CBR-008

May 8, 2015

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:	)	
	)	Docket No. 40-8943
CROW BUTTE RESOURCES, INC.	)	
	)	ASLBP No. 08-867-02-OLA-BD01
(License Renewal)	)	

INITIAL WRITTEN TESTIMONY OF CROW BUTTE RESOURCES WITNESSES DOUG PAVLICK, LARRY TEAHON, AND ROBERT LEWIS ON CONTENTIONS 6 AND 9

TABLE OF CONTENTS

Page

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EXPERT WITNESSES

A. Doug Pavlick

Q1. Please state your full name.

A1. Doug Pavlick (DP)

Q2. By whom are you employed and what is your position?

A2. (DP) I am employed by Cameco Resources as the General Manager for U.S. Operations.

Q3. Please summarize your professional qualifications.

A3. (DP) A copy of my qualifications statement is attached to Exhibit CBR-009.

Q4. What is the purpose of your testimony?

A4. (DP) The purpose of my testimony is to address the issues raised in Contentions 6 and 9 involving site restoration issues.

Q5. What documents have you reviewed to prepare your testimony?

A5. (DP) I am familiar with the Crow Butte License Renewal Application ("LRA") as well as the NRC Staff review documents, including the Environmental Assessment ("EA") and the final Safety Evaluation Report ("SER"). To prepare this testimony I also reviewed the filings made to date by the Intervenors on these two issues as well as the Atomic Safety and Licensing Board decision (LBP-15-11) admitting the two contentions for hearing.

B. <u>Larry Teahon</u>

Q6. Please state your full name.

A6. Larry Teahon (LT)

Q7. By whom are you employed and what is your position?

A7. (LT) I am employed by Crow Butte Resources as the Safety, Health, Environment, and Quality (SHEQ) Manager at the Crow Butte in-situ recovery ("ISR") facility. I oversee radiation protection, health and safety, and environmental programs at the site and ensure compliance with all applicable regulatory requirements. I assist in the development and review of radiological and environmental sampling and analysis procedures and am responsible for routine auditing of the programs.

Q8. Please summarize your professional qualifications.

A8. (LT) A copy of my professional qualifications statement is attached to Exhibit CBR-006.

Q9. What is the purpose of your testimony?

A9. (LT) The purpose of my testimony is to address the issues raised in Contentions 6 and 9 involving site restoration issues.

Q10. What documents have you reviewed to prepare your testimony?

A10. (LT) I am familiar with the Crow Butte LRA as well as the NRC Staff's EA and the final SER. To prepare this testimony I also reviewed the filings made to date by the Intervenors on these two issues as well as the Atomic Safety and Licensing Board decision (LBP-15-11) admitting the two contentions for hearing.

C. ***Robert Lewis***

Q11. Please state your full name.

A11. Robert Lewis (RL)

Q12. By whom are you employed and what is your position?

A12. (RL) I am the owner and Principal Hydrogeologist of AquiferTek LLC, providing specialized hydrogeologic and environmental consulting services. I was retained by Cameco Resources while employed by Worley Parsons to assist with a variety of restoration issues, including development of a comprehensive, model-based restoration plan ("MBRP") for the Crow Butte uranium in-situ recovery facility. I was subsequently employed by Aqui-Ver, Inc. With Aqui-Ver and my present employer, I have worked continually with Cameco Resources to refine and improve the MBRP and restoration efficiency for Crow Butte, to the present.

Q13. Please summarize your professional qualifications.

A13. (RL) A copy of my professional qualifications statement is attached to Exhibit CBR-003. I have over 27 years of experience as a groundwater scientist and environmental consultant, and am a registered Professional Geologist in Wyoming. I have been involved in more than 300 consulting projects and environmental investigations worldwide. I have expertise in the areas of groundwater flow and transport modeling, mine hydrology, soil and groundwater contamination investigation and remediation, fate and transport of organic, inorganic, and radiological constituents, and water resource development. I also have authored technical papers, peer-reviewed journal articles, and book chapters concerning mine hydrology and water quality, groundwater modeling, and water resource evaluation. I have served as Associate Editor of *Ground Water* journal, and have been a member of ASTM subcommittees D.18.04 (Determination of Hydrogeological Parameters) and D18.21.10 (Ground Water Modeling).

