stream.[791] Similarly, the EA states that from 1990 to 2010, not only did radionuclide concentrations in English Creek and Squaw Creek remain at or below preoperational levels,[792] but there was also no evidence of any contamination being transported to surface waters outside the License Area.[793] The NRC Staff's witnesses testified that the absence of any such contamination is attributable to Crow Butte's operational controls that are designed to prevent contaminants from reaching the White River alluvium.[794]

The EA notes that Crow Butte took upstream and downstream samples of the sediment in Squaw and English Creeks, as well as samples of the sediment in the surface impoundments in the License Area, at six month intervals for one year prior to construction in the area.[795] Following construction, Crow Butte took annual samples from locations upstream and downstream from the License Area, specifically three locations on Squaw Creek, two locations on English Creek, and three surface impoundments on English Creek.[796] Crow Butte analyzed sediment samples for natural uranium, radium, and lead-210.[797] The EA also states that the monitoring data Crow Butte collected showed no clear indication of downstream contamination

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[790] Ex. CBR-001 at 45–46.

[791] Id. at 46.

[792] EA § 4.6.1.2 at 83.

[793] Ex. NRC-001-R at 19.

[794] Id. at 19–20.

[795] EA § 4.6.1.2 at 83.

[796] Id.

[797] Id.; id., figs. 4-1 to 4-2, at 84–85; see also LRA, tbl. 5.8-14, at 5-129–30. All of this data is presented in semiannual effluent monitoring reports that Crow Butte submits to the NRC. See Ex. CBR-018, Cameco Resources, Semiannual Radiological Effluent and Environmental Monitoring Report for the Crow Butte Uranium Project (Feb. 28, 2014).

from surface spills or leaks[798] and, "[b]ased upon minimal historical impacts, permitting and reporting requirements, the NRC Staff concludes that potential impacts to surface water from the ongoing plant operations would be SMALL."[799]

In addition to this sampling, Crow Butte's state-issued National Pollutant Discharge Elimination System (NPDES) Permit obligates Crow Butte to implement procedures to control runoff and the deposition of sediment in surface waters whenever Crow Butte undertakes any routine construction and maintenance in the License Area.[800]

Intervenors' witnesses asserted that Crow Butte should have sampled the White River itself, downstream of the License Area.[801] Crow Butte's witnesses, however, disputed the necessity of doing so, asserting that NDEQ conducts water quality sampling of the White River and has found no impacts associated with Crow Butte's operations.[802] Moreover, as the NRC Staff's witnesses testified, SDDENR samples the water quality of the White River further downstream, at a monitoring station near Oglala, South Dakota (i.e., within the PRIR), and tests for uranium and other constituents associated with uranium mining.[803] The NRC Staff's witnesses further testified that SDDENR specifically chose to sample at the Oglala monitoring station to detect potential impacts "due to in-situ uranium mining upstream in Nebraska and the naturally occurring uranium in the highly erodible soils in the White River basin."[804] SDDENR

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[798] EA § 4.6.1.2 at 83–84.

[799] EA § 4.6.1.2 at 85.

[800] Id.

[801] Ex. INT-003 at 4.

[802] Ex. CBR-001 at 46.

[803] Ex. NRC-001-R at 23–24.

[804] Id. at 23 (citing Ex. NRC-022).

reported that its sampling results indicated that Crow Butte's ISL operations are not impacting the White River in this area.[805]

Based on the sampling by Crow Butte of the on-site streams and on the sampling by NDEQ and SDDENR of the White River, the NRC Staff's witnesses opined that additional sampling along the White River is not needed.[806] Rather, they claimed that insofar as there were elevated levels of uranium in wells at the PRIR, those results should be attributed instead to natural sources[807]—which is reflected in several of the exhibits referenced by Intervenors' witnesses during their testimony.[808]

e. Parties' Positions on Operational Groundwater Impacts from Spills and Leaks

In his testimony, Dr. LaGarry claimed that there are three principal means "through which contaminated water could migrate away from the uranium-bearing strata through adjacent confining layers . . . : 1) secondary porosity in the form of joints and faults, 2) thinning or pinching out of confining layers, and 3) perforations made by improperly cased or capped wells."[809] In any of these three instances, Dr. LaGarry opined that contaminants from a spill or leak could enter the shallow Upper Brule Aquifer and migrate to one of the on-site streams or to the White River alluvium.[810] Similarly, Dr. Kreamer testified that contaminants from surface spills and leaks could be transmitted through faulted regions or discharged through surface

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[805] Ex. NRC-022 at 2.

[806] Ex. NRC-001-R at 25.

[807] Ex. NRC-095 at 24.

[808] Id. (citing Ex. INT-072; Ex. INT-074).

[809] Ex. INT-013 at 2.

[810] Id. at 2–6.

outcrops of the BC/CPF Aquifer and, as a result, would have the potential to reach and infiltrate the White River alluvium.[811]

But, as previously noted,[812] Crow Butte has implemented an SPCC Plan to prevent and control inadvertent releases of contaminated water to groundwater. Crow Butte's SPCC Plan includes extensive controls and procedures for investigating and responding to spills and leaks, reporting accidental discharges, and implementing cleanup measures.[813]

The NRC Staff's witnesses testified that Crow Butte's SPCC Plan contains specific provisions governing how it will operate its underground piping system, including: (1) pressure-testing pipelines at operating pressures prior to use; (2) incorporating real-time monitoring and control of flow rates and trunk line pressures; and (3) installing alarms, sensors and other instrumentation to monitor the status of the ISL injection system and to alert operators to leaks or spills.[814] Dr. Kreamer, however, claimed that Crow Butte's SPCC Plan was designed to address only large leaks and so Crow Butte's pipeline monitoring efforts would not be able to detect small, chronic leaks, which could become sizable in the long-term.[815] Crow Butte's witnesses disputed Dr. Kreamer's claim, testifying that Crow Butte has yet to detect any small, chronic leaks—and added that any such leak would have been noticed within a year after it

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[811] Ex. INT-046 at 3.

[812] See supra § III.F.1.a, Parties' Positions on First Pathway: License Area to White River Feature to White River Alluvium at 114–20; § III.F.1.b, Board Findings on the First Pathway: License Area to White River Feature to White River Alluvium at 120–23.

[813] EA § 4.6.1.2 at 83; see also supra § III.F.1.b, Board Findings on the First Pathway: License Area to White River Feature to White River Alluvium at 120–23.

[814] Ex. NRC-001-R at 17–18; see also EA § 4.6.2.2.2 at 88; SER § 3.1.3.4 at 56.

[815] Ex. INT-069 at 8.

occurred because there would be an absence of frost on the ground at the spot of the leak during winter, a condition that has not to date occurred at the License Area.[816]

As for Crow Butte's wastewater evaporation ponds, the EA states that Crow Butte designed them to minimize potential leaks and spills in conformance with the criteria in NRC Regulatory Guide 3.11.[817] The EA further states that Crow Butte's evaporation ponds employ primary and secondary impermeable liners with leak detection systems installed between the liners.[818] The EA also notes that these ponds are subject to regular inspections, including the pond liners and the berms.[819] Witnesses for Crow Butte testified that Crow Butte's process buildings are constructed with secondary containment, and that a regular program of inspections and preventive maintenance is in place there as well.[820]

In her testimony, Intervenors' witness, Ms. McLean, testified that the plastics used in the liners for Crow Butte's evaporation ponds are easily degraded.[821] She also testified that the manufacturer of the liners provides a warranty of only two years for the polyethylene, even though Crow Butte's operations within the License Area are projected to endure for decades.[822] It was Ms. McLean's opinion that Crow Butte's liners contain plasticizers likely to be leached by the highly oxidative chemical wastewaters and metals found in the evaporation ponds.[823] Ms.

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[816] Tr. at 1532–33.

[817] EA § 4.6.1.3 at 85; Ex. NRC-020, Office of Nuclear Regulatory Research, Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities, Regulatory Guide 3.11 (rev. 3 Nov. 2008).

[818] EA § 2.2.2.2 at 22; id. § 4.6.2.2.3 at 90–91.

[819] Id. § 4.6.2.2.3 at 90–91.

[820] Ex. CBR-001 at 47; LRA § 7.4.3.3 at 7-16.

[821] Ex. INT-048 at 24.

[822] Id.

[823] Id.

McLean further opined that she would expect Crow Butte's liners to become brittle and to leak once they degrade.[824] Ms. McLean did concede, however, that the warranty for this product is usually a much shorter time frame than is its service life.[825]

The NRC Staff's witnesses testified that, in order to prevent overflow of the evaporation ponds, these ponds are designed to maintain sufficient freeboard to accommodate rain events.[826] The NRC Staff's witnesses also testified that monitoring wells were installed around the ponds to detect any possible leaks, and that the leaks to date had not produced any impacts on shallow groundwater.[827] In addition, the NRC Staff's witnesses testified that Crow Butte monitors the pond levels daily, and that dikes and berms were installed to divert runoff away from these ponds, as required by License Condition 10.16.[828]

With respect to the potential for leaks from abandoned boreholes and well casings, Dr. Kreamer claimed that Crow Butte and the NRC Staff failed to present necessary information and data related to borehole and well abandonment (e.g., "no mathematical quantitative analysis is presented," "[c]omplete documentation for all boreholes is not given," "the number and location of improperly abandoned boreholes . . . is not reported") and that, had Crow Butte provided this information, regulatory agencies, the public, and other external reviewers would have been afforded a reasonable basis for evaluating Crow Butte's conceptual model for the License Area.[829] Crow Butte's witnesses testified that more than 10,000 drill holes made at the License Area have been plugged in order to prevent co-mingling of the Upper Brule Aquifer and the

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[824] Id.

[825] Tr. at 1545.

[826] Ex. NRC-001-R at 19 (citing Ex. NRC-012 at 9 (License Condition 10.16)).

[827] Id. (citing EA § 4.6.2.2.3 at 90).

[828] Id. (citing EA § 4.6.2.2.4 at 91).

[829] Ex. INT-079 at 11–12.

BC/CPF Aquifer, and to isolate the Ore Zone.[830] Crow Butte's witnesses also claimed that the effectiveness of Crow Butte's borehole abandonment was verified by the results of its four aquifer pumping tests that demonstrated a lack of communication between these aquifers, i.e., "[s]uccessful plugging was confirmed by four successful hydrologic tests prior to" commencing operations in an individual mine unit.[831]

Furthermore, Crow Butte is required to leak test all piping prior to production flow and following any repairs or maintenance[832] and to conduct mechanical integrity testing (MIT) of its mining wells (1) after a well is serviced, and (2) at intervals of once every five years thereafter.[833] Moreover, in the event a leak in a well is detected during MIT, that well must be repaired and a new mechanical integrity test performed.[834] If the well cannot be repaired or if it still fails MIT after repair, it must be plugged and abandoned.[835] Crow Butte's well integrity is also subject to oversight under its NDEQ Class III injection well permit, which obligates Crow Butte to ensure its wells are constructed properly and are capable of maintaining pressure without leakage.[836]

2. Board Findings on Contention C: Mining Impacts on Surface Water

Based on the evidentiary record of this proceeding, we make findings with respect to: (1) impacts from surficial spills and leaks on surface waters within the License Area (which include potential impacts to surface water resources on or near the License Area including White Clay

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[830] Ex. CBR-045 at 17; Ex. CBR-001 at 35–36; Tr. at 1236–38.

[831] Id. at 35.

[832] EA § 4.6.2.2.2 at 88.

[833] EA § 4.6.2.2.2 at 89; Ex. NRC-012 at 8 (License Condition 10.5).

[834] Ex. NRC-012 at 8 (License Condition 10.5).

[835] Id.

[836] EA § 4.6.2.2.2 at 89; see also Ex. CBR-001 at 35–36.

Creek, Squaw Creek, English Creek, the White River, the White River alluvium, and the eight livestock watering impoundments); (2) Crow Butte's SPCC Plan; (3) Crow Butte's surface water monitoring program; and (4) impacts from surficial spills and leaks on groundwater resources.

a. Board Findings on Operational Surface Water Impacts and Monitoring

We find that the EA takes the requisite hard look at potential impacts to surface waters over the license renewal period and appropriately concludes that these impacts would be SMALL. Specifically, the EA addresses potential spills and leaks from pipes, wells, evaporation ponds, and vertical excursions and it identifies Crow Butte's protective measures for preventing spills and leaks as well as for minimizing their impacts.[837] The EA also reviews Crow Butte's resolution of its historical spills and leaks and confirms that Crow Butte's monitoring results of these spills and leaks indicates there were negligible impacts to surface waters from Crow Butte's mining operations.[838]

Although Intervenors' witnesses asserted that Crow Butte may have experienced small chronic pipe leaks, there is no record evidence that such events would be likely to occur in the future or that, even were they to occur, they would have significant impacts. Moreover, as we have previously found,[839] there is no record evidence of specific, plausible pathways by which any such contaminants have reached, or even could reach, the White River alluvium or the PRIR. Accordingly, we find that the EA, as supplemented by testimony and evidence presented during the hearing, takes the requisite hard look at surface water impacts and so complies with NEPA with respect to this issue.

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[837] EA § 4.6.1.2 at 82–83; id. § 4.6.2.2.3 at 88–90; id. § 4.13.6.1.2 at 125.

[838] EA § 4.6.1.2 at 82–83; id. § 4.6.2.2.3 at 88–90.

[839] See supra § III.F.1.b, Board Findings on the First Pathway: License Area to White River Feature to White River Alluvium at 120–23; § III.F.2.b, Board Findings on the Second Pathway: Northeasterly Flow to the PRIR at 131–32; § III.F.3.b, Board Findings on the Third Pathway: Northwesterly Flow from License Area to BC/CPF Outcrops to the PRIR at 134.

Contrary to the allegations of Intervenors' witnesses that the drawdown of impoundment water levels can be attributed to Crow Butte's mining operations within the License Area,[840] we find there is no record evidence to support this claim. In fact, there is no data that specifically correlates changes in the Upper Brule Aquifer water table to the observed changes in the on-site impoundments.

We also find that the EA considers all reasonably foreseeable impacts that an accident at the License Area might have on surface waters, including Squaw Creek, English Creek, and the White River.[841] We further find that the EA correctly concludes that Crow Butte has taken the necessary steps to minimize the potential for leaks and spills and has a comprehensive monitoring program in place to detect any such leaks or spills should they occur.[842] Finally, we find that the EA considers the potential for contamination of the White River, as well as the potential impacts on downstream users, from surface spills in the License Area.[843]

We note that EA §§ 4.6.1.2 and 4.6.2.2.2 discuss the impacts of spills and leaks on surface waters and on the Upper Brule Aquifer.[844] The EA concludes that, based upon Crow Butte's 20-plus years of operating history, there have been minimal surface water impacts.[845] Considering Crow Butte's obligations under its NRC license, its NDEQ-issued NPDES permit, and its SPCC Plan, there are sufficient monitoring, permitting, and reporting requirements in place to minimize potential impacts to surface water during the period of license renewal. Accordingly, we find the EA correctly concludes that impacts to surface waters from Crow

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[840] Tr. at 1458.

[841] EA § 3.5.1 at 45; id. § 4.6.1.2 at 82–85; id. § 4.13.6.1.2 at 127.

[842] Id. § 4.6.1.2 at 82–85; id. § 4.13.6.1.2 at 127.

[843] Id. § 4.6.1.2 at 82–85; id. § 4.13.6.1.2 at 127.

[844] Id. § 4.6.1.2 at 82–85; id. § 4.6.2.2.2 at 88–90.

[845] Id. § 4.6.1.2 at 85.

Butte's ongoing plant operations, as well as its decommissioning and reclamation activities, will be SMALL.[846]

We also find that, despite the fact there have been spills, leaks, and excursion events during Crow Butte's operations at the License Area, there is no record evidence that any of these events resulted in the transport of contaminants outside of the License Area. We further find that all of the record evidence in this regard presented during the hearing (i.e., Crow Butte's quarterly sampling of surface water and its annual sampling of stream sediment in Squaw and English Creeks during more than 20 years of operation) indicates that contaminants from Crow Butte's operations have remained within the License Area.[847] In addition, we find that there is no justification for requiring Crow Butte to sample the White River itself because the monitoring by NDEQ and SDDENR is sufficient in this regard. We also find that, to the extent elevated levels of uranium have been detected in wells at the PRIR, such results are most likely explained by natural sources,[848] which is substantiated by Intervenors' own exhibits.[849]

In regards to the control of spills and leaks, we find that the EA's discussion of the control and management of spills and leaks,[850] combined with testimony presented during the hearing,[851] is sufficient to establish that the impact of Crow Butte's excursions, spills, and daily operations on surface water is SMALL.

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[846] Id. § 4.6.1.3 at 85–86.

[847] See, e.g., id. § 4.6.1.2 at 83.

[848] See supra § III.F.2.b, Board Findings on Second Pathway: Northeasterly Flow to the PRIR at 131–32.

[849] Ex. NRC-095 at 24; see also Ex. INT-072; Ex. INT-074.

[850] EA § 4.6.1.2 at 69.

[851] Tr. at 1529–42, 1548–50, 1555–62, 1565–66, 1619–23, 1810–15.

b. Board Findings on Groundwater Impacts from Surface Spills and Leaks

As discussed earlier,[852] Dr. LaGarry posited three principal means through which contaminated water from spills and leaks could migrate through confining layers, and reach one of the on-site creeks or to the White River alluvium,[853] including: (1) secondary porosity in the UCU, (2) thinning or pinching out of the UCU, and (3) leaks from improperly abandoned boreholes or from holes in the casing or caps of wells.[854] With respect to the extent and integrity of the UCU, we have already found that this unit is composed of low permeability material that is continuous over the entire License Area.[855] As we have previously found, because of the absence of significant fractures in the UCU underlying the License Area, there is sufficient evidence to demonstrate that the UCU provides adequate confinement of the BC/CPF Aquifer within the License Area.[856] In regards to Intervenors' claims of improperly abandoned boreholes or well leaks, we find that the more than 10,000 drill holes made by Crow Butte have been plugged effectively to isolate the Ore Zone, as verified by the hydrologic tests they conducted prior to mining.[857] As required by its NRC renewed license and its NDEQ Class III injection well permit, Crow Butte must ensure that its wells are constructed properly, are capable of maintaining pressure without leakage, are leak tested, and, in the event of a leak, are properly repaired or abandoned.[858]

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[852] See supra § IV.B.1.e, Parties' Positions on Operational Groundwater Impacts from Spills and Leaks at 149–53.

[853] Ex. INT-013 at 2; Ex. NRC-001-R at 16–17.

[854] Ex. INT-013 at 2.

[855] See supra § II.B.3, Upper Confining Unit (UCU) at 20–25.

[856] See supra § III.D.2.b, Board Findings on Secondary Porosity/Permeability from Fracturing at 97–99.

[857] Ex. CBR-001 at 35–36; Tr. at 1236–38.

[858] EA § 4.6.2.2.2 at 89; Ex. NRC-012 at 8 (License Condition 10.5).