Q14. What is the purpose of your testimony?

A14. (RL) The purpose of my testimony is to address the issues raised in connection with Contentions 6 and 9 involving site restoration issues. In particular, I will describe the Model-Based Restoration Plan ("MBRP") that was developed and first implemented beginning in May 2009. The MBRP is documented in a report prepared by WorleyParsons entitled "Wellfield Restoration Modeling, Crow Butte Resources Mine Units 2-5," dated February 19, 2009 ("MBRP") (Exh. CBR-041). The MBRP has been continually updated and improved since it was originally developed. I will explain that as a result of our modeling, the efficiency of groundwater restoration has improved significantly since implementation of the MBRP. These efficiency gains can be expected to be achieved in the future restoration of additional mine units.

Q15. What documents have you reviewed to prepare your testimony?

A15. (RL) I am familiar with the documentation describing the development of the MBRP (Exh. CBR-041) and the Pore Volume Restoration Analysis for Crow Butte (Exh. CBR-038) I was the primary technical author of all work by WorleyParsons and Aqui-Ver for Cameco Resources. I also have general familiarity with the relevant portions of the Crow Butte LRA as well as the NRC Staff review documents (the EA and the final SER). To prepare this testimony I also reviewed the filings made to date by the Intervenors on these two issues as well as the Atomic Safety and Licensing Board decision (LBP-15-11) admitting the two contentions for hearing.

BACKGROUND

Q16. What is your understanding of Contention 6?

A16. (All) Contention 6 is entitled "[t]he EA violates NEPA in concluding that the short-term impacts from consumptive ground water use during aquifer restoration are MODERATE." According to the intervenors, the short-term impact of mine restoration is greater than MODERATE. The Licensing Board admitted Contention 6 based on references to EA Sections 4.6.2.2.1 and 4.6.2.3. The former section addresses consumptive water use during operations, which the NRC Staff appropriately expects to remain the same during the renewal period. That section does not directly address consumption during restoration. On the other hand, the latter section of the EA addresses ground water quantity impacts from consumptive use during restoration. The EA indicates, based on past experience, that restoration of a mine unit will need at least eleven pore volumes and that Crow Butte may need to extract "more than eleven restoration pore volumes for all mine units." The EA described this short term impact from consumptive ground water use as a MODERATE impact. We understand that the contention asserts that the experience at Crow Butte indicates that the restoration consumptive use is greater than expected by the NRC Staff in the EA, and therefore the impact is greater than MODERATE. The NRC Staff also concluded that water levels would eventually recover after aquifer restoration, resulting in an overall SMALL impact from consumptive water use. It appears that the contention challenges that conclusion as well.

Q17. What is your understanding of Contention 9?

A17. (All) Contention 9 is entitled "the EA violates 10 C.F.R. §§ 51.10, 51.70 and 51.71, and NEPA and implementing regulations by failing to include the required discussion of ground water restoration mitigation measures." The Board admitted Contention 9 to the extent it alleges that the EA's discussion of ground water restoration mitigation measures is inadequate. The intervenors specifically allege that the NRC Staff has not justified its assumption that aquifer levels will eventually be restored naturally, and that runoff control procedures and monitoring and mitigation activities for ground water have not been developed. The Intervenors focus on a previously completed restoration that resulted in "uranium contaminant levels 18 times greater than baseline" and Crow Butte's experience that significant improvement could not be achieved by additional restoration efforts (*i.e.,* additional pore volumes).[1] The Board characterized the discussion of additional mitigation and the effect of increased pore volumes on water restoration quality and quantity in Sections 4.6.2.2 and 4.6.2.3 of the EA (Exh. NRC-010) to be a "cursory discussion, without substantive analysis." So we read the contention as asserting the need for more explanation and analysis related to restoration of water quality in the aquifer, the relationship to consumptive water use, and monitoring activities.

Q18. Can you briefly summarize your approach to responding to the issues raised in Contention 6?

[1] LBP-15-11, slip op. at 37, quoting CI Reply at 15.

A18. (All) Yes. With respect to Contention 6 and consumptive water use, we will show that Crow Butte has implemented a model-based restoration plan ("MBRP") since May 2009. As a result, Crow Butte has achieved increased efficiency in the groundwater treatment and restoration process. The consumptive water use in restoration has been much lower than was achieved prior to May 2009. To date the model has been applied to the latter stages of restoration for Mine Units 2 and 3, which have been restored and are in stability monitoring. It is being applied to Mine Units 4, 5, and 6, which are currently in restoration. The results show that going forward we can complete restoration that meets the restoration plan within the total of eleven pore volumes assumed in the EA.

(RL) We also concur with the EA conclusion that the longer term impact on the aquifer will be SMALL because water levels in the confined aquifer will recover.

The confined production aquifer at Crow Butte will depressurize somewhat but remain fully saturated and recover relatively quickly during all phases of mining and restoration. This is in contrast to shallow unconfined aquifers that desaturate as water levels fall and must rely heavily on adequate local recharge to prevent the aquifer from becoming depleted. Because the confined aquifer will not be measurably depleted during mining or restoration, the ultimate impact to water resources will be minimal.

Q19. Can you briefly summarize your approach to responding to Contention 9?

A19. (All) With respect to Contention 9, Crow Butte is committed to restoration in accordance with the quality standard in 10 C.F.R. Part 40, Appendix A. Mitigation of groundwater below the levels set by regulation is not required.

Specific target values for restoration are established by NDEQ based on pre-mining water quality samples (*i.e.*, benchmarking data). The NDEQ permits also specify secondary (or "alternate") concentration limits. Under the license condition imposed by the NRC Staff, these secondary targets will be applied only subject to NRC approval (by a license amendment) based on a showing that a diligent effort based on best practicable technology has been made to restore water quality to the target value. This assures restoration to appropriate levels while also not unnecessarily increasing consumptive use of groundwater. There will also be monitoring to assure that the restoration has been successful. Additional mitigation measures do not need to be established at this time.

ASSESSMENT OF RESTORATION ISSUES

A. Restoration Standards

Q20. What are the restoration standards for Crow Butte?

A20. (DP, LT) Under 10 C.F.R. Part 40, Appendix A, Criterion 5B(5), after termination of production activities the concentration of each hazardous constituent must be restored to not exceed (a) the background concentration, (b) the maximum values in the Criterion 5C Table, if the constituent is listed in the table and the background level is lower than the value in the table, or (c) an alternate concentration limit ("ACL") proposed by the licensee and established in accordance with Criterion 5B(6) of Part 40, Appendix A.

There are restoration quality standards for ground water at Crow Butte set by the Nebraska Department of Environmental Quality ("NDEQ"). The NDEQ values are established for each mine unit in connection with the Notice of Intent to Operate ("NOI"). As explained in Section 6.1.3 of the LRA (Exh. CBR-011), Crow Butte set a primary restoration goal to return the quality to the pre-operational baseline values on a parameter-by-parameter basis for each mine unit. Baseline data are used to establish this goal for restoration on a mine unit average. If this baseline cannot be achieved after diligent application of the best practicable technology ("BPT"), Crow Butte committed to NDEQ to returning the ground water to secondary values set by NDEQ in the Class III Underground Injection Control ("UIC") Permit. The secondary restoration values approved by the NDEQ in the NOI for each mine unit and are based on the following:

- For parameters where NDEQ has established a maximum contaminant level ("MCL") in its regulations, the restoration goal is the MCL.
- If the baseline concentration exceeds the MCL for a contaminant, the restoration standard is set at the mine unit baseline average plus two standard deviations.
- If there is no MCL for an element, the restoration value is based on BPT.
- The restoration values for the major cations (Ca, Mg, K, Na) allow the concentrations to vary up to one order of magnitude as long as the TDS [total dissolved solids] is met. The total carbonate restoration criterion allows the total carbonate to be less than 50 percent of the TDS. The TDS restoration value is set at the baseline mine unit average plus one standard deviation.