As we also explained above,[859] Dr. Kreamer opined that surface spills and leaks could flow through faulted regions or be discharged through outcrops of the BC/CPF Aquifer and would thereby have the potential to reach the White River alluvium.[860] We disagree. We find that the record evidence establishes that because the BC/CPF Aquifer does not outcrop anywhere within the License Area and the integrity of the UCU is sound, there is no such mechanism present for the transmission of contaminants from surface spills. Furthermore, we find there is adequate record evidence to support the EA's conclusion that spills and leaks (the source of the contaminants of concern to Dr. Kreamer here) would only result in a SMALL impact, in part as a result of Crow Butte's SPCC Plan that prevents and controls inadvertent releases of contaminated water to groundwater through extensive processes for leak testing, investigating and responding to spills and leaks, reporting accidental discharges, and providing for cleanup measures.[861]

As we discussed above,[862] it is undisputed that: (1) Crow Butte's piping is durable PVC or high density polyethylene with butt welded joints; (2) most of this piping is buried to eliminate the most common accidents with vehicular traffic; (3) Crow Butte has effectively minimized the potential for major leaks by pressure testing each of its pipelines both at the time of its installation and following any repairs or maintenance on the pipeline; (4) Crow Butte maintains continuous real-time monitoring and control of flow rates and trunk line pressures, and has installed alarms, sensors and other instrumentation to monitor the status of its injection system

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[859] See supra § IV.B.1.e, Parties' Positions on Operational Groundwater Impacts from Spills and Leaks at 149–53.

[860] Ex. INT-046 at 3.

[861] EA § 4.3.2 at 79; id. § 4.6.1.2 at 82–85; id. § 4.6.2.2.2 at 88–90.

[862] See supra § IV.B.1.c, Parties' Positions on Spill Prevention, Control, and Countermeasure Plan at 145–46.

and to alert its operators to leaks or spills; and (5) Crow Butte's institution of mechanical integrity testing of monitoring wells upon installation, and at every five years thereafter, effectively aids in preventing leaks.[863] We find that the EA correctly concludes that these steps are sufficient to ensure that impacts to surface waters and groundwater from any leaks or spills from this piping will be SMALL.[864]

With respect to Intervenors' claim that Crow Butte's wastewater evaporation ponds might release contaminants that could ultimately reach the PRIR, we find no record evidence to support this claim. We find that Crow Butte has minimized potential leaks and spills from these ponds by installing primary and secondary impermeable liners with leak detection systems between the liners, as recommended in NRC Regulatory Guide 3.11,[865] and by conducting daily inspections of the ponds.[866] We further find that there is no record evidence to support Ms. McLean's claim that the liner material for Crow Butte's wastewater evaporation ponds will degrade soon after its two-year warranty period, particularly after she conceded that the service life of a material far exceeds the length of the manufacturer's warranty life. We further find that Crow Butte: (1) installed berms to divert runoff away from these ponds;[867] and (2) installed monitoring wells around these ponds to assess impacts in the event of leaks. While Crow Butte has experienced some leakage from the ponds, such leaks had no appreciable impact on shallow groundwater due to Crow Butte's design, monitoring, and corrective actions when leaks were detected.[868] Accordingly we find the EA correctly concludes that Crow Butte's steps are

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[863] EA § 4.6.2.2.2 at 88–90; SER § 3.1.3.4 at 56; Ex. CBR-001 at 44.

[864] EA § 4.6.2.2.2 at 89.

[865] <u>Id.</u> § 4.6.1.3 at 85.

[866] <u>Id.</u> § 2.2.2.2 at 22; <u>id.</u> § 4.6.2.2.4 at 91.

[867] <u>Id.</u> § 4.6.2.2.3 at 91.

[868] <u>Id.</u>

sufficient to ensure that impacts to surface waters and groundwater from any leaks or spills from Crow Butte's wastewater evaporation ponds will be SMALL.[869]

C. Contention D – Communication Between Aquifers

In Contention D, Intervenors assert:

> [The NRC Staff] incorrectly states there is no communication among the aquifers, when in fact, the [BC/CPF Aquifer], where mining occurs, and the aquifer, which provides drinking water to the [PRIR], communicate with each other, resulting in the possibility of contamination of the potable water. Based on this potential communication between the aquifers, the EA's environmental justice analysis, including analysis of cumulative effects, should be expanded to consider potential impacts on the aquifer which provides drinking water to the [PRIR].[870]

Intervenors' witnesses opined that there is communication between the BC/CPF Aquifer and the overlying Upper Brule Aquifer that would enable contaminants to migrate from the License Area and ultimately impact drinking water wells on the PRIR.[871] As we have previously explained, Intervenors' witnesses base their concerns primarily on the assumptions that: (1) there are fractures in the UCU; and (2) there is sufficient porosity caused by these fractures that contaminated groundwater could migrate up into the overlying Upper Brule Aquifer and from there to the PRIR aquifers (collectively with the Upper Brule Aquifer we refer to these as "Upper Aquifers") through several potential pathways.[872] Given this, Intervenors' witnesses maintained that the EA should expand its analysis of Environmental Justice (including the evaluation of cumulative effects) to consider potential impacts on aquifers that provide drinking water to the PRIR.[873]

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[869] Id. § 4.6.2.2.2 at 89.

[870] LBP-15-11, 81 NRC at 451, app. A.

[871] See supra § III.F, Pathways for Contaminant Migration at 113–34; see also Ex. INT-003 at 3–4; Ex. INT-010 at 6.

[872] See supra § II.B.3, Upper Confining Unit (UCU) at 20–25; § III.D, Integrity of the UCU at 75–101.

[873] Consolidated Intervenors' New Contentions Based on the Final Environmental Assessment (October 2014) (Jan. 5, 2015) [hereinafter Intervenors' New Contentions].

1. Hydraulic Communication between the BC/CPF Aquifer and Upper Aquifers

Section III discussed the various means by which Intervenors' posited that contaminants could travel from the License Area to the PRIR. Consequently, we have already presented the parties' positions on the topics relating to the first part of Contention D, i.e., the alleged hydraulic communication between the BC/CPF and the Upper Aquifers, including: (1) the integrity of the UCU and the possibility of fracturing within the License Area; (2) the transmissive nature of the White River Feature; (3) the Brule Aquifer's water levels during mining; and (4) Crow Butte's aquifer pumping tests, which were designed to test the adequacy of the BC/CPF Aquifer's confinement. Accordingly, we do not reiterate the parties' positions on those topics here, but rather set forth our findings on the first part of Contention D immediately below.

a. Board Findings on Communication between the BC/CPF and Upper Aquifers

We find that the characteristics and integrity of the UCU demonstrate that the UCU provides more than adequate containment of the contaminants associated with Crow Butte's mining operations within the Ore Zone of the BC/CPF.[874]

i. Board Findings on Fracturing/Secondary Porosity

Although Intervenors' witnesses presented testimony (not disputed by any party) of mapped lineaments within the License Area, we have previously found that Dr. LaGarry's aerial photographic interpretation technique is not conclusive as to whether there is fracturing in the License Area.[875] Instead, we found that mapped lineaments resulting from aerial photographic

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[874] See supra § II.B.3, Upper Confining Unit (UCU) at 20–25; § III.D, Integrity of the UCU at 75–101.

[875] See supra § III.D.2.a, Board's Findings on Lineaments at 96–97.

interpretation must be confirmed with visual observations of stratigraphic outcrops of a linear feature.[876]

Likewise, we have previously found that there is insufficient evidence of fractures in the UCU within the License Area[877] but that, even were it possible for contaminants from Crow Butte's mining operation to migrate to other aquifers because of fracturing, any such migration would be severely limited because of the inward groundwater gradients that Crow Butte maintains during mining and restoration operations.[878] Finally, we have previously found that, based on monitoring results of private wells near the License Area that provide drinking water from the Upper Brule Aquifer, there have been no changes in water quality during the period of Crow Butte's mining operations within the License Area.[879]

ii. Board Findings on the White River Feature

We have previously found that the White River Feature is more likely a fold than a fault.[880] Nevertheless, whether we characterize it as a fold, rather than as a fault, is not outcome determinative here because the critical issue for resolving this contention is the actual transmissivity of the White River Feature.[881] In this regard, both Crow Butte and the NRC Staff presented compelling evidence that: (1) the White River Feature is not sufficiently transmissive

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[876] See supra § III.D.2.a, Board Findings on Lineaments at 96–97; see also supra § III.D.1.a, Parties' Positions on Lineaments at 76–80.

[877] See supra § III.D.2.b, Board Findings on Secondary Porosity/Permeability from Fracturing at 97–99.

[878] See supra § III.D.2.b, Board Findings on Secondary Porosity/Permeability from Fracturing at 97–99; see also Ex. NRC-001-R at 21.

[879] See supra § III.E.2.b, Board Findings on Operational Groundwater Impacts to Private Wells at 113; see also EA § 4.6.2.2.6 at 94.

[880] See supra § III.B.2, Board Findings on the Structure of the White River Feature at 150–53.

[881] See supra § III.B.2, Board Findings on the Structure of the White River Feature at 150–53; see also Ex. CBR-001 at 23–25; Ex. NRC-095 at 22; Tr. at 1173, 1187, 1192.

to act as a significant conduit for the migration of contaminants from Crow Butte's mining operations; and (2) to the extent there is any contaminant migration from Crow Butte's mining operation, the lengthy travel time and distance from the License Area to the White River Feature would significantly reduce the concentration of such contaminants in the groundwater.[882]

iii. Board Findings on Differences in Potentiometric Surfaces and Geochemistry

We have previously found that a comparison of historical groundwater levels shows there has been little change in the potentiometric elevations in the Upper Brule Aquifer since Crow Butte initiated its mining operations on the License Area.[883] Similarly, we have previously found that the potentiometric level of the BC/CPF Aquifer has decreased about 47 feet over the same time period.[884] Finally, we have previously found that, because the potentiometric level in the Upper Brule Aquifer did not decline in tandem with the BC/CPF Aquifer, the two are not likely in communication.[885] For these reasons, we find that the Upper Brule Aquifer and the BC/CPF Aquifer are not in significant transmissive communication.

With respect to geochemistry, we have previously found that there are distinct differences in geochemistry between the water quality in wells screened in the Upper Brule Aquifer and wells screened in the BC/CPF Aquifer.[886] For this reason as well, we find that the Upper Brule Aquifer and the BC/CPF Aquifer are not in significant transmissive communication.

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[882] See supra § III.B.2, Board Findings on the Structure of the White River Feature at 150–53; see also Ex. NRC-001-R at 38–39.

[883] See supra § III.D.2.c, Board Findings on Brule Aquifer Water Levels During Mining at 99–101; see also EA § 4.13.6.2.3 at 132; SER § 3.1.3.5.6 at 61.

[884] See supra § III.D.2.c, Board Findings on Brule Aquifer Water Levels During Mining at 99–101; see also EA § 4.13.6.2.3 at 132; SER § 3.1.3.5.6 at 61.

[885] See supra § III.D.2.c, Board Findings on Brule Aquifer Water Levels During Mining at 99–101.

[886] See supra § III.D.2.c, Board Findings on Brule Aquifer Water Levels During Mining at 99–101; see also EA § 4.13.6.2 at 128; SER § 2.4.3.2.2 at 41; LRA, tbl. 2.2-9, at 2-28.

iv. Board Findings on Aquifer Pumping Tests

We have previously found that because there was no groundwater response in any of the Upper Brule Aquifer observation wells, Crow Butte's four aquifer pumping tests demonstrate the impermeable nature of the UCU.[887] Likewise, we have previously found that, after comparing Crow Butte's actual drawdown data collected from BC/CPF Aquifer wells with the predicted values derived from Crow Butte's aquifer pumping test results, the predicted values consistently overestimate the actual drawdown.[888] We also previously found that, after taking these together, even though the aquifer pumping test results assume a simplified representation of the hydrogeology in and near the License Area, they do provide a conservative overestimate of the drawdowns from Crow Butte's consumptive use rates.[889] In regards to the small aquifer recharge observed in some aquifer pumping test data, the NRC Staff's witnesses attributed this recharge to the extensive stress applied to the confining units during these aquifer pumping tests.[890] We agree and find that the NRC Staff properly confirmed that all four aquifer pumping tests showed that virtually no leakage occurred through the 200 feet to 500 feet thick UCU, and that the Upper Brule Aquifer and the BC/CPF Aquifer are not in any significant transmissive communication.[891]

v. Board Findings on Potential Pathways for Communication between Aquifers

We have previously found that it is unlikely that contaminants from the License Area would reach the White River Feature or the White River alluvium either directly through fractures

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[887] See supra § III.C.2, Board's Findings on Aquifer Pumping Testing at 73–75.

[888] See supra § III.C.2, Board's Findings on Aquifer Pumping Testing at 73–75.

[889] See supra § III.C.2, Board's Findings on Aquifer Pumping Testing at 73–75.

[890] Ex. NRC-076-R2 at 38.

[891] See supra § III.C.2, Board Findings on Aquifer Pumping Testing at 73–75; see also Ex. NRC-076-R2 at 38.

in the UCU or more indirectly via the Upper Brule Aquifer because (1) there is insufficient record evidence of fractures in the UCU that could provide a significant transmissive connection between the BC/CPF Aquifer and either the White River or the Upper Brule Aquifer; and (2) Crow Butte is required to maintain an inward hydraulic gradient and to monitor for and correct excursions.[892] As we have previously found, other than the White River Feature (which we have found to be a non-transmissive fold), there is insufficient evidence of specific, field-verified fractures in the vicinity of the License Area that would permit contaminant migration along the pathways suggested by Intervenors' witnesses.[893] We have also previously found that it is unlikely contaminants could flow northeasterly through fractures in the UCU to the Arikaree Aquifer and then migrate another 50 miles or so to the nearest of the PRIR wells.[894] Finally, we agree with Dr. LaGarry that because of the presence of the Pierre Shale forming the Chadron Arch, it is extremely unlikely that there could be lateral migration of contaminants from the License Area, over or through the Chadron Arch, and then on to the PRIR.[895] For these reasons, we find that there is insufficient evidence of significant pathways for contaminants to travel from the License Area to the PRIR.

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[892] See supra § III.F.1.b, Board Findings on the First Pathway: License Area to White River Feature to White River Alluvium at 120–23; § III.F.2.b, Board Findings on Second Pathway: Northeasterly Flow to the PRIR at 131–32; § III.F.3.b, Board Findings on Third Pathway: Northwesterly Flow from License Area to BC/CPF Outcrops to the PRIR at 134.

[893] See supra § III.F.1.b, Board Findings on the First Pathway: License Area to White River Feature to White River Alluvium at 120–23; § III.F.2.b, Board Findings on Second Pathway: Northeasterly Flow to the PRIR at 131–32; § III.F.3.b, Board Findings on Third Pathway: Northwesterly Flow from License Area to BC/CPF Outcrops to the PRIR at 134.

[894] See supra § III.F.3.b, Board Findings on Third Pathway: Northwesterly Flow from License Area to BC/CPF Outcrops to the PRIR at 134.

[895] See Tr. at 2582–83.

vi. Board Findings on Impacts to Drinking Water on the PRIR

We have previously found that, in addition to there being no credible northeasterly pathway from the BC/CPF Aquifer to the drinking water aquifers on the PRIR, the elevated levels of uranium in the PRIR wells were most likely caused by naturally-occurring uranium and are not the result of contaminants migrating to the PRIR from the License Area. This finding is supported by the following facts: (1) the activity ratios of U-234 to U-238 in the PRIR well water are within the range typically encountered in groundwater in that area; and (2) the Th-234 detected in the PRIR wells could not have originated in the License Area due to the long travel time that would vastly exceed its half-life.[896] For these reasons, we find there is insufficient evidence that uranium decay-chain radioactive constituents detected in the PRIR wells could be attributed to Crow Butte's mining operation.

b. Summary of Board Findings on Hydraulic Communication between the Aquifers

Based on the preceding, we find that the EA, as supplemented by record evidence from this proceeding, is not deficient with respect to this portion of Contention D.

2. Expansion of Environmental Justice Analysis to Consider Impacts to PRIR Drinking Water

a. Parties' Positions on the Expansion of Environmental Justice Analysis to Consider Impacts to PRIR Drinking Water

The second portion of Contention D concerns Intervenors' claim that the EA's Environmental Justice analysis is inadequate because it does not consider whether contaminants from Crow Butte's operations within the License Area have the potential to impact water in the PRIR,[897] and, in fact, have already impacted the water quality in wells at the PRIR.[898] As a result, Intervenors assert that the EA is deficient because it failed to evaluate

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[896] See supra § III.F.2.b, Board Findings on Second Pathway: Northeasterly Flow to the PRIR at 131–32.

[897] See LBP-15-11, 81 NRC at 451, app. A.

[898] Ex. OST-001 at 7–8.

Environmental Justice from the impacts of contaminated groundwater on the minority group that resides on the PRIR. Intervenors claim that the EA erroneously limited its review area to a radius of four miles around the Crow Butte facility, where it did not identify any minority or low-income populations, and, as a result, they claim a more detailed analysis is required in the EA.[899]

Based on this limited radius of four miles, the NRC Staff's witnesses testified that impacts to surface and groundwater would be SMALL, and opined that there would be no significant impacts and thus no Environmental Justice impacts.[900] The NRC Staff relied on a guidance document ("Environmental Review Guidance for Licensing Actions Associated with NMSS Programs," NUREG-1748), which recommends a four-mile radius for Environmental Justice considerations.[901] In the estimation of the NRC Staff's witnesses, there was no basis for expanding its Environmental Justice analysis beyond this four-mile radius because of the absence of any documented impact from Crow Butte's surface and groundwater quality data (presented in semiannual effluent and environmental monitoring reports and the regulatory oversight of the License Area) during Crow Butte's over 20-year operating history.[902]

Crow Butte's witnesses argued that there are no impacts beyond the mining area, much less 50 miles away at the nearest PRIR wells, and that there was no resulting need for the NRC Staff to conduct an Environmental Justice analysis for the PRIR.[903]

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[899] See Intervenors' New Contentions at 47.

[900] Ex. NRC-001-R at 51–52.

[901] Id. at 49–50 (citing Ex. NRC-014, NUREG-1748 at C-4).

[902] Id.

[903] Ex. CBR-001 at 55.

b. Board Findings on Expansion of Environmental Justice Analysis to Consider Impacts to PRIR Drinking Water

We have previously found that there is insufficient evidence that the uranium and thorium detected in the drinking water on the PRIR is anything other than a natural constituent of the groundwater endemic to the region.[904] Likewise, we have previously found that there is insufficient evidence that contaminants from Crow Butte's mining operation could be the source of this radioactivity, given the confining properties of the UCU, the inward gradients maintained within the License Area, the geographical distance between the License Area and the PRIR translating into a travel time for Th-234 that far exceeds its 24-day half-life, and the lack of a plausible pathway for contaminant migration during Crow Butte's 20-plus years of mining in the License Area.[905] Based on these findings, we further find that the absence of radioactive elements in PRIR drinking water that can be tied to Crow Butte's mining activities precludes the need for the NRC Staff to expand its Environmental Justice analysis for impacts that are implausible.[906] We therefore conclude that the EA, as supplemented by record evidence from this proceeding, is not deficient with respect to the Environmental Justice portion of Contention D and that there is no need for considerations in the EA to be expanded beyond the four-mile radius that NUREG-1748 recommends.

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[904] See supra § III.F.2.b, Board Findings on Second Pathway: Northeasterly Flow to the PRIR at 131–32.

[905] See supra § III.F.2.b, Board Findings on Second Pathway: Northeasterly Flow to the PRIR at 131–32.

[906] Private Fuel Storage L.L.C. (Indep. Spent Fuel Storage Installation), CLI-02-25, 56 NRC 340, 348 (2002) (stating that NEPA only requires a discussion of "reasonably foreseeable impacts" and that courts have excluded "remote and speculative impacts" from NEPA analysis); see also Nuclear Regulatory Commission, Final Policy Statement: "Policy Statement on the Treatment of Environmental Justice Matters in NRC Regulatory and Licensing Actions," 69 Fed. Reg. 52,040, 52047 (Aug. 24, 2004) ("The agency's assessment of environmental justice-related matters has been limited in the context of EAs . . . . If there will be no significant impact as a result of the proposed action, it follows that an [Environmental Justice] review would not be necessary.").