Baseline and NDEQ restoration standards were included in the LRA Table 6.1-1 for Mine Units 1-10. These restoration values ensure that groundwater is returned to a quality consistent with the uses for which it was suitable prior to uranium mining.

Under the renewed NRC license, the NRC will treat the NDEQ standards for Mine Units 7-11, as secondary goals to be approved by the NRC as an ACL, if necessary.

Q21. Explain the NRC Staff conclusion regarding the restoration standards?

A21. (DP, LT) In the SER the NRC Staff recognized Crow Butte's commitment in the LRA to meeting the regulations in 10 C.F.R. Part 40, Appendix A, Criterion 5B(5) and concluded that the commitment is consistent with the regulations. Given the secondary restoration values in the NDEQ UIC permit, the NRC Staff concluded that for clarity it would impose a license condition specifying that hazardous constituents shall be restored to the standards required by Appendix A. But consistent with Appendix A, Crow Butte may propose an ACL as described above. To be approved Crow Butte must demonstrate that for a constituent of concern it has made a reasonable effort to return the constituent to pre-operational baseline levels or to the Appendix A, Table 5C value (if applicable). This request for approval would be by a future license amendment application.

The NRC Staff also addressed Crow Butte's sampling methodology to establish baseline water quality. The NRC established a license condition to assure that baseline water quality is assessed in accordance with Criterion 5B(5). *See* LC 6.1.4 in the Final SER (Exh. NRC-009).

B. Overview of Aquifer Restoration

Q22. What is the Crow Butte restoration program?

A22. (All) The groundwater restoration program is described in the approved Crow Butte Groundwater Restoration Plan (Revision 2, dated January 30, 2003) (Exh. CBR-037). The restoration program consists of two stages: The restoration stage and the stabilization stage. Aquifer restoration activities involve the treatment of ground water using process equipment to return the ground water quality to the ground water protection standards in the affected wellfield area. The goal of the restoration program is to return ground water contaminants on a mine unit average to the target concentrations. (If those concentrations are not achieved, after reasonable efforts based on BPT as discussed above, ACLs may be necessary subject to NRC approval.)

More specifically, restoration of an affected aquifer commences following cessation of ISR operations for a particular mine unit. The current ground water restoration plan for the CBR facility mine units consists of four activities:

- Ground water transfer;
- Ground water sweep;
- Ground water treatment; and
- Well field circulation.

The stabilization stage consists of monitoring the wells following successful completion of the restoration phase (return of concentrations to acceptable levels). The monitoring is intended to ensure that there is no increase in concentrations.

After the stabilization period, Crow Butte will make a request to regulatory agencies to decommission the mine unit and terminate licenses as appropriate.

Q23. Briefly explain the phases of the restoration process.

A23. (All) The groundwater restoration process is described in Section 6.1.4.2 of the LRA. Ground water transfer is the process of transferring ground water from the underground aquifer (typically from a mine unit commencing operations) to the mine unit undergoing restoration. Higher TDS water from the mine unit in restoration will be injected into the mine unit commencing operation. This will lower the TDS in the restoration mine unit by displacing water affected by mining with baseline quality water. The recovered water may be passed though ion exchange ("IX") columns and filtration. This transfer approach reduces the amount of affected water ultimately sent to the wastewater disposal system.

During ground water sweep, water is extracted from all or portion of the former production zone with the injection system shutdown. This causes an influx of baseline quality water to "sweep" across an affected portion of the aquifer. This can be applied to the entire mine unit or, as for the units currently undergoing restoration, only to the edges of the mine unit. The cleaner baseline water has lower ion concentrations and acts to strip off cations that have attached to clays during mining. The extracted water must be sent to the wastewater disposal system during this activity.