D. Contention F – Recent Research on Hydrogeology

Contention F asserts that Crow Butte and the NRC Staff: (1) failed to consider recent research on geology and hydrogeology by using the antiquated "layer cake" concept in characterizing the geologic strata at the License Area;[907] and (2) ignored recent interpretations of the stratigraphic formations at and near the License Area by continuing to use "outdated nomenclature" when referring to the lower aquifer found on-site at the License Area as the "Basal Chadron Formation" rather than accepting Intervenors' preferred term, the "Chamberlain Pass Formation."[908] We address each below.

1. Parties' Positions on Failure to Include Recent Research

a. Parties' Positions on Layer Cake Concept

Dr. LaGarry and Dr. Kreamer testified that Crow Butte and the NRC Staff improperly applied the "layer cake concept" that was in vogue from the 1930s to the 1960s and under which geologists assumed that rock layers: (1) exhibited uniform thickness and uniform lithology, and (2) spread out in all directions.[909] Dr. LaGarry stated that these assumptions resulted here in an overestimation of the areal extent and thickness of stratigraphic units pertinent to the License Area,[910] opining that "recent mapping of the geology of northwestern Nebraska has shown that the simplified, 'layer cake' concept that was applied by geologists before the 1990s is incorrect, and overestimates the thickness and areal extent of many formations by 40-60%."[911] Dr. LaGarry further criticized Crow Butte and the NRC Staff for ignoring that, with the advent of plate tectonics and the recognition of local uplifts, geologists

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[907] See Ex. INT-003 at 3; Ex. INT-069 at 2–3; Tr. at 1068–70.

[908] See Ex. INT-003 at 3; Tr. at 1054–55.

[909] Ex. INT-003 at 3; Ex. INT-069 at 2–3; Tr. at 1068–70.

[910] Ex. INT-003 at 3; Ex. INT-069-at 2–3; Tr. at 1068–70.

[911] Ex. INT-003 at 3.

now view rock layers not as uniform, but as discontinuous and pinching out in lateral directions.[912]

To counter Dr. LaGarry's criticism in this regard, the NRC Staff's witnesses testified that cross-sections in the LRA (Figures 2.6-4 to 2.6-11) provide the best depiction of the stratigraphy at, and in the vicinity of, the License Area.[913] Specifically, the NRC Staff's witnesses (supported by Crow Butte's witnesses) maintained that, rather than assuming a uniform thickness and lateral extent, the LRA's estimate of the thickness of the geologic units at each mine site in the License Area was based on thousands of exploration and development boreholes that more accurately characterize the lithologic and geophysical characteristics of the subsurface strata.[914] As a result they (along with Crow Butte's witnesses) asserted that, in lieu of a simple "layer cake" system, the stratification suggested in the LRA was based on direct measurements of the extent of each geologic formation from site-specific explorations.

The NRC Staff's witnesses also claimed that Crow Butte's well logs and other hydrogeological data characterization (e.g., aquifer pumping tests, water level measurements, core testing) justified the grouping of the regional stratigraphic units according to their similar hydrogeological properties. According to the NRC Staff's witnesses, rather than employing the uniform hydrogeologic characterization of a "layer cake model," Crow Butte's approach measured and incorporated the actual properties of the geologic formations, and that this accordingly provides a far more accurate depiction of the strata's non-uniformity.[915] The NRC Staff's witnesses also asserted that "analysis of ground water flow systems typically relies on

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[912] Id.; Ex. INT-069-at 2–3; Ex. INT-082-R at 5; Tr. at 1069.

[913] Ex. NRC-001-R at 55 (citing to LRA, figs. 2.6-3 to 2.6-11, at 2-109–24).

[914] Id.; Tr. at 1058–60.

[915] Ex. NRC-001-R at 55–56.

the grouping of various regional stratigraphic units that have similar hydrogeological properties" and that "[t]his grouping has been successfully used in hydrogeology and is absolutely necessary as the available measured subsurface data can never be sufficient to capture the true complexity of the geology."[916]

b. Parties' Positions on Nomenclature for the Ore Zone Formation

Though he did not dispute the general characterization of the geologic strata in and around the License Area, Dr. LaGarry maintained that Crow Butte and the NRC Staff failed to incorporate current scientific knowledge that updates the nomenclature and thus the structure for the Ore Zone and ignores recent interpretations of stratigraphic geology of this formation.[917] Specifically, Dr. LaGarry stated that the NRC Staff's use of the term "Basal Chadron Formation," is erroneous and should instead be called the "Chamberlain Pass Formation," in order to acknowledge its separate depositional environment in a separate episode of earth history with different volcanos.[918] As such, he claimed, renaming the Basal Chadron Formation as the Chamberlain Pass Formation is not simply a nomenclatural issue, but is a conceptual issue.[919]

In addition to citing several studies documenting this updated nomenclature,[920] Dr. LaGarry noted that, in the past, when this formation was referred to as the Basal Chadron Formation,[921] it was assumed that the formation had lateral extent and shape equal to that of the overlying Chadron Formation.[922] Instead, Dr. LaGarry opined, the Chamberlain Pass Formation

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[916] Id. at 56.

[917] Tr. at 1054.

[918] Tr. at 1055.

[919] Tr. at 1055.

[920] Tr. at 1058; see generally Ex. BRD-005.

[921] Ex. INT-003 at 3.

[922] Id.

is 1 to 1.5 million years older than the Chadron Formation, and has a lateral extent and shape determined by the ancient topography of the Pierre Shale prior to the deposition of this sandstone layer.[923]

The NRC Staff's witnesses testified that they were aware of the nomenclature revisions that Dr. LaGarry was seeking for the Basal Chadron Formation.[924] They noted that USGS does not identify the Chamberlain Pass Formation in Nebraska, but rather states that the Basal Chadron Formation underlies the Brule Formation.[925] The NRC Staff's witnesses further testified that, even though a 2007 letter from NDEQ[926] initially questioned Crow Butte's outdated nomenclature, NDEQ later referred to this deposit in another proceeding as the "Basal member of the Chadron Formation."[927] Moreover, the NRC Staff's witnesses noted, NDEQ continued to allow Crow Butte to refer to its mined aquifer as the Basal Chadron Formation in order to maintain consistency with historical permitting and to prevent confusion as to where Crow Butte's mining was occurring.[928]

Crow Butte's witnesses agreed that the primary difference in renaming the ore body from the Basal Chadron Formation to the Chamberlain Pass Formation relates to: (1) assumptions regarding the thickness of the Ore Zone as influenced by its depositional history, and (2) a recognition that the varying thickness of this sandstone is determined by the eroded surface of the underlying Pierre Shale.[929] Regardless, Crow Butte's witnesses maintained that nothing in

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[923] Id.

[924] Ex. NRC-001-R at 57 (citing SER § 2.3.3.2 at 33–35).

[925] Id.

[926] See Ex. INT-011 at 1.

[927] Id. (citing Ex. CBR-019 at 1).

[928] Ex. CBR-019, attach. C, at 3.

[929] Ex. CBR-001 at 32.

the naming conventions for the geologic units in Nebraska (and specifically in the License Area) changes the basic interpretation of the physical or hydraulic features of the subject rock units.[930] According to Crow Butte's witnesses, this is because, in lieu of relying on historical assumptions assigned to the Basal Chadron Formation regarding the thickness of the Ore Zone, Crow Butte actually determined the thickness and shape of this sandstone unit at each mine site in the License Area, based on the lithologic and geophysical characteristics shown by over 10,000 boreholes in the License Area.[931]

Even after acknowledging the value of consistency with historic nomenclature and of Crow Butte's collection of actual data to define the thickness and shape of this sandstone layer, Dr. LaGarry still advocated for the use of current concepts in science as a means to demonstrate due diligence.[932] Nevertheless, Dr. LaGarry ultimately conceded that he saw no harm in combining the terms as "Basal Chadron/Chamberlain Pass Formation" (which we have abbreviated herein as "BC/CPF") when referring to this Ore Zone in order to maintain the appropriate historical context for this proceeding.[933] While the NRC Staff's witness, Mr. Back, agreed with Dr. LaGarry's professional opinion on the differing depositional environments between the Basal Chadron and the Chamberlain Pass Formations, he testified that such differences are immaterial with respect to the performance of the mine.[934] Nevertheless, Mr. Back (as well as Crow Butte's witnesses) indicated there was no harm in calling this deposit the "Chamberlain Pass Formation."[935]

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930 Id. at 10, 55–56.

931 Tr. at 1059; Ex. CBR-001 at 32; see also LRA § 2.6.2.2 at 2-127–28.

932 Tr. at 1060.

933 Tr. at 2570–71.

934 Tr. at 1055.

935 Tr. at 1071.

c. Parties' Positions on EPA Documents

In addition to Intervenors' arguments concerning the layer cake concept and the proper nomenclature of the formation containing the Ore Zone, we stated, at the time we admitted this contention, that Intervenors "offer[ed] the comments and recommendations of Paul Robinson, Research Director for Southwest Research and Information Center, who notes that two of Crow Butte's references in the [LRA] were Environmental Protection Agency guidance documents for groundwater monitoring (from 1974 and 1977) that he claims are out of date and that more recent and appropriate guidance documents (from 1992 and 2000) should have been used."[936] These "outdated" EPA documents were initially utilized by Crow Butte in its preoperational baseline groundwater quality data submitted in conjunction with its initial 1987 license application to mine the License Area.[937] In disputing Intervenors' claim in this regard, the NRC Staff's witnesses testified that Crow Butte's LRA referred to these EPA documents because they were applicable at the time of Crow Butte's original baseline measurements, and, accordingly, the EA's references to them were provided only for historical context and not in support of the EA's conclusions with respect to Contention F.[938]

2. Board Findings on Failure to Include Recent Research

a. Board Findings on Layer Cake Concept

We find that neither the LRA nor the EA assumed a "layer cake concept" of on-site stratigraphy with uniform thickness and limits, as Intervenors suggest. Instead, the EA adopted

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[936] LBP-08-24, 68 NRC at 739 (citing Ex. INT-005, Paul Robinson, Southwest Research and Information Center, Comments and Recommendations Regarding the "Application for 2007 License Renewal USNRC Source Materials License SUA-1534 Crow Butte License Area" (July 28, 2008)).

[937] See LRA § 2.9.1 at 2-275; see also Ex. NRC-001-R at 59.

[938] Tr. at 1651–52; Ex. NRC-001 at 59; see also LRA § 2.9.1 at 2-275; Ex. NRC-037 at 4.4(80).

the characterization of this formation that appears in the LRA,[939] and we find that it adequately analyzed the stratigraphy and hydrostratigraphy of the License Area. Through its actual field measurements, we find that Crow Butte illustrated a variation in thickness and areal extent of the various subsurface strata over the License Area and justified the grouping of the regional stratigraphic units according to their similar hydrogeological properties.[940]

b. Board Findings on Nomenclature for the Ore Zone Formation

We find that there are sound scientific arguments supporting the characterization of the geologic formation overlying the Pierre Shale as having a different depositional era and formation history than that associated with what has historically been called the Basal Chadron Formation. We further find that these arguments warrant the use of the updated name "Chamberlain Pass Formation" and anticipate that the geologic community will eventually accept this nomenclature to describe this sandstone deposit.

The name selected for this strata, however, has little practical impact on the resolution of the contentions in this proceeding because (1) the EA referenced the actual lithologic and geophysical characteristics measured from Crow Butte's numerous boreholes to define the thickness and shape of the subject deposit (rather than making any assumptions based on its depositional origins), and (2) there is no evidence that the Chamberlain Pass Formation has significantly different hydrogeologic properties (as characterized by Crow Butte's LRA for the License Area)[941] than those possessed by the Basal Chadron Formation (at least as they pertain to Intervenors' arguments with respect to this contention). Furthermore, while the NRC Staff's witnesses were not willing to change the EA's nomenclature for this deposit, i.e., "the

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[939] LRA, figs. 2.6-4 to 2.6-11, at 2-111–19.

[940] EA, tbl. 3-5, at 38.

[941] See LRA § 2.6.2.2 at 2-127–28; id. § 2.7.2.1 at 2-171–93.

Basal Chadron," unless and until the USGS officially were to adopt the name suggested by Dr. LaGarry, i.e., "the Chamberlain Pass Formation in Nebraska,"[942] they did acknowledge that the deposit is the result of a completely different formational process than had originally been envisioned.

In recognition of these competing interests, we have accordingly acknowledged both terms for historical context and due diligence to updated nomenclature by referring to the lower aquifer overlying the Pierre Shale as the Basal Chadron/Chamberlain Pass Formation or BC/CPF throughout in this decision.

c. Board Findings on EPA Documents

We find, based on the testimony of the NRC Staff's witnesses, that Crow Butte properly used the two relevant EPA documents in conjunction with its preoperational baseline groundwater quality data, which were provided in its initial 1987 license application, and that the EA's subsequent references to these EPA documents were provided solely for historical context.

E. Contention 6 – Short-Term NEPA Impacts from Consumptive Groundwater Use during Restoration

In Contention 6, Intervenors assert: "The Final EA violates the National Environmental Policy Act in concluding that the short-term impacts from consumptive ground water use during aquifer restoration are MODERATE."[943] The EA predicts that overall groundwater consumption will increase once restoration activities commence,[944] and that the greatest depletion of groundwater will occur during the "sweep" phase of Crow Butte's restoration because, at that time, water from the BC/CPF Aquifer will be removed and, rather than being returned to the

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[942] Tr. at 1653.

[943] LBP-15-11, 81 NRC at 451, app. A.

[944] EA § 4.6.2.3 at 96.

BC/CPF Aquifer, is injected into one of two deep underground injection wells, thereby reducing the concentrations of hazardous constituents in the BC/CPF Aquifer.[945] This contention asserts that the impact will instead be LARGE and that the EA inadequately discusses the magnitude of both excessive consumptive use of groundwater and the resulting drawdown of the groundwater levels in destabilizing the BC/CPF Aquifer during restoration.[946] Each of these impacts is discussed in the following sections.

1. Parties' Positions on Short-Term NEPA Impacts from Groundwater Use During Restoration

a. Parties' Positions on Groundwater Impacts from Consumptive Use

The EA defines consumptive use as groundwater that is pumped from the BC/CPF Aquifer but that is not returned to that aquifer because it is disposed of elsewhere.[947] During mining operations, Crow Butte's actual pumping rate is higher than its consumptive use rate because most of its pumped water is returned to the BC/CPF Aquifer and is therefore not "consumed."[948] According to the EA, Crow Butte consumes 35 to 105 gpm of groundwater during its production activities.[949]

To assess the impact of water consumption required for restoration activities, the NRC Staff used data provided by Crow Butte to perform both "a water-balance analysis"[950] and a

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[945] Id.

[946] Intervenors' Joint Position Statement at 109.

[947] See EA § 4.6.2.2.1 at 87–88; see also Office of Federal and State Materials and Environmental Management Programs, Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities, NUREG-1910, § 4.2.4.2.2.2 at 4.2-21 (May 2009) [hereinafter ISL Mining GEIS].

[948] See EA § 4.6.2.2.1 at 88.

[949] Id.

[950] Id. § 4.6.2.3 at 96 (citing SER § 5.7.9.4). Although the EA mistakenly cites to SER § 5.7.9.4, the water balance is actually found elsewhere, i.e., SER § 3.1.3.5.6.

"drawdown analysis."[951] These analyses, which are discussed in the SER, state that restoration of a single mine unit will require the consumptive use of at least 11 pore volumes[952] (a pore volume is a measurement of the total volume of water residing in the voids in a given rock or sedimentary body) of groundwater, but that the ore-bearing body for that mine "should still remain saturated" (i.e., the pore spaces in the formation will remain filled with water) even during restoration.[953] The EA concludes that the short-term impacts from restoration are elevated to MODERATE because (1) Crow Butte may need to extract more than 11 pore volumes of water for the restoration of each mine unit, thus extending Crow Butte's restoration schedule; and (2) Crow Butte's greater-than-expected consumptive use rates could increase the drawdown in the potentiometric surface of the BC/CPF Aquifer.[954] Nonetheless, the EA goes on to state that the potentiometric levels would eventually recover after restoration of the BC/CPF Aquifer is complete, and so there would be an overall SMALL impact from long-term consumptive groundwater use.[955]

Intervenors' witnesses, however, disputed this, arguing that the short-term impacts should be LARGE[956] because the EA significantly understates the quantity of water that will be required for restoration.[957] Intervenors' witnesses assert in this regard that Crow Butte would

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[951] Ex. NRC-001-R at 86–88; see also § SER 3.1.3.5.6 at 61.

[952] A pore volume is a measurement of the total volume of water residing in the voids in a given rock or sedimentary body. See LRA § 6.1.4.2 at 6-22.

[953] EA § 4.6.2.3 at 96; see also Ex. CBR-008, Initial Written Testimony of Crow Butte Resources Witnesses Doug Pavlick, Larry Teahon, and Robert Lewis on Contentions 6 and 9 at 22–23 (May 8, 2015).

[954] EA § 4.6.2.3 at 96.

[955] Id.

[956] Intervenors' Joint Position Statement at 109.

[957] Ex. INT-069 at 7–8; Ex. INT-070 at 2–4.

need to use more than 11 pore volumes to restore a given mine unit because a much larger volume—more than 36 pore volumes—was required to restore Mine Unit 1.[958] In particular, given the challenges that Crow Butte encountered in restoring Mine Unit 1, Mr. Wireman maintained that the EA should have presented information about Crow Butte's planned future restoration efforts for its remaining mine units, including the number of pore volumes that would be required at each restoration stage.[959]

In response, Crow Butte's witnesses testified that Crow Butte learned valuable lessons from Mine Unit 1's restoration, and that this experience has been incorporated into its Model-Based Restoration Plan (MBRP).[960] In particular, they claim that Crow Butte's MBRP has led to "significant improvements in restoration efficiency for Mine Units 2, 3, 4, and 5 to date," and, accordingly, that these mines will not require the number of pore volumes that were needed to restore Mine Unit 1.[961] Crow Butte's witnesses further testified that the MBRP "has been refined and expanded as restoration has progressed . . . [which has] greatly improved restoration efficiency [for each future mine unit] by strategically focusing on water that needs to be treated and minimizing water that is treated multiple times."[962]

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[958] Intervenors' Joint Position Statement at 109; Ex. INT-050, Crow Butte Resources, Inc., Response to U.S. Nuclear Regulatory Commission Request for Additional Information, Mine Unit 1 Groundwater Restoration Completion, Crow Butte Uranium Project § 2.2.1 at 3 (Aug. 24, 2001).

[959] Ex. INT-047 at 8; Ex. INT-070 at 3–4.

[960] Ex. CBR-008 at 18–21. Specifically, Crow Butte's witnesses described Crow Butte's MBRP as a site-specific groundwater model that employs the USGS's MODFLOW-2000 as a base algorithm and enables Crow Butte to plan and track its restoration of individual mine units in the License Area. Tr. at 1356–58; see also Ex. CBR-008 at 18–20; Ex. CBR-045 at 19; Ex. CBR-041, Worley Parsons, Wellfield Restoration Modeling Crow Butte Resources Mine Units 2–5 at 1 (Feb. 2009).

[961] Id.

[962] Ex. CBR-052, Rebuttal Testimony of Crow Butte Resources Witnesses Doug Pavlick, Larry Teahon, and Robert Lewis on Contentions 6 and 9 at 7 (June 8, 2015).

Nonetheless, Intervenors' witnesses opined that increases in consumptive use will further reduce the available potentiometric head in the BC/CPF, which, in turn, impacts groundwater receptors (e.g., private wells, surface waters, and wetlands).[963] Specifically, these impacts include decreasing the yield from private wells placed in the BC/CPF and depleting the volume of discharges from the aquifer downgradient of the mine, thereby impacting surface waters and wetlands.[964] The NRC Staff's witnesses, on the other hand, maintained that the BC/CPF Aquifer is not crucial for maintaining surface water flow or wetlands, and asserted that the testimony of Intervenors' witnesses did not designate any private well that had been affected by Crow Butte's operational drawdown of the potentiometric levels in the BC/CPF Aquifer.[965]

Intervenors' witnesses also claimed that reducing the available potentiometric head may affect Crow Butte's uranium recovery operations, induce or increase downward leakage from the overlying Upper Brule Aquifer, and decrease well yields and discharges from the BC/CPF Aquifer downgradient of the mine.[966] Yet, Intervenors' witnesses did not identify any specific well or surface water body that was influenced by Crow Butte's increased consumptive use and its associated potentiometric drawdown during restoration.

Under examination at the hearing, Mr. Back testified that, in order for the short-term impact level to be increased from MODERATE to LARGE, Crow Butte would have to destabilize the aquifer (i.e., pumping at a rate that exceeds recharge flow of the aquifer such that the water in the aquifer is depleted).[967] However, Mr. Back continued, while, in theory, Crow Butte could

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[963] See Ex. INT-081 at 4–5; Ex. INT-082 at 4; Ex. INT-083, Rebuttal Statement of Mickel Wireman at 1–2 (Sept. 27, 2015); Tr. at 1690, 2603.

[964] See Ex. INT-081 at 4–5; Ex. INT-082 at 4; Ex. INT-083 at 1–2; Tr. at 1690.

[965] See Ex. NRC-095 at 8.

[966] Ex. INT-081 at 4–5; Ex. INT-082 at 4; Tr. at 1690, 2600–02.

[967] Tr. at 1408–09; see also Ex. NRC-076-R2 at 64–65.

dramatically increase the pumping rate to speed up the restoration process, other factors would prevent this from occurring. Specifically, Mr. Back testified that if Crow Butte lowered the potentiometric surface below the top of the BC/CPF Aquifer, Crow Butte would need to pump significantly more water to maintain the necessary radius of influence, which would affect the entire Crow Butte mining operation within the License Area.[968] Simply put, Crow Butte has a strong operational incentive not to lower the potentiometric surface below the top of the BC/CPF Aquifer, a fact acknowledged by Dr. Kreamer.[969]

As the NRC Staff's witnesses opined, even if the BC/CPF Aquifer level dropped below the top elevation of the BC/CPF Aquifer and part of this aquifer became desaturated, the impact would not necessarily become LARGE as long as Crow Butte's consumptive use rates remained below the sustainable yield of the aquifer such that the groundwater was not being depleted.[970] In this instance, the groundwater resource would not become destabilized, and the impact would not be greater than MODERATE, because the primary impact of reducing the potentiometric head in the aquifer would be the increased energy costs needed to pump from the lower potentiometric levels.[971] Therefore, the NRC Staff's witnesses maintained that decreasing the potentiometric level below the top of the BC/CPF would be a necessary, but not sufficient, condition for a LARGE groundwater quantity impact—and that this could only occur if Crow Butte's pumping rates were sufficient to dewater (i.e., destabilize) the BC/CPF Aquifer by exceeding its sustainable yield once unconfined.[972]

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[968] Tr. at 1407–08.

[969] Tr. at 1451–52.

[970] Tr. at 1408–09.

[971] Ex. NRC-095 at 8.

[972] Id.

b. Parties' Positions on Available Potentiometric Head in the BC/CPF Aquifer during Restoration

Intervenors' witness Mr. Wireman testified that Crow Butte's rate of consumptive use has the potential to impact the BC/CPF Aquifer by lowering its potentiometric levels which, in turn, would reduce the water pressure in this aquifer.[973] Specifically, he stated that Crow Butte's ISL mining, restoration, and water treatment operations have required the withdrawal of large volumes of groundwater from the BC/CPF Aquifer, which, in turn, has already lowered the available potentiometric head in this aquifer.[974] Mr. Wireman maintained that, as a result of this, there is a difference in available potentiometric head in the BC/CPF Aquifer that ranges from 250 feet to 300 feet in the central and southeastern parts of the License Area to less than 150 feet in the northwestern part of the License Area.[975]

Crow Butte's witnesses presented evidence that, even after the more than 20 years of Crow Butte's continuous pumping of the BC/CPF Aquifer in the License Area, the available head within various mine units ranges from 147 feet in the northwest part of the License Area to 435 feet in the southeast part of the License Area (based on August 2015 data).[976] In the LRA, Crow Butte also predicted potential impacts on the potentiometric surface in the BC/CPF Aquifer for private water wells outside of the License Area, using an expected consumptive use rate of 105 gpm,[977] and calculated that the highest percentage that the available water level would be reduced due to consumptive water use is 16.7 percent, with an average drawdown in the

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[973] Ex. INT-081 at 1.

[974] Id. at 1, 4–5.

[975] Id.

[976] Ex. CBR-062.

[977] Ex. NRC-059, Crow Butte Resources, Inc., LRA Responses to NRC Request for Additional Information, Technical Review, License Renewal Amendment Request, Source Material License SUA-1534 at 2–13 (May 2009).

surrounding the wells of nine percent.[978] As part of their response to a 2009 Request for Additional Information from the NRC, Crow Butte compared actual drawdown data collected from surrounding wells in the BC/CPF Aquifer with its predicted values, and in every instance the predictive values overestimated the actual measured drawdown.[979]

With respect to Mr. Wireman's concern about the lower potentiometric head measured in the northern portion of the License Area,[980] Crow Butte's witnesses asserted that this lower head results from the natural decrease in the thickness of the geologic strata caused by the orientation of surface topography and the underlying geologic surfaces of the Pierre Shale and the BC/CPF Aquifer.[981] To illustrate this point, Crow Butte presented an exhibit that depicts a cross-section through the License Area.[982] Crow Butte's witnesses claimed that this exhibit illustrated that the decrease in the available drawdown in the northern portion of the License Area is caused by the fact that: (1) the surface topography drops several hundred feet in elevation from the south end to the north end of the License Area; (2) the Pierre Shale surface rises from south to north by about 100 feet; and (3) the potentiometric level of the BC/CPF Aquifer drops only minimally from south to north.[983]

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[978] Id. at 10.

[979] Id. at 11–13; id., tbl. 2A, at 13; see also Ex. NRC-087.

[980] Ex. INT-081 at 1–4.

[981] Ex. CBR-074 at 8–9.

[982] Id. at 9.

[983] Id.

We have previously discussed the NRC Staff's "water-balance" and "drawdown" analyses,[984] referenced in its EA,[985] performed to determine whether the BC/CPF Aquifer would remain saturated during restoration.[986] Using its water balance analysis as described in both the EA and SER,[987] the NRC Staff's witnesses estimated that its historical average consumptive use rate of 105 gpm decreased the potentiometric levels within the BC/CPF Aquifer by approximately 47 feet between 2002 and 2010,[988] or about ten percent of the available potentiometric head above the top of the BC/CPF.[989] For an estimated consumptive use rate of 210 gpm, the NRC Staff calculated a drawdown of approximately 108 feet.[990] To lower the head an additional 147 feet (i.e., the lowest potentiometric head currently available in the BC/CPF Aquifer),[991] the NRC Staff estimated it would require a consumptive use rate of 495 gpm.[992]

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[984] See supra § IV.E.1.a, Parties' Positions on Groundwater Impacts from Consumptive Use at 177–82.

[985] EA § 4.6.2.2.1 at 87–88; id., § 4.6.2.3 at 96; id., § 4.13.6.2.2 at 130–32.

[986] Ex. CBR-008 at 8, 22–23.

[987] EA § 4.6.2.3 at 96 (NRC Staff noted that the section reference to the SER in its EA is inaccurate with the correct cite being SER § 3.1.3.5.4 at 59); SER § 3.1.3.5.4 at 59–60.

[988] Ex. NRC-001-R at 86–87.

[989] SER § 3.1.3.5.6 at 61.

[990] Ex. NRC-095 at 7.

[991] Ex. CBR-062; see also Ex. NRC-095 at 8.

[992] Ex. NRC-095 at 7–8. In regards to estimating the consumptive pumping rate required to drop the potentiometric levels below the top of the BC/CPF Aquifer, the lowest available head in the License Area existing in the northern part of the Ore Zone as of 2015 was 147 feet. See Ex. CBR-062. At the time this available head was estimated, the aquifer potentiometric level had been drawn down 108 feet from pre-mining levels due to about 210 gpm of consumptive use. This value was calculated by comparing the measured head nearest this location in 1983 to the measured head in 2015. In 1983, the measured head was 3,746 feet. See Ex. NRC-058, Crow Butte Resources, Inc., Regional Water Level Map Basal Chadron Sandstone 1982-1983, Figure 2.7-4a at 1 (2009) (selecting the value for RC4). The measured head was 3,638 feet in 2015. See Ex. CBR-062 (using average of the 2015 water levels in CM10-26 of 3,639 feet and CM10-1 of 3,637 feet). This drawdown for the pumping rate means that 1.944 gpm of pumping will result in one foot of head drop in the potentiometric level. Using this linear relationship between

Witnesses for both the NRC Staff and Crow Butte asserted that this use rate is not realistic for two reasons: (1) Crow Butte's historic consumptive use rates are significantly less than this rate; and (2) the limitations on waste disposal capacity (whether by deep well injection or by surface water evaporation from existing ponds)[993] preclude higher consumptive use.[994] Crow Butte's witnesses emphasized that no new mine units are to be commissioned in the License Area, and, as such, not only are pumping rates at or near their projected maximum, but, in addition, those pumping rates will decline as production concludes in each mine unit and restoration is completed.[995] Crow Butte's witnesses added that "[l]icensed flow rates for operations are insufficient to lower the water level to that point. There is more than ample available head to accommodate the remaining wellfield production and restoration activities, particularly since consumption/pumping will only be reduced going forward as mine unit operations are sequentially shut down."[996]

In summary, Crow Butte's witnesses opined that the EA correctly concludes that the environmental impacts of increased consumptive use during restoration would not rise above MODERATE for four separate reasons: (1) the peak rate of 495 gpm needed to drop the potentiometric level below the top of the BC/CPF Aquifer is not realistic given on-site conditions, licensed flow rates, and disposal capacity;[997] (2) the current 210 gpm consumptive use flow rate

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drawdown and pumping rates for the confined BC/CPF Aquifer, see Ex. NRC-001-R at 88, pumping the potentiometric level down to the top of the BC/CPF Aquifer (i.e., a total of 255 feet from the sum of the available head, 147 feet, and measured drawdown, 108 feet at this location), would require a consumptive use rate of close to 495 gpm. See Ex. NRC-095 at 7–8.

[993] Ex. NRC-001-R at 86–87, 100.

[994] Ex. NRC-095 at 8; Ex. CBR-074 at 8; Tr. at 2499.

[995] Ex. CBR-067 at 7.

[996] Id.

[997] Ex. CBR-074 at 8; Tr. at 2499.

is insufficient to lower the potentiometric level of the BC/CPF Aquifer to the critical levels envisioned in Mr. Wireman's opinion; (3) there currently is sufficient available potentiometric head in the BC/CPF Aquifer to accommodate all of Crow Butte's production, and restoration activities; and (4) consumptive use will continue to be reduced going forward as Crow Butte shuts down each mine unit operation and completes its restoration in a sequential fashion.[998]

2. *Board Findings on Short-Term NEPA Impacts from Consumptive Groundwater Use During Restoration*

Our findings on the groundwater impacts from consumptive use and on the available head in the BC/CPF are set forth below.

a. *Board Findings on Groundwater Impacts from Consumptive Use*

Regarding Intervenors' witnesses' assertion that the EA does not address the impacts of Crow Butte's mining operation on either public use of the BC/CPF Aquifer or on other groundwater receptors,[999] we find there is insufficient record evidence to establish widespread public use of the BC/CPF Aquifer. Of the 19 private wells within a mile of the License Area, only one is placed in the BC/CPF Aquifer.[1000] Although Intervenors were afforded the opportunity to present evidence that other private wells rely on this formation and have been impacted by Crow Butte operations, they offered none. Mr. Back testified that the NRC Staff had "never received any correspondence from any individual indicating that their well is no longer pumping water at the same rate."[1001] At the same time, we find that the evidence presented during the hearing clarifies and augments the EA's consideration of public use.

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[998] Ex. CBR-067 at 7.

[999] Tr. at 1687–88.

[1000] See Tr. at 1685.

[1001] Tr. at 1418.

In a similar vein, we find there is insufficient record evidence to establish that the drawdown of the BC/CPF Aquifer has impacted any surface water or wetlands receptors. Intervenors did not identify any specific receptors (e.g., wetlands, streams, etc.) in the area of outcrops where the BC/CPF Aquifer discharges to the ground surface that had been, or would be, impacted as a result of any reduction in the available potentiometric head of the BC/CPF Aquifer due to Crow Butte's increased consumptive use.

b. Board Findings on Available Potentiometric Head in the BC/CPF and Destabilizing the BC/CPF Aquifer during Restoration

We also find there is insufficient evidence to support Intervenors' claim that the NRC Staff's current estimated consumptive rate of 210 gpm[1002] would lower the potentiometric level below the top of the BC/CPF Aquifer. Furthermore, we find that, even were the potentiometric level to drop below the top of the BC/CPF Aquifer, the aquifer would not necessarily be destabilized. In addition, we find it is unrealistic that Crow Butte would employ the estimated consumptive rate of 495 gpm needed to draw down the aquifer level to the top of the BC/CPF Aquifer, given the consumptive use rates historically used by Crow Butte within the License Area and the limitations on disposal capacity.

We find that Intervenors' concerns about reducing the available potentiometric head in the BC/CPF (i.e., adversely affecting Crow Butte's uranium recovery operations, potentially inducing or increasing downward leakage from the overlying Upper Brule Aquifer and decreasing well yields and discharge from the BC/CPF Aquifer downgradient of the mine) are unsupported by record evidence. First, we find it unlikely that Crow Butte's mining operations will lower the potentiometric head below the top of the BC/CPF Aquifer and turn this confined aquifer into an unconfined one. As Intervenors' witnesses themselves agreed,[1003] Crow Butte

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[1002] Ex. NRC-095 at 7.

[1003] Tr. at 1451–52.

has a strong operational incentive not to lower the potentiometric surface below the top of the BC/CPF Aquifer because doing so would require Crow Butte to pump significantly more water to maintain the necessary radius of influence, which would adversely affect Crow Butte's entire mining operations.[1004] Second, we find it unlikely that Crow Butte would employ an estimated pumping rate of 495 gpm (required to drawdown the level to the top of the sandstone), given Crow Butte's historic consumptive use rates and its limitations in treatment capacity.[1005] But, even if this were to occur, we find that lowering the potentiometric head below the top of the BC/CPF Aquifer and rendering this confined aquifer into an unconfined aquifer would not, in-and-of-itself, destabilize the BC/CPF Aquifer. The NRC Staff's testimony demonstrated that it is unlikely Crow Butte's consumptive use rate will ever exceed the sustainable yield of the BC/CPF Aquifer.[1006]

With regard to increasing the downward leakage from the overlying Upper Brule Aquifer into the BC/CPF Aquifer, we previously have found that there is no record evidence pointing to a permeable connection between these two aquifers due to the integrity of the thick UCU.[1007] And, regarding the impacts on well yields and discharges to surface water, we find that there is no record evidence that Crow Butte's mining operations on the License Area, ongoing for more than 20 years, have affected existing wells and surface water features. We further find that there is no record evidence that Crow Butte's mining operations on the License Area will affect existing wells and surface water features in the future, given that Crow Butte's consumptive use rates are at or near their projected maximum, with no new mine units to be commissioned.

[1004] Tr. at 1407–08.

[1005] See SER § 3.1.3.5.4 at 59.

[1006] Tr. at 1408–09; Ex. NRC-095 at 7–8.

[1007] See supra § III.D.2, Board Findings on the Integrity of the UCU at 96–101.

We find that, based on historical flow rates, Crow Butte may have to extract more than 11 restoration pore volumes for each mine unit and thus the EA reasonably concludes that Crow Butte's restoration schedule may extend beyond the dates Crow Butte anticipates needing for restoration.[1008] We further find that while the BC/CPF Aquifer should remain saturated during this time, the EA properly concludes that such an extension of the restoration periods, as well as greater than expected consumptive use rates, could significantly increase the drawdown in the potentiometric level in this aquifer.[1009]

We find that the EA, as supplemented by record evidence in this proceeding, did not err in concluding that the short-term environmental effects from consumptive water use rise to the level of MODERATE because the restoration schedule may be extended, should Crow Butte need to process more than 11 pore volumes of water for the restoration of each mine unit. We further find that the EA correctly concludes that there would not be a LARGE impact in the short-term, as there is no evidence Crow Butte's consumptive use rate would be sufficient to destabilize the BC/CPF Aquifer. We also find that the EA, as supplemented by the record evidence, correctly concludes that the long-term effects are SMALL because the water levels in the BC/CPF Aquifer will eventually recover after Crow Butte's aquifer restoration is complete.[1010] In sum, we find that there is sufficient record evidence to support the EA's conclusions that the short-term environmental effects from restoration are MODERATE, and that the long-term effects are SMALL.[1011]

[1008] EA § 4.6.2.3 at 96.

[1009] Id.

[1010] Id.

[1011] Id.

3. Discrepancies in the NRC Staff's Understanding of Restoration Activities

We find nothing in the evidence and testimony proffered in this proceeding to contradict the testimony of witnesses for both Crow Butte and the NRC Staff that Crow Butte's consumptive use of the groundwater for more than 20 years at the License Area has not significantly changed the hydrogeological conditions at the License Area, based on the absence of change in wellfield operations, aquifer groundwater levels, and environmental monitoring data.

But, having said this, we also find that the EA incorrectly describes Crow Butte's restoration plans,[1012] and that this error was repeated in the pre-filed testimony of the NRC Staff's witnesses.[1013] Specifically, the description of Crow Butte's restoration plans in the EA suggests that Crow Butte will employ a four-phase restoration cycle, in which the first, or transfer phase, consists of the exchange of groundwater between a new mine unit and a mine unit at the end of production, in order to lower the concentrations of total dissolved solids.[1014] The EA also suggests that this is followed by an independent sweep phase that consumes all of the water used in the transfer phase.[1015] Yet, during the hearing, Mr. Teahon testified that Crow Butte's restoration plan no longer includes a transfer phase because all mine units are in production with the last mine unit, Mine Unit 11, having gone into production in 2014.[1016] Additionally, Crow Butte now operates an integrated sweep-and-treatment phase rather than

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[1012] See id.

[1013] See Ex. NRC-001-R at 85.

[1014] Id.; EA § 2.3.1 at 23; id. § 4.6.2.3 at 95–96.

[1015] EA § 2.3.1 at 23; id. § 4.6.2.3 at 95–96.

[1016] Tr. at 1735–36.

these being separate phases, which results in a different water consumption profile than that described in the EA.[1017]

Licensing boards frequently hold hearings on contentions challenging the NRC Staff's final environmental review documents, and in such cases, "[t]he adjudicatory record and Board decision (and . . . any Commission appellate decisions) become, in effect, part of the [agency's final environmental analysis]."[1018] In such instances, a licensing board's primary concern is to ensure that the environmental impacts of the proposed action are adequately described in those environmental review documents. Insofar as this can be achieved with the adjudicatory record curing deficiencies in the EA, there is no need to return the EA to the NRC Staff to correct such deficiencies.[1019] That is the case here. While the EA incorrectly describes Crow Butte's restoration processes, additional record evidence at the hearing supplements the EA to correct this error and supports the EA's conclusion that consumptive use during Crow Butte's restoration will produce a MODERATE environmental impact. Accordingly, we hereby supplement and correct the EA to note that Crow Butte uses an integrated sweep-and-treatment phase and no longer uses a separate transfer phase in its restoration activities.[1020]

[1017] Tr. at 1731–37; cf. EA § 4.6.2.3 at 95–96.

[1018] Nuclear Innovation N. Am. LLC (S. Texas Project, Units 3 & 4), CLI-11-6, 74 NRC 203, 208–09 (2011) (quoting La. Energy Servs., CLI-98-3, 47 NRC at 89 and Philadelphia Elec. Co. (Limerick Generating Station, Units 1 & 2), ALAB-819, 22 NRC 681, 705–07 (1985)).

[1019] See Entergy Nuclear Operations, CLI-15-6, 81 NRC at 388.

[1020] We note one final discrepancy revealed at the hearing concerning restoration activities that may require action by the NRC Staff. License Condition 10.6 requires that Crow Butte's restoration activities for Mine Units 1 through 5 meet the schedule set forth in an NRC Staff letter dated February 18, 2010. See Ex. NRC-012 at 8 (License Condition 10.6) (citing Letter from NRC Staff to Crow Butte, Regarding Request for Alternate Decommissioning (Groundwater Restoration) Schedule (Feb. 18, 2010) (ADAMS Accession No. ML092510030) [hereinafter Decommissioning Letter]). Although the NRC Staff stated in that February 18, 2010 letter that restoration for Mine Unit 4 would be completed by January 1, 2015, see Decommissioning Letter at 3, Mine Unit 4 was still in the treatment phase of restoration during the August 2015 hearing. Tr. at 1748. Consequently, Crow Butte is not in compliance with its

F. Contention 9 – Failure to Address Groundwater Restoration Mitigation Measures

Contention 9, as admitted, states: "The Final EA violates 10 C.F.R. §§ 51.10, 51.70 and 51.71, and the National Environmental Policy Act and implementing regulations by failing to include the required discussion of ground water restoration mitigation measures."[1021] Intervenors primarily argue that the post-restoration water quality levels required by Crow Butte's renewed license are unclear and insufficient to return the area to baseline (i.e., pre-operation) water quality levels.[1022]

According to the EA, "[t]he purpose of aquifer restoration is to return the ground water quality in the production zone to compliance with the [NRC's] ground water protection standards in 10 C.F.R. Part 40, Appendix A, Criterion 5B(5)."[1023] The EA explains that Crow Butte can meet these Criterion 5B(5) standards in one of three ways: (1) returning the groundwater constituents to their original pre-mining level (i.e., "the Commission-approved background concentration"); (2) bringing those constituents below the values listed in Table 5C of 10 C.F.R. Part 40, Appendix A; or (3) meeting an "alternate concentration limit" (ACL) for those constituents that is "as low as reasonably achievable, after considering practicable corrective actions."[1024] The EA does not discuss which of these three standards Crow Butte will meet,

License Condition 10.6 obligations as set forth in the NRC Staff's letter. Accordingly, we expect that the NRC Staff to expeditiously address Crow Butte's noncompliance on this issue.

[1021] LBP-15-11, 81 NRC at 451, app. A.

[1022] Intervenors' Joint Position Statement at 113–19; see also Consolidated Intervenors' Rebuttal Statement at 12 (June 8, 2015).

[1023] EA § 4.6.2.3 at 95.

[1024] Id.; 10 C.F.R. pt. 40, app. A, crit. 5B(6).

much less how it will do so. Rather, the EA merely asserts that by meeting these standards, Crow Butte's operations will have a "negligible" environmental impact.[1025]

1. Parties' Positions on Failure to Address Groundwater Restoration Mitigation Measures

Mr. Wireman and Dr. Kreamer testified that Crow Butte cannot meet its restoration goals.[1026] Mr. Wireman maintained that the water quality levels required by Crow Butte's renewed license are unclear and could be undercut if Crow Butte obtains ACLs.[1027] He also pointed to Mine Unit 1 as an example of how difficult restoration can be, noting that Crow Butte failed to achieve restoration standards for many groundwater constituents, including "radium 226, uranium, cadmium, chloride, manganese, sulfate and [total dissolved solids]."[1028] Although Crow Butte implemented its new MBRP for all subsequent mine restoration projects,[1029] Dr. Kreamer asserted that: (1) Crow Butte's LRA did not adequately discuss that model or its updates; (2) the MBRP model is inadequate; and (3) the MBRP modeling that Crow Butte undertook is insufficient.[1030] In his estimation, Crow Butte's use of models and data analysis relied on assumptions of uniformity, homogeneity, and isotropy, none of which the EA adequately justifies.[1031]

Crow Butte's witnesses disputed Dr. Kreamer's criticism of its MBRP modeling by asserting that Crow Butte accounted for the hydrologic limitations mentioned by Dr. Kreamer, by

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[1025] EA § 4.6.2.3 at 95. Crow Butte must meet these standards under its renewed license. Ex. NRC-012 at 8 (License Condition 10.6).

[1026] See Ex. INT-046 at 4; Ex. INT-047 at 7–8; Ex. INT-070 at 2–4.

[1027] Ex. INT-047 at 8; Ex. INT-070 at 2–4.

[1028] Ex. INT-047 at 7.

[1029] See Ex. CBR-041.

[1030] Ex. INT-069 at 7–8.

[1031] Ex. INT-046 at 2–3.

taking into account heterogeneity, non-uniform thickness, and other measured conditions at the License Area. In particular, Crow Butte's witnesses maintained that its "groundwater flow model was calibrated to pre-mining conditions using water level data collected prior to the mining activities in January 1983 and subsequently has been validated through observation of the site-wide aquifer response during production and restoration."[1032] Crow Butte's witness, Mr. Lewis, testified that, in order to develop the actual surface elevations of the geologic formations in the License Area, Crow Butte's MBRP restoration analysis model incorporated actual values of the geologic stratigraphy from about 5,000 production and injection wells.[1033] In 2009, Crow Butte simulated the flow conditions on a site-wide basis, taking into account heterogeneity, non-uniform thickness, and other conditions from boreholes and wells that had been installed at the License Area during the entire period of Crow Butte's mining operations.[1034] Subsequently, Mr. Lewis stated that this data was updated to add the holes that had been drilled and the wells that had been installed after 2009.[1035]

Intervenors also challenged whether Crow Butte's restoration program accurately determines baseline water quality values, includes the appropriate list of hazardous groundwater constituents, and provides a sufficient monitoring timeline to assure compliance with applicable standards.[1036] With respect to baseline water quality values, Dr. Kreamer testified that the values used by Crow Butte "were not exclusively sampled and measured in a

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[1032] Ex. CBR-008 at 20.

[1033] Tr. at 1360–61, 1373. Mr. Lewis testified that, within the License Area, a total of 4,530 exploration and development holes have been completed, and an additional 6,330 mining and monitoring wells have been installed. Ex. CBR-045 at 17.

[1034] Ex. CBR-052 at 6–7; Ex. CBR-041.

[1035] Tr. at 1373.

[1036] Intervenors' Joint Position Statement at 17–19, 22–23, 43–46.

[true] pre-mining, pre-drilling, and unperturbed environment," but were instead sampled while other mine units were operating, and thus would have been influenced by the nearby mines.[1037] For this reason, Dr. Kreamer asserted that Crow Butte should instead have used regional baseline constituent values.[1038] Finally, with respect to the restoration standards themselves, Mr. Wireman asserted that the current license allows Crow Butte to rely on Nebraska's more lenient "Class of Use" standards, instead of restoring the mines to the NRC's Criterion 5B(5) standard.[1039]

After acknowledging that Crow Butte had difficulty restoring Mine Unit 1, the NRC Staff's witnesses maintained that the lengthy restoration process for Mine Unit 1 (and the more successful, recent restorations of Mine Units 2 and 3) demonstrated that, ultimately, Crow Butte's mitigation measures (including frequent testing, leak detection systems, and spill contingency plans)[1040] were successful because they brought the groundwater quality in the Ore Zone of the BC/CPF Aquifer back to baseline, or at least to safe, levels.[1041] The NRC Staff's witnesses also maintained that Intervenors' concerns about Nebraska's "Class of Use" standards were rendered moot when the NRC Staff issued a Regulatory Information Summary in 2009 that concluded Nebraska's "Class of Use" standards conflicted with the more stringent levels required by Criterion 5B(5).[1042] Further, Dr. Striz emphasized that meeting the Criterion

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[1037] Ex. INT-046 at 4.

[1038] Id.

[1039] Ex. INT-047 at 7.

[1040] Ex. NRC-001-R at 93–94.

[1041] Ex. NRC-076-R2 at 68–69, see Ex. NRC-086, Letter from Larry Teahon, Manager of Safety, Health, Environment, and Quality, Crow Butte Operation, to Ronald A. Burrows, Project Manager, Decommissioning and Uranium Recovery Licensing Directorate, NRC at 7, 11 (Aug. 8, 2013).

[1042] Ex. NRC-001-R at 95 (citing Ex. NRC-061, Office of Federal and State Materials and Environmental Management Programs, NRC Regulatory Information Summary 2009-05, 5B(5) standards is a condition in Crow Butte's renewed license[1043] that applies to all of its mine units, including those in restoration and stabilization, i.e., Mine Units 2 through 11.[1044]

Although Crow Butte's witnesses, Mr. Pavlick, Mr. Teahon, and Mr. Lewis, asserted that Crow Butte viewed the Criterion 5B(5) standards as applying only to Mine Units 7 through 11,[1045] Mr. Teahon testified at the hearing that Crow Butte will comply with the Criterion 5B(5) requirements for Mine Units 2 through 11, as stated by Dr. Striz.[1046] Crow Butte's witnesses further testified that, insofar as Crow Butte seeks ACLs, any "request for approval would be by a future license amendment application."[1047] This position was confirmed at the hearing by Dr. Striz, who further stated that such an amendment request for ACLs would afford members of the public an opportunity to challenge that request.[1048] In regards to using regional baseline water quality, Crow Butte's witnesses, Mr. Teahon and Mr. Pavlick, maintained that the constituent concentrations in the Ore Zone of the BC/CPF Aquifer are fundamentally different from those found elsewhere in this aquifer.[1049]

Crow Butte's witnesses also presented a chart to demonstrate that there is no rising trend in baseline groundwater constituent concentrations for the subsequently-opened mine

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Uranium Recovery Policy Regarding: (1) The Process For Scheduling Licensing Reviews of Applications For New Uranium Recovery Facilities and (2) The Restoration Of Groundwater at Licensed Uranium In Situ Recovery Facilities (Apr. 29, 2009)).

[1043] Ex. NRC-012 at 8 (License Condition 10.6).

[1044] Tr. at 1847–48.

[1045] Ex. CBR-052 at 14; see also Ex. CBR-008 at 9–10.

[1046] Tr. at 1878–79.

[1047] Ex. CBR-008 at 11.

[1048] Tr. at 1849–50.

[1049] LRA § 2.7.3 at 2-214; Ex. CBR-052 at 8.

units as compared to earlier mine units.[1050] The NRC Staff's witnesses accepted Crow Butte's data in this regard as support for their opinion that baseline values at these newer mine units were not affected by ongoing operations because Crow Butte maintained an inward gradient in all of its mine units that prevented mobilized groundwater constituents from migrating out of an operating mine unit into adjacent mine units.[1051]

The LRA states that Crow Butte's process for developing baseline values includes sampling baseline water quality wells every four acres, collecting three samples per well, and taking each sample 14 days apart.[1052] Intervenors' witness Dr. Kreamer asserted that this is inadequate, arguing that Crow Butte monitors too few groundwater constituents in its restoration program, and, in particular, does not sample for uranium.[1053] Witnesses for both the NRC Staff and Crow Butte testified that uranium is one of the groundwater constituents that must be monitored in accordance with Criterion 13 of 10 C.F.R. Part 40, Appendix A, and that it is listed as such in Crow Butte's renewed License Conditions 10.6 and 11.3.[1054] Intervenors' witnesses also asserted that Crow Butte's post-restoration monitoring program is flawed, and that, as a consequence, the EA does not adequately evaluate whether Crow Butte has restored, or will restore, its mine units to the levels required by Criterion 5B(5).[1055]

[1050] Ex. CBR-052 at 10 (citing Ex. CBR-057, Mine Unit Average for Baseline (undated)).

[1051] Ex. NRC-076-R2 at 72–73.

[1052] LRA § 6.1.3.1 at 6-5.

[1053] See Ex. INT-069 at 6.

[1054] Tr. at 1875–79; see also Ex. NRC-012 at 11 (listing uranium as an element to be monitored in License Condition 11.3).

[1055] Ex. INT-046 at 3–4; Ex. INT-069 at 6.

2. Board Findings on Failure to Address Groundwater Restoration Mitigation Measures

a. Board Findings on Crow Butte's Restoration Requirements

Intervenors' concern that Crow Butte intended to rely on the more lenient Nebraska "Class of Use" standards for restoration of Crow Butte Mine Units 2 through 6 was not resolved until the hearing, when Dr. Striz and Mr. Teahon confirmed that Crow Butte's renewed license requires all of Crow Butte's mine units that have not completed restoration (Mine Units 2 through 11) to comply with the Criterion 5B(5) standards.[1056] Although the Commission did accept NDEQ's "Class of Use" standards for Mine Unit 1 under the terms of Crow Butte's 2003 license,[1057] the Commission abandoned this approach with its issuance in 2009 of a Regulatory Interpretation Summary document.[1058] Because both the NRC Staff's and Crow Butte's witnesses testified that Crow Butte's renewed license obligates it to meet the Criterion 5B(5) standards, we find that restoration of Mine Units 2 through 11 are governed by the Criterion 5B(5) requirements and not by the more lenient Nebraska "Class of Use" standards that were applied to Mine Unit 1.

b. Board Findings on Criterion 5B(5) and Environmental Impact

Intervenors' witness Dr. Kreamer asserted that Crow Butte lacks mine-specific baseline data for restoration and so instead should use regional baseline data.[1059] Contrary to Dr. Kreamer's call for the use of regional data, however, we find that the evidence presented by two of Crow Butte's witnesses, Mr. Teahon and Mr. Pavlick, demonstrated that the constituent concentrations in the Ore Zone of the BC/CPF Aquifer are fundamentally different from those

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[1056] Tr. at 1848–49, 1878–79; <u>see also</u> SER § 6.1.3.1 at 154–55.

[1057] Tr. at 1848; LRA, tbl. 1.7-1, at 1-13.

[1058] Ex. NRC-001-R at 95 (citing Ex. NRC-061).

[1059] Ex. INT-046 at 4.

found elsewhere in this aquifer, due in part to the high uranium concentrations that made the License Area appealing as a site for a uranium ISL mine.[1060] As a result, we find that the use of regional baseline constituent values in this instance would be inappropriate. Also, on balance, we find that data provided by Crow Butte and the NRC Staff support Crow Butte's methodology for determining baseline values, and, as such, the EA is not in error in accepting Crow Butte's approach.[1061]

Based on the record evidence presented relating to the number of constituents the NRC Staff requires to be monitored to comply with its restoration program, the Board finds that Crow Butte's selection of parameters to test for groundwater contamination and its obligation to continue to test for those parameters in its renewed license is sufficient to detect migration of groundwater constituents, including uranium.

In regards to Intervenors' witnesses' assertion that Crow Butte's post-restoration monitoring program is flawed, we find that this assertion is belied by the renewed license (License Condition 10.6), which states that post-stabilization monitoring is required, not for a mere six months, but rather "until the data show the most recent four consecutive quarters indicate no statistically significant increasing trend for all constituents of concern which would lead to an exceedance above the respective Criterion 5B(5) standard."[1062] In effect, this license condition requires a minimum of 12 months of post-stabilization monitoring. Moreover, Mr. Teahon testified that Mine Units 2 and 3 have actually been in stabilization monitoring for more

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[1060] LRA § 2.7.3 at 2-214; Ex. CBR-052 at 8.

[1061] See EA § 3.5.2.4 at 52–53; id. § 4.6.2.2.4 at 91–92.

[1062] Ex. NRC-012 at 8 (License Condition 10.6); see also Ex. NRC-088, Letter from Daniel Gillen, Director, NRC Office of Nuclear Material Safety and Safeguards, Division of Fuel Cycle Safety and Safeguards, Fuel Cycle Facilities Branch, to Michael Griffin, Manager of Environmental and Regulatory Affairs, Crow Butte Resources, Inc. at 5 (Feb. 12, 2003).

than 12 months—in fact, they have been in stabilization monitoring for nearly two years.[1063] Contrary to Intervenors' concerns, the Board finds that there is no record evidence suggesting that 12 months is an insufficient amount of time to account for rebound effects.

c. Board Findings on Feasibility of Restoration to Criterion 5B(5) Standards

Intervenors next argued that Crow Butte cannot meet the Criterion 5B(5) limits. In support of this claim, Intervenors pointed to Mine Unit 1 as an example of a failed restoration effort that was not discussed in the EA.[1064] We find that Intervenors are correct that the EA neither mentioned any of the challenges that Crow Butte faced in restoring Mine Unit 1 nor acknowledged that Crow Butte did not return the subject aquifer to levels that would be consistent with the Criterion 5B(5) standards.[1065] In addition, neither the EA nor the SER discuss the MBRP modeling that Crow Butte instituted as a result of the difficulties it encountered with restoring Mine Units 1, 2, and 3.[1066]

At the hearing, however, witnesses for both the NRC Staff and Crow Butte testified that Crow Butte's MBRP modeling has achieved satisfactory restoration of the portion of the BC/CPF Aquifer affected by individual mine units and that as a consequence, this experience justifies the likely success of Crow Butte's future restoration plans.[1067] In particular, Mr. Teahon testified that

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[1063] Tr. at 1745–48. Mr. Teahon indicated, however, that some of that extended monitoring period for these two mine units was due to additional requirements imposed, not by the NRC Staff, but by NDEQ. Tr. at 1746.

[1064] Intervenors' Joint Position Statement at 115–16; Ex. INT-047 at 6–8; Ex. INT-069 at 6–7; Ex. INT-070 at 3.

[1065] See EA § 4.6.2.3 at 94–96.

[1066] See id.; SER § 6.1 at 154–61.

[1067] See, e.g., Ex. NRC-076-R2 at 63; Ex. CBR-008 at 15–16; Ex. CBR-052 at 4–7; Tr. at 1356–65, 1777, 1783–84.

Mine Units 2 and 3 have already achieved the Criterion 5B(5) background restoration requirements using this plan, and that Crow Butte would soon submit reports to that effect.[1068]

We find that the NRC Staff and Crow Butte presented sufficient evidence at the hearing to satisfactorily address Intervenors' specific concerns about the difficulties Crow Butte encountered with restoring Mine Unit 1, i.e., the measures Crow Butte implemented in its restoration of Mine Units 2 and 3, based on its experience with Mine Unit 1.

3. Summary of Board Findings on Contention 9 – Failure to Address Groundwater Restoration Mitigation Measures

The record evidence of this proceeding established that Crow Butte is required to restore Mine Units 2 through 11 to the Criterion 5B(5) standards under License Condition 10.6, and that while the EA's analysis of this was deficient, the NRC Staff's testimony cured such deficiencies and supported the EA's Finding of No Significant Impact.[1069] Appendix A of 10 C.F.R. Part 40 ensures that there will be no significant impact because affected groundwater either must be restored to its original water quality or must be returned to a level that the Commission has found "pose[s] no incremental hazards."[1070] We emphasize that our conclusion that the NRC Staff has met its burden of proof in showing no significant environmental impact rests on the fact that Crow Butte cannot rely on ACLs under the terms of its current renewed license.[1071] Should Crow Butte seek an ACL in the future, such a request will require a license amendment

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[1068] Tr. at 1746–48.

[1069] EA § 4.6.2.3 at 96.

[1070] 10 C.F.R. pt. 40, app. A, criterion 5B(6); see also Uranium Mill Tailings Regulations; Conforming NRC Requirements to EPA Standards, Final Rule, 50 Fed. Reg. 41,852, 41,852–83 (Oct. 16, 1985).

[1071] Tr. at 1849–50, 1858–59; SER § 6.1.4 at 159–61; see also Cleveland Elec. Illuminating Co. (Perry Nuclear Power Plant), CLI-96-13, 44 NRC 315 (1996); cf. Strata Energy, LBP-15-3, 81 NRC at 119–20, 133.

application, a NEPA review appropriate for a license amendment, and an opportunity for interested persons to challenge such an amendment through an evidentiary hearing.[1072]

G. Contention 12 – Tornadoes and Land Application of ISL Wastewater

Contention 12 contains two topics—tornadoes and land application of ISL wastewater. We address them separately because they rely on different testimony and evidence. The first part of this contention, designated Intervenors' Contention 12A, as previously narrowed, asserts that "[t]he Final EA omits a discussion of the impact of tornadoes on the license renewal area."[1073] The LRA briefly discusses tornadoes in a section on wind hazards and concludes that tornadoes are "rare in the License Area."[1074] The EA does not discuss tornadoes or the possible environmental impacts of tornadoes.[1075]

The second part of Intervenors' Contention 12, as previously narrowed, asserts that the Final EA "inadequately discusses the potential impacts from land application of ISL mining wastewater."[1076] Intervenors' primary focus in this contention is on the potential impacts of selenium on wildlife.[1077]

[1072] See Tr. at 1849–50.

[1073] LBP-15-11, 81 NRC 451, app. A.

[1074] LRA § 2.5.5 at 2-92 (citing Ex. BRD-012, Office of Nuclear Material, Final Generic Environmental Impact Statement on Uranium Milling, NUREG-0706 (Sept. 1980) [hereinafter Ex. BRD-012, NUREG-0706]). Although the LRA refers to the draft of NUREG-0706 (NUREG-0511), there is no difference between the draft and final versions of this NUREG with respect to the topic of tornadoes. Tr. at 1969–71.

[1075] See Ex. NRC-001-R at 98–99.

[1076] LBP-15-11, 81 NRC at 451, app. A.

[1077] Id. at 438.

1. Contention 12A - Tornadoes

a. Parties' Positions on Contention 12A - Tornadoes

Intervenors' challenge to the adequacy of the EA's discussion of tornadoes is based on the difference between the LRA, which presented a value for the risk of tornadoes, and the EA, which does not.[1078] While Intervenors presented no evidence in support of the tornado portion of this contention, this is not by itself fatal to Contention 12A because the NRC Staff bears the ultimate burden of proof for showing that it complied with NEPA.[1079]

The NRC Staff's witness Mr. Goodman confirmed that the EA does not include a discussion of wind effects related to tornadoes because the NRC Staff determined there was a low probability that tornadoes would occur in the License Area.[1080] Similarly, Crow Butte's witness, Mr. Teahon, testified that the probability of a tornado strike in the License Area is "very low," approximately 1 in 48,000.[1081] He added that Crow Butte maintains NRC-approved emergency plans on-site that could be applied if a tornado hit the License Area.[1082]

b. Board Findings on Contention 12A - Tornadoes

We find that the NRC Staff's witnesses adequately explained why the EA omits tornadoes and provided sufficient evidence that tornadoes do not pose a significant environmental impact. Although not discussed in the EA, the NRC Staff covered the probability of a tornado strike in the SER and relied on Crow Butte's estimate of an annual probability value

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[1078] Id. at 437.

[1079] Duke Power Co. (Catawba Nuclear Station, Units 1 & 2), CLI-83-19, 17 NRC 1041, 1049 (1983).

[1080] Ex. NRC-001-R at 98–99 (citing Ex. NRC-014, NUREG-1748 § 6.3.6 at 141–43; Ex. NRC-017, NUREG/CR-6733 § 4.6 at 4-55–56).

[1081] Ex. CBR-010 at 2–3 (citing LRA § 2.5.5 at 2-92).

[1082] Id. at 3–4.

of 1 in 48,000.[1083] This value comes from an NRC guidance document, "Final Generic Environmental Impact Statement on Uranium Milling, Project M-25" (NUREG-0706), and is based on the frequency of tornadoes near Rapid City, South Dakota, which is more than 100 miles from Crawford, Nebraska.[1084] The tornado frequency maps cited in NUREG-0706, however, suggest that tornadoes are approximately twice as likely to occur at Crawford than at Rapid City.[1085] Nonetheless, the Board finds that, even were the probabilities doubled, the overall chance of a tornado strike remains remote.

Furthermore, according to the NRC Staff's witnesses, in drafting this section of the SER, the NRC Staff also considered information in NUREG/CR-6733 ("A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees"), and NUREG-1748 ("Environmental Review Guidance for Licensing Actions Associated with NMSS Programs Final Report") in order to conclude that a site-specific discussion of tornadoes was not necessary in the EA.[1086] NUREG/CR-6733 identifies "the potential widespread release of radioactive material from a tornado strike" as a possible hazard for ISL mining, but nonetheless concludes that tornadoes are not a significant threat to the environment if they strike ISL facilities.[1087] Using data from NUREG-0706 (the Final GEIS on Uranium Milling, which discusses the risk of tornado strikes on uranium milling facilities), NUREG/CR-6733 concluded

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[1083] SER § 7.3.5 at 176 (citing LRA § 2.5.5 at 2-92); Tr. at 1951; Ex. NRC-001-R at 99.

[1084] Ex. BRD-012, NUREG-0706 § 7.1.3.1 at 7-4; see also LRA § 2.5.5 at 2-92; Tr. at 1978.

[1085] Ex. BRD-012, NUREG-0706 § 7.1.6.3.1 at 7-13 (citing Ex. BRD-013, Herbert Conrad Schlueter Thom, Tornado Probabilities, 1963 Monthly Weather Review 730 (1963)).

[1086] Ex. NRC-001-R at 97–99.

[1087] Ex. NRC-017, NUREG/CR-6733 § 4.6 at 4-55–56.

that, even though ISL facility buildings cannot themselves withstand a tornado strike, any resulting release into the air of yellowcake uranium would pose minimal radiological hazards.[1088]

Finally, the SER concluded that Crow Butte had established emergency protocols for natural disasters to reduce public exposure risks, and that the SER deemed these protocols adequate, which removed any need to re-examine them for the current license renewal.[1089] Mr. Teahon testified that Crow Butte's emergency plans address risks posed by tornadoes; Intervenors' witnesses presented no evidence that disputed this testimony.[1090]

It is well-settled that NEPA "does not call for certainty or precision, but an *estimate* of anticipated (not unduly speculative) impacts."[1091] In anticipating these impacts, NEPA only requires a discussion of those impacts that are "reasonably foreseeable;"[1092] i.e., it does not require a discussion of impacts that are "remote and speculative" or that have "a low probability of occurrence."[1093] We find that the record evidence presented during this proceeding supports the NRC Staff's position that tornadoes do not pose a significant environmental impact to the License Area, and, due to the improbability of tornadoes having an impact at the License Area, the NRC Staff did not violate NEPA by failing to discuss tornadoes in the EA. Accordingly, we find that the EA is not deficient in this regard.

1088 Id. at 4-56 (citing Ex. BRD-012, NUREG-0706).

1089 SER § 7.3.5 at 176 (citing Ex. NRC-013, NUREG-1569 at 211, app. A).

1090 Ex. CBR-010 at 3–4; Tr. at 1963.

1091 La. Energy Servs., L.P. (Nat'l Enrichment Facility), CLI-05-20, 62 NRC 523, 536 (2005) (emphasis in original).

1092 Private Fuel Storage, CLI-02-25, 56 NRC at 348.

1093 Id. at 348–49 (internal quotation marks omitted).

2. Contention 12B – Land Application of ISL Wastewater

The EA states that one of Crow Butte's options for handling its ISL wastewater stored in on-site evaporation ponds is to spread such wastewater on the grounds of the License Area, a method called "land application"[1094] or "land irrigation."[1095] The EA, as corrected by an errata, acknowledges that Crow Butte has an NDEQ state permit authorizing land application, which allows such irrigation to occur "during and immediately after wet weather events."[1096] Nevertheless, the EA excludes any discussion of the environmental impacts of land application of ISL wastewater on the grounds that Crow Butte has not used land application as a means for wastewater control in the past and "has not indicated [it] will in the future."[1097]

a. Parties' Positions on 12B - Land Application of ISL Wastewater

Intervenors claim that the EA "fails to properly account for impacts to wildlife resulting from land application of ISL wastes," and that the heavy metals in ISL wastewater, particularly selenium, are highly toxic and hazardous to humans and wildlife.[1098] Intervenors' witness, Ms. McLean, described the heavy metal wastes generated in ISL mining and opined that those metals have toxic human health effects.[1099] She further testified that these metals can become bound to organic compounds, easing their entry to and bioaccumulation in wildlife and

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[1094] EA § 2.4.1 at 25; id. § 2.4.2 at 25; id. § 2.4.3 at 25–26; id. § 4.6.1.3 at 85–86.

[1095] See, e.g., Ex. NRC-012 at 9–10 (License Condition 10.17); SER § 4.2.3.1.1 at 77.

[1096] EA § 2.4.1 at 25; Ex. NRC-092, Errata to the Final Environmental Assessment (July 23, 2015); see also EA § 4.6.1.3 at 85–86; Ex. CBR-043, Nebraska Department of Environmental Quality, Authorization to Discharge Under the National Pollutant Discharge Elimination System (NPDES) (Oct. 1, 2011).

[1097] EA § 4.6.1.3 at 85–86.

[1098] Intervenors' Joint Position Statement at 121–22; see also Ex. INT-048 at 5, 19–20.

[1099] Ex. INT-048 at 5, 19–23; see also Ex. INT-049, PowerPoint Presentation of Linsey McLean (undated).

humans.[1100] In support of Ms. McLean's testimony, Intervenors provided: (1) a 2007 letter from the U.S. Fish and Wildlife Service (FWS) to the NRC concluding that waterborne selenium concentrations above 2 micrograms per liter (µg/L) are potentially hazardous to the health and long-term survival of fish and wildlife;[1101] and (2) a detailed report, issued in 2000, on selenium contamination in a Wyoming community as a result of ISL mining.[1102]

Mr. Goodman for the NRC Staff testified that, even though both Crow Butte's renewed license[1103] and its state-issued NPDES permit[1104] allow Crow Butte to perform land application, the EA's limited discussion of land application of ISL wastewater is nevertheless adequate because Crow Butte "has no current plans for treating and discharging the pond water" via land application.[1105] Even were Crow Butte to use land application, however, Mr. Goodman opined that all impacts to surface waters and wildlife would be SMALL because Crow Butte would still be obligated to meet the concentration limits of its NPDES permit issued by NDEQ and Condition 10.17 of its renewed NRC license, both of which limits selenium concentrations to EPA's primary drinking water standard of 50 µg/L.[1106]

[1100] Ex. INT-048 at 5.

[1101] Ex. INT-018, Letter from Mike Stempel, Assistant Regional Director, Fisheries—Ecological Services, U.S. Dep't of the Interior, to Patrice Bubar, Deputy Director, Division of Intergovernmental Liaison and Rulemaking at 1 (Sept. 5, 2007).

[1102] Ex. INT-019, Pedro Ramirez, Jr. & Brad Rogers, U.S. Fish & Wildlife Service Region 6, Selenium in a Wyoming Grassland Community Receiving Wastewater from an In Situ Uranium Mine (Sept. 2000).

[1103] Ex. NRC-012 at 9–10 (License Condition 10.17). Although Crow Butte's renewed license uses the phrase "disposal by irrigation" its meaning is essentially the same as land application of wastes.

[1104] Ex. CBR-043 at 5.

[1105] Ex. NRC-001-R at 100.

[1106] Id. at 101–02, 105; Ex. NRC-076-R2 at 76–77; see also Ex. CBR-043 at 3–5.

Mr. Goodman further testified that the NRC Staff considered the information in both the 2007 FWS letter and the 2000 FWS report. Mr. Goodman stated that the 2000 FWS report was not applicable to the License Area because the sites it examined had far higher concentrations of selenium in the wastewater—approximately 340 to 450 µg/L—as compared to EPA's primary drinking water standard of 50 µg/L.[1107] But Mr. Goodman did not address the FWS's conclusions in its 2007 letter that waterborne selenium concentrations above 2 µg/L are potentially hazardous to fish and wildlife.

Mr. Teahon testified that Crow Butte does not currently plan to use land application.[1108] Nonetheless, he maintained that, in the event Crow Butte were to commence land application, its wastewater would be "passed through reverse osmosis equipment to remove metals and other contaminants, including selenium," and that the application area would be monitored periodically.[1109] Mr. Teahon also testified that the reverse osmosis process Crow Butte would employ is capable of reducing selenium concentrations down to 1 µg/L or even lower[1110] (which is less than the concentrations that FWS estimated to be potentially toxic to wildlife),[1111] an approach that the SER found not to pose an unacceptable level of risk.[1112]

b. Board Findings on Land Application

We find that there is sufficient record evidence to support Intervenors' claim that selenium in ISL wastewater poses potentially significant risks to wildlife and that this is not discussed in the EA. To be sure, witnesses for Crow Butte and the NRC Staff provided four

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[1107] Ex. NRC-001-R at 103–05 (citing Ex. INT-018; Ex. INT-019).

[1108] Ex. CBR-010 at 4–5; Ex. CBR-054, Rebuttal Testimony of Crow Butte Resources Witness Larry Teahon on Contention 12 at 4 (June 8, 2015).

[1109] Ex. CBR-010 at 5–6; see also Ex. CBR-054.

[1110] Ex. CBR-010 at 5.

[1111] Id. at 10–11.

[1112] Id. at 6–7 (citing SER § 4.2.3.1.1 at 158).

separate rationales to justify their claim that the EA requires no further discussion of the land application—i.e., that: (1) there are no specific hazards on-site at the License Area; (2) Crow Butte lacks current plans to use land application; (3) land application is discussed in documents other than the EA; and (4) there is a 50 μg/L limit imposed by the renewed license. Nevertheless, we conclude that each of these four rationales is inadequate. We address each below.

i. Board Findings on Health Impacts of Selenium

The presence of heavy metals in ISL wastewater is not in dispute. As part of the operations and restoration of an ISL mine, the lixiviant solution injected into the ore-bearing body mobilizes the toxic elements vanadium and radium, as well as "metals such as copper, arsenic, molybdenum, and selenium," thus increasing the concentration of these constituents in groundwater.[1113] These mobilized constituents are removed from the groundwater and are set aside in wastewater, which, according to the EA, can be disposed of either by placement in an existing evaporation pond, injection into an existing deep disposal well, or by land application.[1114] As we have noted, of the constituents present in ISL wastewater, selenium is the primary focus of this contention.[1115]

As is made clear in the FWS letter and report, when ISL wastewater is applied on land, selenium from the wastewater is mobilized and can bioaccumulate in the food chain.[1116] According to FWS, small insects, birds, and fish are especially vulnerable to mobile selenium.[1117] Ms. McLean's testimony and slide presentation at the hearing further amplified

[1113] LRA § 2.7.3 at 2-225.

[1114] EA § 2.2.2 at 9.

[1115] LBP-15-11, 81 NRC at 438.

[1116] Ex. INT-018 at 1; Ex. INT-019 at i, 1, 14.

[1117] Ex. INT-018 at 1–2; Ex. INT-019 at 1–2.

the potential health hazards of ISL wastewater by providing an expanded list of constituents mobilized by ISL mining,[1118] a discussion of the chemical reactivity of selenium and other metals and how they bond to organic chemicals,[1119] and studies on the potential harm to wildlife from selenium.[1120] Based on this information, Ms. McLean opined that the constituents in ISL wastewater can also be harmful to humans, either through direct absorption or through bioaccumulation in the food chain.[1121]

Although witnesses for both the NRC Staff and Crow Butte argued that Intervenors' claims are generic and do not raise site-specific concerns regarding the current License Area,[1122] we find that there is no dispute that Crow Butte's mining operation creates ISL wastewater that would contain the constituents discussed above[1123] and that none of the witnesses for the NRC Staff or Crow Butte disputed the general science on selenium toxicity as set forth in Ms. McLean's testimony.[1124]

We find no legitimate reason for the EA not to have discussed the possible impacts of on-site application of ISL wastewater. Instead, the EA merely notes that land application is an option[1125] and that Crow Butte's renewed license (which refers to land application as "land

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1118 Ex. INT-049 at 4; Ex. INT-048 at 2.

1119 Ex. INT-048 at 2–3; Ex. INT-049 at 9–10.

1120 Ex. INT-049 at 23–27.

1121 Ex. INT-048 at 9, 19–20; Tr. at 1564–65, 1649.

1122 Ex. NRC-076-R2 at 76–78; Ex. CBR-054 at 2–3.

1123 See LRA § 2.7.3 at 2-225; id. § 4.2.1.1 at 4-2.

1124 There is no dispute as to the toxicity of selenium, as well as other metals, and the ISL Mining GEIS recognizes the potential risks of land application. See, e.g., ISL Mining GEIS § 4.2.3.2 at 4.2-12 ("Land application of the treated wastewater could also cause radiological and/or other constituents (e.g., selenium or other metals) to accumulate in the soils, thereby degrading the site potential for subsequent recreational or agricultural use.").

1125 EA § 2.2.2 at 22.

irrigation")[1126] and its NDEQ permit allow Crow Butte to land-apply its wastewater,[1127] but that Crow Butte has no immediate future plans to do so.[1128] We find that it was error for the EA not to discuss, either generically or on a site-specific basis, the environmental impacts of land application of ISL wastewater that could contain selenium.

ii. Board Findings on Potential for Future Land Application

NEPA requires the EA to address the "reasonably foreseeable effects of a proposed action."[1129] As applied here, given that the NDEQ NPDES permit and the renewed NRC license authorize this activity, and that the EA mentions it as an alternative for waste disposal, we find the EA improperly relies on the absence of Crow Butte's current plans for land application of ISL wastewater.

The record evidence establishes that Crow Butte sought NRC approval for land application of its mining wastewater in 1993,[1130] subsequently obtained the requisite federal and state permits authorizing such land application, and currently intends to renew its NDEQ NPDES permit authorizing such land application.[1131] Mr. Teahon testified that Crow Butte is pursuing all necessary approvals for land application so that it can be employed as a backup disposal technique.[1132] While it is undisputed that Crow Butte would be required to incur

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[1126] Ex. NRC-012 at 9–10 (License Condition 10.17).

[1127] EA § 4.6.1.3 at 85–86.

[1128] Id.

[1129] Fla. Power & Light Co. (Turkey Point Nuclear Generating, Units 3 & 4), CLI-15-25, 82 NRC 389, 396 n.46 (2015).

[1130] Ex. NRC-062, Letter from Stephen P. Collings, President, Ferret Exploration Company of Nebraska, to Ramon Hall, NRC Region IV Uranium Recovery Field Office at 1 (June 7, 1993); Tr. at 1916.

[1131] Tr. at 1923–24.

[1132] Tr. at 1928–29.

additional costs were it to initiate land application (including requesting a license amendment from the NRC Staff and, thereafter, installing the infrastructure necessary to land apply wastewater),[1133] Mr. Teahon's testimony demonstrated his considerable knowledge of how Crow Butte would construct such a system.[1134] Mr. Teahon's testimony, when placed in the context of the EA's statement that Crow Butte has all necessary NRC and NDEQ permits to conduct land application,[1135] demonstrates that land application is a reasonably foreseeable alternative. Accordingly, we find that this warrants discussion under NEPA and so must be addressed in the EA.[1136]

iii. Board Findings on Review of Land Application in Other Documents

Witnesses for the NRC Staff and Crow Butte claimed that, even were there to be land application, other state and federal environmental review documents conclude that there would be minimal adverse effects to soils, surface water, and wildlife.[1137] More specifically, Mr. Teahon asserted that the NRC Staff's Environmental Assessment from the 1998 license renewal (the 1998 EA), along with the SER issued in conjunction with this current license renewal, satisfactorily discuss the impacts of land application of treated ISL wastewater and conclude that it would be acceptable.[1138] The NRC Staff's witnesses agreed with Mr. Teahon's

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[1133] Tr. at 1929–30.

[1134] See Tr. at 1925–30.

[1135] EA § 2.4.1 at 25; id. § 4.6.1.3 at 85–86.

[1136] See Turkey Point, CLI-15-25, 82 NRC at 396 n.46.

[1137] Ex. NRC-001-R at 100–01, 104–05; NRC Staff's Initial Statement of Position at 67–68 (May 8, 2015) [hereinafter Staff's Initial Statement of Position]; Staff Proposed Findings at 119; see also Ex. CBR-010 at 6–7.

[1138] Ex. CBR-010 at 6–7.

assertion and claimed that the ISL Mining GEIS[1139] thoroughly discussed the impacts of land application of ISL wastewater.[1140]

Crow Butte and the NRC Staff, however, cannot rely wholesale on previous environmental review documents that have not been properly incorporated into the EA.[1141] While the NRC Staff may in certain circumstances incorporate by reference previous work that addresses a particular environmental issue, it may only do so where the EA provides specific citations and briefly summarizes how those external documents support the EA's conclusion.[1142] Similarly, to properly tier[1143] to the ISL Mining GEIS, the EA must reference and summarize the specific issues addressed in the GEIS that are to be discussed in the EA.[1144]

That was not done here. We find that none of the documents on which the NRC Staff claims it relied were properly incorporated into the EA, and that there is nothing in the EA to explain how these allegedly incorporated documents support the EA's conclusion regarding possible land application of Crow Butte's ISL mining wastewater. Neither the 1998 EA nor the SER is referenced in the EA's discussion of land application or ISL wastewater. Further, we find

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[1139] The ISL Mining GEIS assessed "the potential environmental impacts associated with the construction, operation, aquifer restoration, and decommissioning of an ISL uranium recovery facility in four specified regions in the western United States." ISL Mining GEIS at iii. Ex. NRC-045 is an excerpt from this GEIS.

[1140] Ex. NRC-001-R at 104–05.

[1141] Ex. NRC-014, NUREG-1748 § 1.6.4 at 24 ("The NEPA document must be able to stand alone and provide sufficient analysis to allow the decision maker to arrive at a conclusion.").

[1142] 40 C.F.R. § 1502.21; see also 10 C.F.R. pt. 51, app. A.1(b) (adopting "[t]he techniques of tiering and incorporation by reference described respectively in 40 CFR 1502.20 and 1508.28 and 40 CFR 1502.21 of CEQ's NEPA regulations" (footnote omitted)).

[1143] As explained above, see supra § I.A, Legal Standards at 8–10, tiering is a form of incorporation by reference whereby an agency incorporates a GEIS into a site-specific analysis. 40 C.F.R. §§ 1502.20, 1508.28.

[1144] 40 C.F.R. § 1502.20; see also Ex. NRC-014, NUREG-1748 § 1.6.2 at 1-10.

that the EA does not mention the ISL Mining GEIS in the context of restoration activities or land application, and is therefore not properly tiered to the EA.

But, even if these documents had been properly incorporated, we find that they still would not support the EA's conclusion that, based on Crow Butte's "implementation of mitigation measures in the past," the impact to soils, surface waters, and wildlife from land application of ISL wastewater will be "SMALL."[1145] First, the 1998 EA contains the same information as the current EA—i.e., that Crow Butte has approval for, but no current plans to implement, land application of ISL wastewater,[1146] and that "[t]he release limits for various ionic species, metals, and some radionuclides are established by appropriate NRC, EPA, and State of Nebraska standards."[1147] It contains nothing else on this subject. We find that the 1998 EA differs from the current EA in this regard only insofar as it states "[s]hould [Crow Butte] decide in the future to begin land application of treated effluents, the staff recommends that it also should implement vegetation sampling within the land-applied areas so that assumptions in the . . . modeling concerning soil and plant uptake can be verified."[1148] The current EA, however, makes no mention of any such biological monitoring, and Mr. Teahon testified that Crow Butte's NPDES permit does not require Crow Butte to undertake such testing.[1149] Likewise, the SER for the current license renewal states only that land application is an option Crow Butte does not

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[1145] See Ex. NRC-001-R at 101; Ex. CBR-010 at 12.

[1146] Ex. CBR-044, Office of Nuclear Material Safety and Safeguards, Division of Waste Management, Environmental Assessment for Renewal of Source Material License No. SUA-1534 § 3.6.2.2 at 33 (Feb. 1998).

[1147] Id.

[1148] Id. § 3.7.3 at 39.

[1149] See Tr. at 1947.

currently plan to pursue and it does not analyze any measures that might be needed were Crow Butte to commence such land application.[1150]

We also note that, in its general discussion of the land application of ISL wastewater,[1151] the ISL Mining GEIS acknowledges that selenium concentrations are an issue at ISL mining sites and that licensees are required to monitor and control soil impacts through their environmental monitoring programs.[1152] According to the GEIS, "[m]onitoring includes analyzing water before it is applied to land to make sure release limits are met and soil sampling to ensure that concentrations of uranium, radium, and other metals are within allowable limits."[1153] The ISL Mining GEIS explains that NRC-licensed ISL facilities must monitor soils during decommissioning and that a state environmental agency may impose additional requirements.[1154] It also indicates that the NRC prohibits ISL mining wastewater from entering surface waters or shallow aquifers.[1155]

Although the ISL Mining GEIS is certainly more instructive than either the 1998 EA or the SER, it in no way establishes that the overall effects at the License Area would be SMALL for wildlife. In fact, the ISL Mining GEIS does not even discuss the impact of land application on fauna.

[1150] SER § 3.1.3.5.4 at 59.

[1151] See, e.g., ISL Mining GEIS § 2.7.2 at 2-37; id. § 4.2.3.2 at 4.2-12; id. § 4.2.4.2.2.1 at 4.2-20; id. § 4.2.5.2 at 4.2-34; id. § 4.2.12.2 at 4.2-61; id. § 4.4.3.2 at 4.4-7; id. § 4.4.4.2.2.1 at 4.4-12; id. § 4.5.3.2 at 4.5-7; id., tbl., 7.4-1, at 7-3 to-6.

[1152] Id. § 4.2.3.2 at 4.2-12; id. § 4.2.5.2 at 4.2-34.

[1153] Id. § 4.2.3.2 at 4.2-13.

[1154] Id. § 2.7.2 at 2-37; id. § 4.2.3.2 at 4.2-12–13; id. § 4.2.12.2 at 4.2-62.

[1155] Id. § 4.2.4.2.2.1 at 4.2-20; id. § 4.2.12.2 at 4.2-62; id., tbl. 7.4-1, at 7-3–6.

The 2007 FWS letter explicitly specifies that concentrations in water as low as 2 µg/L of selenium may be harmful to wildlife as a result of bioaccumulation.[1156] The ISL Mining GEIS did not respond in any way to this FWS concern. It could have, for example, declared that ISL facilities should land-apply wastewater only where the concentrations of selenium were lower than 2 µg/L, or it could have demonstrated that the FWS documents are overly conservative with respect to the selenium concentration values or its bioaccumulation risks. The ISL Mining GEIS, however, is completely silent in this regard. Accordingly, we find that these generic statements in the ISL Mining GEIS do not fulfill the NRC Staff's obligations under NEPA with regard to the significant impacts that could reasonably be posed to wildlife at the License Area were Crow Butte to commence land application of ISL wastewater.[1157]

iv. Board Findings on Reliance on Drinking Water Standards

Both Mr. Goodman and Mr. Teahon testified that Crow Butte is prohibited under both its renewed license (License Condition 10.17) and its state-issued NPDES permit from performing land application of its wastewater insofar as that wastewater contains selenium concentrations greater than 50 µg/L.[1158] Mr. Goodman argued that the NDEQ concentration limit of 50 µg/L is a sufficient safeguard and "[c]onsequently, there is no evidence to suggest that the environmental impacts of selenium, specifically, would be sufficiently significant or probable to require a separate discussion in the EA."[1159] The NRC Staff's witnesses also argued that the 50 µg/L limit

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[1156] Ex. INT-018 at 1.

[1157] 40 C.F.R. § 1500.2(b); Ex. NRC-014, NUREG-1748 § 1.2; see also Klamath-Siskiyou Wildlands Ctr. v. BLM, 387 F.3d 989, 993–94 (9th Cir. 2004); Neighbors of Cuddy Mountain v. U.S. Forest Serv., 137 F.3d 1372, 1380 (9th Cir. 1998).

[1158] Ex. NRC-001-R at 102 (citing Ex. NRC-012 at 9–10 (License Condition 10.17)); Ex. NRC-062, tbl. 2.5, at 18; Ex. CBR-010 at 5, 7–8; see also 40 C.F.R. § 141.62(b); 118 Neb. Admin. Code, ch. 4 § 002 (2016).

[1159] Ex. NRC-001-R at 102.

is safe for the environment, including wildlife, because the Nebraska NDEQ permit adopted that limit, and the NRC Staff is allowed "to give substantial weight to NDEQ's decision that issuing the permit would be environmentally acceptable."[1160]

We find that the NDEQ concentration limit for selenium reflects the safe level for humans, but not necessarily for wildlife.[1161] For land application to be characterized as having only a SMALL environmental impact on wildlife, it must not "noticeably alter any important attribute of" the subject wildlife.[1162] The 2007 FWS letter states that selenium concentrations that can be harmful to wildlife are as low as 2 μg/L,[1163] a level far lower than the maximum contaminant limits set for human drinking water and upon which the NRC Staff and Crow Butte seek to rely.[1164] Both the 2000 FWS Report and the 2007 FWS Letter indicate that selenium in land-applied ISL wastewater could seep into soils and vegetation and, through bioaccumulation, produce increased selenium concentrations in the food chain.[1165] Yet, in the face of the FWS concern, the NRC Staff's witnesses could only assert the erroneous claim that because ISL wastewater does not exceed human maximum contaminant levels, there is no threat to wildlife.[1166]

As for the NRC Staff's argument that it may defer to NDEQ's judgment, certainly it is true that an EA may accord "limited reliance" to a state agency's environmental analyses—but that is

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[1160] Staff's Initial Statement of Position at 67 (citing Pub. Serv. Co. of N.H. (Seabrook Station, Units 1 & 2), CLI-77-8, 5 NRC 503, 527 (1977)).

[1161] See 118 Neb. Admin. Code, ch. 1 § 003, ch. 3 § 001 (2016).

[1162] EA at 8.

[1163] Ex. INT-018 at 1; Ex. INT-019 at 1.

[1164] See Ex. NRC-001-R at 102; Ex. CBR-042 at 4–6.

[1165] Ex. INT-048 at 5.

[1166] Ex. NRC-001-R at 102–05; see also 40 C.F.R. § 141.1 (citing Safe Drinking Water Act, Pub. L. No. 93-523, 88 Stat. 1660 (1974) (codified at 42 U.S.C. § 300f et seq.)).

so only where it is clear that the state agency conducted a thorough review.[1167] We find there is no record evidence demonstrating that NDEQ ever considered impacts to wildlife in its issuance of Crow Butte's NPDES permit for land application of ISL wastewater. In fact, just as was the case with EPA's maximum contaminant levels from the Safe Drinking Water Act,[1168] the 50 μg/L selenium concentration limit imposed in NDEQ's NPDES permit appears to be based solely on a regulation designed to protect drinking water quality for humans and does not in any way address possible ingestion and ultimate bioaccumulation in wildlife.[1169] Furthermore, regardless of whether NDEQ considered impacts on wildlife in granting the NPDES permit, the NRC Staff's "limited reliance" on NDEQ's judgment cannot act as substitute for its own independent NEPA review of the potential impacts of selenium on wildlife.[1170]

With respect to Mr. Teahon's claim that Crow Butte's reverse osmosis process is capable of reducing selenium concentrations down to 1 μg/L or even lower, we note that Intervenors have presented no evidence that concentrations at or less than 2 μg/L pose any threat to wildlife, nor did they dispute that Crow Butte can achieve reductions in selenium concentrations to this level. Regardless, the EA fails to examine the potential environmental impacts of either the 2 μg/L or 50 μg/L selenium limit on wildlife, and such impacts should have been considered.

[1167] Seabrook, CLI-77-8, 5 NRC at 527.

[1168] See 40 C.F.R. § 141.1.

[1169] Ex. CBR-010 at 8–9; see also 118 Neb. Admin. Code, ch. 3 § 001 (2016) (Nebraska groundwater standards are designed to protect "beneficial uses" of groundwater); 118 Neb. Admin. Code, ch. 1 § 003 (2016) (defining beneficial use as protecting groundwater quality).

[1170] See S. Fork Band Council of W. Shoshone of Nev. v. U.S. Dep't of Interior, 588 F.3d 718, 726 (9th Cir. 2009).

c. Summary of Board Findings on Contention 12B Land Application

In sum, we find that the EA fails to discuss the environmental effects of land application of ISL wastewater on wildlife, now or in the future. We further find that land application is a feasible alternative for disposal of Crow Butte's ISL wastewater given that: (1) Crow Butte is authorized to use land application both in its renewed license and its state NPDES permit; (2) Crow Butte has stated it will be applying to renew its state permit for land application; (3) Crow Butte has clearly considered how it would perform land application; and (4) Crow Butte has suggested that it would consider using land application as a backup for wastewater disposal.[1171] The impacts of selenium on wildlife are not discussed in the EA, and insofar as such impacts may be discussed elsewhere, they are not incorporated into the EA.[1172] Therefore, we find that the EA, and the NRC Staff's Finding of No Significant Impact, is deficient with respect to its discussion of the land application of ISL wastewater and any potential impacts from selenium on wildlife. We do not find, at this time, that land application of ISL wastewater at selenium concentrations of 50 µg/L will cause a significant impact because that is a matter on which the NRC Staff must reach its own independent conclusion in conformance with NEPA when it cures the deficiencies in its EA.

H. <u>Contention 14 – Earthquakes</u>

Contention 14 states:

> The Final EA violates the National Environmental Policy Act in its failure to provide an analysis of the impacts on the project from earthquakes; especially as it concerns secondary porosity and adequate confinement. These failings violate 10 C.F.R. §§ 51.10, 51.70 and 51.71, and the National Environmental Policy Act, and implementing regulations.[1173]

[1171] <u>See</u> <u>supra</u> § IV.G.2.b.ii, Board Findings on Potential for Future Land Application at 211–212.

[1172] <u>See</u> <u>supra</u> § IV.G.2.b.i, Board Findings on Health Impacts of Selenium at 209–11.

[1173] LBP 15-11, 81 NRC at 451, app. A.

1. Parties' Positions on Failure to Analyze Complete Earthquake Record

Through this contention, Intervenors claim EA § 3.4.3: (1) fails to identify two earthquakes that occurred in South Dakota in 2011 and that were felt in Crawford, Nebraska;[1174] and (2) fails to analyze impacts from earthquakes on the UCU's secondary porosity and adequate confinement.[1175] Although not directly stated by Intervenors, we suggested in LBP-15-11 that "[t]he EA analysis might also be incomplete because it only reviewed earthquakes recorded in Nebraska, neglecting earthquakes felt in nearby states."[1176]

The NRC Staff's witnesses testified that the discussion of seismology in EA § 3.4.3 includes the typical level of seismic hazards found in the vicinity of the License Area, which is located in the "Stable Interior" of the United States.[1177] The EA discusses historical earthquakes in Nebraska (including several that occurred within 100 miles of the License Area) and concludes that the License Area is located in seismic risk Zone 1, i.e., a zone of low seismic accelerations and hazard.[1178] At the same time, the NRC Staff's witnesses conceded that the EA fails to discuss earthquakes in neighboring states, such as southern South Dakota or eastern Wyoming.[1179] In particular, there were two recent (November 2011) seismic events in

[1174] Intervenors' New Contentions at 88.

[1175] Id.

[1176] LBP-15-11, 81 NRC at 448 (citing EA § 3.4.3 at 41–42).

[1177] Ex. NRC-001-R at 106–07.

[1178] EA § 3.4.3 at 41–42.

[1179] Ex. NRC-001-R at 108 (citing Ex. NRC-066, Historical Earthquakes within 100 miles of CBR site at 1–3 (undated); Ex. NRC-068, [Central and Eastern United States] [Seismic Source Characterization] Earthquake Catalog Compilation (undated); Ex. NRC-069, USGS, Search Results – 7 earthquakes in map area (undated)); see also EA § 3.4.3 at 41–42.

South Dakota approximately 25 miles north-northwest of the License Area that were felt in Crawford, Nebraska.[1180]

To attempt to address this contention, the NRC Staff's witnesses' testimony included a table compiled from data in an NRC guidance document, "Central and Eastern United States Seismic Source Characterization for Nuclear Facilities" (NUREG-2115) and in USGS earthquake catalogs that list all historical earthquakes within 100 miles of the License Area.[1181] The NRC Staff's witnesses also prepared a graph of the magnitudes of these earthquakes.[1182]

The NRC Staff's witnesses testified that USGS characterized the two recent South Dakota earthquakes as having magnitudes of 3.3 and 4.0.[1183] The NRC Staff's witnesses asserted that: (1) these two earthquakes reflect magnitudes typical of earthquakes in the vicinity of the License Area and of earthquakes that fall within the range identified in Table 3-8 of the EA, and (2) adding these two South Dakota earthquakes to the EA would not change the accuracy of the EA's description of typical seismic activity and of the level of seismic hazard that is posed at the License Area.[1184]

The NRC Staff's witnesses asserted that the EA appropriately omitted earthquakes outside the state of Nebraska because the vast majority of earthquakes within 100 miles of the License Area (whether in Nebraska, South Dakota, or Wyoming) have magnitudes corresponding to a low earthquake intensity[1185] and are very consistent in depth, i.e., nearly all

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[1180] Ex. NRC-001-R at 107–08; Ex. NRC-066 at 2.

[1181] Ex. NRC-001-R at 108 (citing Ex. NRC-066; Ex. NRC-068).

[1182] Ex. NRC-066 at 1–3; Ex. NRC-068; Ex. NRC-069.

[1183] Ex. NRC-001-R at 107–08.

[1184] Id. at 107–09 (citing EA § 3.4.3 at 41–42).

[1185] Ex. NRC-066 at 1–3; Ex. NRC-067, US Geological Survey, Earthquake Hazards Program, Magnitude/Intensity Program, http://earthquake.usgs.gov/learn/topics/mag_vs_int.php at 1 (last visited Apr. 20, 2015); Ex. NRC-068; Ex. NRC-069.

occurred three miles below the surface.[1186] Based on this claimed similarity, the NRC Staff's witnesses opined that "there is no significant difference in the characteristics of earthquakes discussed in the EA and other historical earthquakes that have occurred outside of Nebraska (in South Dakota or eastern Wyoming)."[1187]

In addition, the NRC Staff's witnesses testified that the 1997 Uniform Building Code's Seismic Zone Map indicates that the area of South Dakota where these 2011 earthquakes occurred is in seismic risk Zone 1,[1188] which is characterized as having low earthquake magnitudes—and is in the very same zone in which the License Area is located.[1189] For these reasons, it was the NRC Staff's witnesses' opinion that the EA is not deficient in describing the "affected environment" in terms of seismic activity, even though it omitted the two South Dakota earthquakes.[1190] But, the NRC Staff's witnesses did concede that selecting all earthquakes within the 100 mile radius of the License Area is preferable to limiting the search to only those occurring within a particular state's geographic boundaries, and that doing so would have improved the quality of the EA.[1191] Nevertheless, Intervenors did not present any evidence to dispute the testimony of the NRC Staff's witnesses that adding the two South Dakota earthquakes as well as those from eastern Wyoming to the EA would have no effect on the EA's conclusions regarding this contention.

[1186] Ex. NRC-001-R at 108–09.

[1187] Id. at 109.

[1188] Ex. NRC-070, International Conference of Building Officials, Uniform Building Code, United States Seismic Zones Map (1997).

[1189] Ex. NRC-001-R at 108.

[1190] Id. at 108–09.

[1191] Id. at 108–09; Tr. at 1656, 1660–62.

Intervenors' witness, Dr. LaGarry, did testify that the area in the vicinity of the License Area is tectonically active. He further noted that, while earthquakes there are relatively mild and will not significantly damage infrastructure, small tremors associated with these earthquakes are continuously creating, closing, and redistributing the secondary porosity of the region's rocks and so are changing groundwater flow paths in the region.[1192]

While acknowledging that small earthquakes do occur periodically, Crow Butte's witnesses disputed Dr. LaGarry's claim in this regard, asserting that the area near the License Area is one of the most tectonically stable in the United States[1193] and that there is no indication such small and infrequent earthquakes would cause a change in the groundwater flow paths or adversely impact Crow Butte's mining operations.[1194]

The NRC Staff's witnesses also disputed Dr. LaGarry's claim that regional earthquakes affect flow patterns at the License Area. The NRC Staff's witnesses opined that: (1) it is highly unlikely that an earthquake could create sufficient changes in the secondary porosity to impact the UCU; (2) not every earthquake, regardless of size, would affect porosity and water flow; (3) there is no evidence that the small earthquakes that have occurred within 100 miles of the License Area (whether originating in Nebraska, South Dakota, or Wyoming) during the period of Crow Butte's operations have had any effect on confinement of the BC/CPF at the License Area; (4) the 2011 earthquakes in South Dakota could have produced only limited changes in subsurface rocks and groundwater flow pathways in the vicinity of the License Area; (5) it is highly unlikely that an earthquake of sufficient magnitude would occur close enough to the License Area to cause changes in subsurface rocks and groundwater flow pathways; and (6)

[1192] Ex. INT-013 at 2–3.

[1193] Ex. CBR-001 at 56.

[1194] Ex. CBR-045 at 6.

the historical record suggests there have been no significant environmental impacts from the small earthquakes that might occur at or near the License Area.[1195] Crow Butte's witnesses agreed with the NRC Staff's witnesses' testimony that minimized the risks posed to the confinement of the BC/CPF Aquifer by these seismic hazards.[1196]

As for the UCU itself, the NRC Staff's witnesses opined that, even were there to be an earthquake large enough to generate small fractures in the UCU, because its saturated clays are not brittle, the UCU's layers would "self-heal" and would not undergo any permanent changes in secondary porosity.[1197]

2. Board Findings on Failure to Analyze Complete Earthquake Record

Given the substantial information in the evidentiary record indicating that earthquakes in and near the License Area are expected to have low magnitudes, we find there is insufficient evidence indicating that the tremors that have occurred during the 20-plus years of Crow Butte's mining operations have changed the flow patterns in and surrounding the License Area sufficiently to adversely affect the containment of contaminants within the BC/CPF Aquifer.

We also find that adding information on all historical earthquakes within 100 miles of the License Area, regardless of the state in which the earthquake occurred, would not affect the EA's description of typical seismic activity and level of seismic hazard. Specifically, we find that adding the 2011 earthquakes in South Dakota to the EA § 3.4.3 would not affect the EA's conclusions because the two 2011 South Dakota seismic events fall within the range of earthquakes that are identified in the EA.

While excluding some of the earthquakes in the region of the License Area does not change the EA's conclusions, we find that the NRC Staff was derelict in failing to include the two

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[1195] Ex. NRC-001-R at 108–17 (citing Ex. NRC-066; Ex. NRC-068; Ex. NRC-069).

[1196] Ex. CBR-045 at 6 (citing Ex. NRC-001-R at 106–15).

[1197] Ex. NRC-001-R at 111.

2011 South Dakota earthquakes in its EA and thus limiting its analysis to only those earthquakes that occurred within the State of Nebraska, where the License Area is located. Because the EA's seismic assessment was limited to Nebraska and specifically omitted recent earthquakes in South Dakota and eastern Wyoming, we find that the EA does not provide sufficient information regarding earthquake activity and hazards near the License Area to satisfy NEPA requirements.

At the same time, however, the NRC Staff's witnesses' testimony analyzed the characteristics and hazards of all historic earthquakes in the three state region including Nebraska, South Dakota, and Wyoming within a 100-mile radius of the License Area, and we find that this additional analysis cures this deficiency in the EA.[1198]

V. CONCLUSIONS OF LAW AND REMEDIES

In materials licensing proceedings, licensing boards are empowered to make "findings of fact and conclusions of law on the matters put into controversy by the parties."[1199] After a licensing board has issued an initial decision on those matters, the Director of the Office of Nuclear Material Safety and Safeguards (NMSS) "shall issue, deny, or appropriately condition the permit, license, or license amendment in accordance with the presiding officer's initial decision."[1200] Although the NRC's regulations allow the NRC Staff to issue a license before an adjudicatory proceeding is concluded,[1201] the Director of NMSS must thereafter deny, or insert

[1198] Claiborne Enrichment Ctr., CLI-98-3, 47 NRC at 89; see also Indian Point, CLI-15-6, 81 NRC at 388 ("We therefore affirm the Board's ruling that the environmental record of decision may be supplemented by the hearing and relevant Board and Commission decisions.").

[1199] 10 C.F.R § 2.340(e)(1); see also id. § 2.321(a).

[1200] Id. § 2.340(e)(2).

[1201] Id. §§ 2.340(e)(2)(ii), 2.1202(a).

appropriate conditions, if any, in the license based on the determinations of the licensing board and the Commission.[1202]

With respect to Contentions A, C, D, F, 6, 12A, and 14, we conclude as a matter of law that the EA, as augmented with record evidence from this proceeding, complied with NEPA.

However, with respect to Contention 12B – Land Application of Wastewater, we have found that the NRC Staff has not satisfied NEPA's requirement to take a hard look at the impacts of selenium on wildlife that may plausibly result from Crow Butte's authorized land application of ISL wastewater within the License Area. This failure prevents us from determining whether renewal of the license will result in "no significant impacts," and therefore places in doubt the NRC Staff's Finding of No Significant Impact.[1203] The question we face here is what actions are possible to address this deficiency.

Where an agency fails to comply with procedural statutes such as NEPA, an injunction is sometimes the proper recourse.[1204] The equivalent of an injunction here would be not granting the license extension. But the Supreme Court of the United States has made clear that such injunctive relief is only warranted when the traditional test justifying it is met, i.e.:

> (1) that [Intervenors have] suffered an irreparable injury; (2) that remedies available at law, such as monetary damages, are inadequate to compensate for that injury; (3) that, considering the balance of hardships between [Intervenors] and [Crow Butte], a remedy in equity is warranted; and (4) that the public interest would not be disserved by a permanent injunction.[1205]

[1202] See id. §§ 2.340(e)(2)(ii), 2.1210(c)(2)–(3); see also id. § 40.41(e).

[1203] See LBP-15-11, 81 NRC at 415.

[1204] See, e.g., Monsanto Co. v. Geertson Seed Farms, 561 U.S. 139, 156–57 (2010); League of Wilderness Defenders/Blue Mountains Biodiversity Project v. Connaughton, 752 F.3d 755, 761, 767 (9th Cir. 2014); Neighborhood Ass'n of the Back Bay, Inc. v. Fed. Transit Admin., 463 F.3d 50, 58 (1st Cir. 2006).

[1205] Monsanto, 561 U.S. at 156–57; Winter v. Natural Res. Def. Council, Inc., 555 U.S. 7, 20 (2008).

The irreparable injury and monetary damages prongs weigh against Intervenors because land application of ISL wastewater is not likely in the immediate future. The Supreme Court in Winter v. Natural Resources Defense Council explained that irreparable injury must be likely, not merely possible, without an injunction.[1206] Here, however, Crow Butte currently lacks the infrastructure to use land application. Although Crow Butte could certainly develop the infrastructure within the next few years, Intervenors have presented no evidence that imminent harm would result from granting the license extension before the NRC Staff fulfills its NEPA obligations. Furthermore, although monetary remedies are not possible in the NRC licensing context, the lack of monetary damages is not an issue here because there is no current environmental harm.

The third prong, balance of hardships, also weighs against Intervenors because the Commission has disfavored imposing “a draconian remedy when less drastic relief will suffice.”[1207] Not granting the license extension here appears not only to be an undue hardship, but also unnecessary to cure the potential harms at issue. In Powertech, the licensing board similarly declined to stay the effectiveness of a license upon a showing of a NEPA violation, instead expressing confidence that the NRC Staff would promptly take steps to rectify the deficiency.[1208] Because of our conviction that the NRC Staff will act with dispatch to cure this NEPA deficiency, we likewise conclude that it would not be appropriate under the circumstances either to lift the effectiveness of the NRC Staff’s action granting the Crow Butte license extension, in accordance with § 2.1213, or to direct that the NMSS Director deny the Crow Butte license extension, in accordance with § 2.340(e)(2).

[1206] Winter, 555 U.S. at 8.

[1207] Hydro Res., Inc. (2929 Coors Road, Suite 101, Albuquerque, NM 87120), CLI-00-8, 51 NRC 227, 241 (2000).

[1208] Powertech, LBP-15-16, 81 NRC at 657–58.

While this Partial Initial Decision makes clear that the NRC Staff has not complied with its obligations under NEPA, we do not direct the NRC Staff regarding the specifics as to how it should achieve such compliance. In our estimation, however, the most efficient method for curing this NEPA deficiency would be for the NRC Staff to publicly supplement its EA with additional analyses and findings with respect to the plausible impacts on wildlife from the land application of ISL wastewater. We leave it to the NRC Staff to identify how it wishes to proceed in light of our rulings herein. We will convene a conference call at a time and date to be determined to discuss with the NRC Staff and the other parties the next steps in addressing the concerns we outline in this decision.

Whenever the NRC Staff makes public its curative actions relating to Contention 12B, including any revised EA (or EA supplement), it shall notify the Board and parties by letter through the Electronic Hearing Docket. Intervenors will be afforded an opportunity to file new contentions to contest the adequacy of the NRC Staff's chosen actions, including any revised EA (or EA supplement), and any new information that may result from the NRC Staff's actions. Any new contentions must comply with applicable timeliness and contention admissibility requirements set forth in 10 C.F.R. § 2.309. We retain jurisdiction for this limited purpose, until the Commission "orders otherwise," or "when the period within which the Commission may direct that the record be certified to it for final decision expires, [or] when the Commission renders a final decision."[1209] And, until its curative actions regarding Contention 12B are completed, the NRC Staff shall provide bi-monthly status reports on the first day of every even-numbered month updating the Board and the parties as to its activities, including the status of any revised EA (or EA supplement).

[1209] 10 C.F.R. § 2.318; see also Powertech, LBP-15-16, 81 NRC at 710 (taking a similar approach).

VI. ORDER

For Contention A, Contention C, Contention D, Contention F, Contention 6, Contention 9, the tornado section of Contention 12 (Contention12A), and Contention 14, we conclude that the EA, as supplemented (where noted) by the record evidence, satisfies the NRC Staff's obligation to conduct a thorough environmental review. But we find, in part, for Intervenors on Contention 12 (Contention 12B) and conclude that the EA is deficient as to its discussion of Crow Butte's possible land application of ISL wastewater. The NRC Staff must reach its own independent conclusion, based on technical support in conformance with NEPA as to any potential impacts of selenium on wildlife from Crow Butte's possible land application of ISL wastewater.

Any party may petition for review of this Partial Initial Decision pursuant to 10 C.F.R. § 2.341(b)(4). Any such petition must be filed within 25 days from service of this Partial Initial Decision. Unless otherwise authorized by law, the filing of a petition for review is mandatory for a party to have exhausted its administrative remedies before seeking judicial review.[1210] This Partial Initial Decision will constitute a final decision of the Commission 120 days from the date of issuance unless a petition is filed or the Commission directs otherwise.[1211]

[1210] 10 C.F.R. §§ 2.341(b)(1), 2.1212.

[1211] 10 C.F.R. § 2.1210(a).

It is so ORDERED.

THE ATOMIC SAFETY
AND LICENSING BOARD

/RA/

Michael M. Gibson, Chairman
ADMINISTRATIVE JUDGE

/RA/

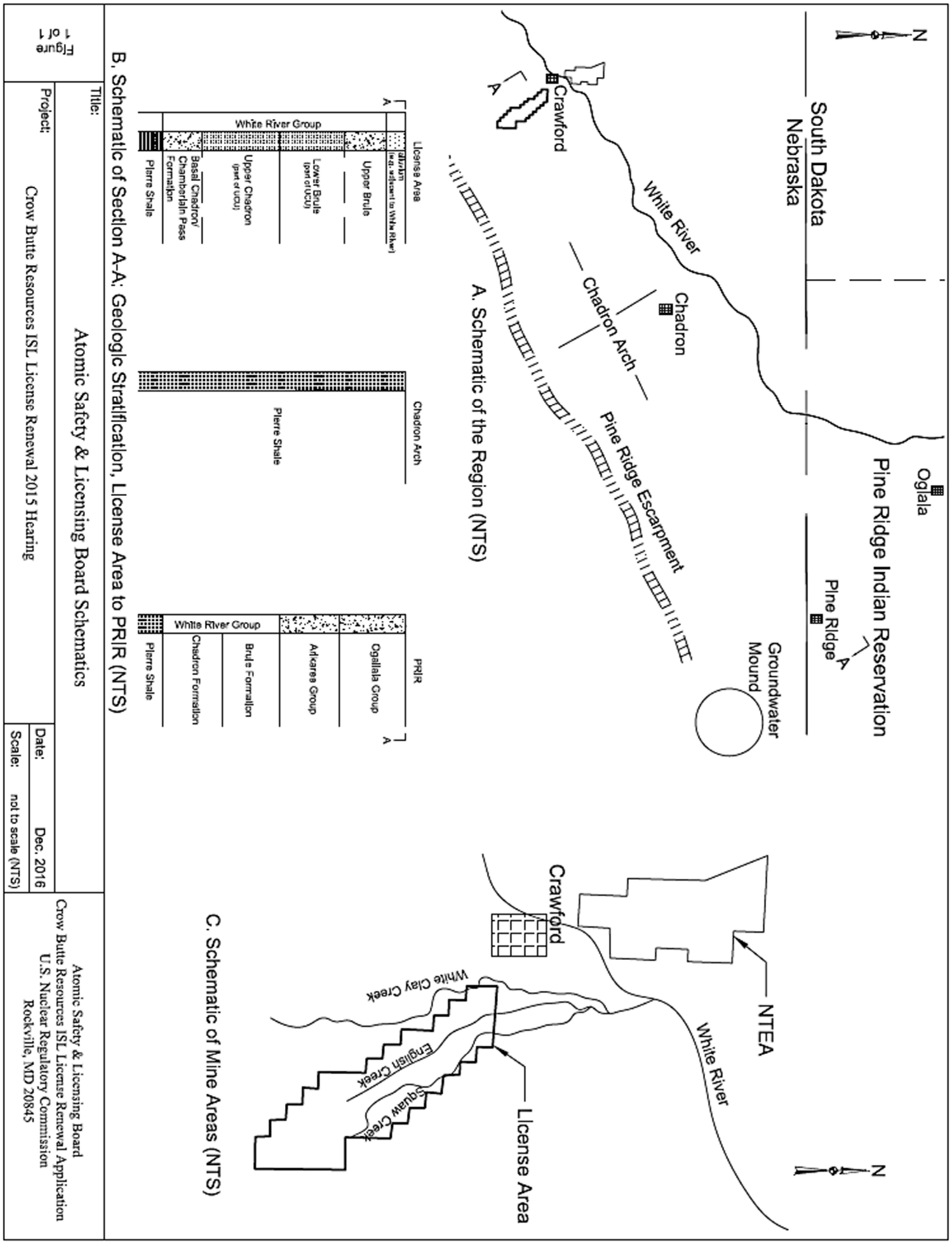
Dr. Richard E. Wardwell
ADMINISTRATIVE JUDGE

/RA/

Brian K. Hajek
ADMINISTRATIVE JUDGE

Rockville, Maryland
December 6, 2016

APPENDIX


N
South Dakota
Nebraska
Pine Ridge Indian Reservation
Oglala
Pine Ridge
A
Crawford
A
White River
Chadron
Chadron Arch
Pine Ridge Escarpment
Groundwater Mound
A. Schematic of the Region (NTS)
A
License Area
Alluvium (only adjacent to White River)
White River Group
Upper Brule
Lower Brule (part of UCU)
Upper Chadron (part of UCU)
Basal Chadron/ Chamberlain Pass Formation
Pierre Shale
Chadron Arch
Pierre Shale
PRIR
A
Ogallala Group
Arikaree Group
White River Group
Brule Formation
Chadron Formation
Pierre Shale
B. Schematic of Section A-A: Geologic Stratification, License Area to PRIR (NTS)
N
NTEA
Crawford
White River
White Clay Creek
English Creek
Squaw Creek
License Area
C. Schematic of Mine Areas (NTS)
Figure
1 of 1
Title:
Atomic Safety & Licensing Board Schematics
Project:
Crow Butte Resources ISL License Renewal 2015 Hearing
Date:
Dec. 2016
Scale:
not to scale (NTS)
Atomic Safety & Licensing Board
Crow Butte Resources ISL License Renewal Application
U.S. Nuclear Regulatory Commission
Rockville, MD 20845

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the Matter of CROW BUTTE RESOURCES, INC. In-Situ Leach Uranium Recovery Facility, Crawford, Nebraska (License Renewal)	))))))))	Docket No. 40-8943-OLA

CERTIFICATE OF SERVICE

I hereby certify that copies of the foregoing **SECOND PARTIAL INITIAL DECISION (LBP-16-13)** have been served upon the following persons by Electronic Information Exchange, and by electronic mail as indicated by an asterisk.

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[Original signed by Clara Sola]
Office of the Secretary of the Commission

Dated at Rockville, Maryland
this 6th day of December 2016