In the treatment phase (full-scale restoration), ground water is pumped to treatment equipment and then re-injected into the well field. Full-scale treatment involves IX plus reverse osmosis ("RO") equipment to lower the ion concentrations of the ground water in the extraction area. The IX columns exchange the majority of the contained soluble uranium for chloride and sulfate. The RO unit is used to reduce the total dissolved solids of the ground water, reduce the quantity of ground water that must be removed from the aquifer to meet restoration limits, concentrate dissolved contaminates to reduce the volume of brine and facilitate waste disposal, and enhance the exchange of ions due to differences in ion concentration. The RO unit produces clean water (permeate) and brine.

A reductant may also be added at any time to the fluids circulated during restoration to lower the oxidation potential of the production zone and thereby render uranium less mobile. A sulfide or sulfite compound also will be added to the injection stream in concentrations sufficient to reduce the mobilized species. At the completion of the treatment phase, well field recirculation may be initiated to homogenize the aquifer. Solutions can be recirculated by pumping from production wells and re-injecting the recovered solution into injection wells.

Q24. How does Crow Butte dispose of the permeate and brine from the restoration processes?

A24. (DP, LT) Crow Butte currently disposes of the permeate and brine by injection of the wastes into the three waste disposal ponds and then into two NDEQ-permitted non-hazardous on-site deep disposal wells. The waste disposal ponds comply with the design, installation, and operation criteria specified in NRC Regulatory Guide 3.11. In 2011, Crow Butte began operating a second deep disposal well to help accommodate the disposal of additional waste water generated by the RO and IX flow.

Q25. What is a pore volume?

A25. (All) A pore volume is defined as the volume of water contained in the pore space of the aquifer affected by mining and required to be restored. The pore volume is calculated by multiplying the area of the ore zone aquifer by the aquifer thickness and the porosity. The number of pore volumes needed for ground water treatment may consist of reverse osmosis, ion exchange, and sulfide reductant addition.

Q26. What is the groundwater stabilization phase?

A26. (All) Groundwater stabilization is described in Section 6.1.5 of the LRA. Essentially, upon completion of restoration a groundwater monitoring program will begin. Restoration and monitoring wells will be sampled and analyzed for the restoration parameters. The sampling frequency is one sample per month for a period of six months for NDEQ and one sample per quarter for the NRC. Restoration will be considered complete if the six monthly samples and the four quarterly samples show that the restoration values are maintained.

At the end of the stabilization period Crow Butte will compile water quality data obtained during restoration and stabilization and submit a final report to the regulatory agencies. If restoration standards are met and the samples do not exhibit any significant increasing trend, Crow Butte would request that the mine be declared restored. Following regulatory approvals, wellfield reclamation, plugging, and abandonment will be completed as described in the LRA.

Q27. What is the current status of restoration at Crow Butte?

A27. (All) Crow Butte completed ground water restoration and received NRC approval for Mine Unit 1 in 2003. Mine Units 2-6 are currently in restoration. Active restoration is complete for Mine Units 2 and 3 and both units are being monitored in advance of final regulatory approvals. Approvals for Mine Units 2 and 3 are projected for 2015. Mine Units 4-5 are currently in active restoration. Restoration and approvals are projected for Mine Unit 4 in 2019 and Mine Unit 5 in 2022. We began work on an MBRP for Mine Unit 6 earlier this year. Restoration and approval for Mine Unit 6 is projected for 2021.

In accordance with NDEQ Permit NE0122611 (Exh. CBR-017), Crow Butte cannot have more than five mine units in production and five mine units in restoration at any one time. Therefore, restoration will need to be completed on one more of the mine units before production begins on another.

Q28. Did the NRC Staff address the restoration process in the SER?

A28. (All) Yes. In SER Section 6.1.3.3 the NRC Staff described the restoration process used by Crow Butte, referring to Section 6.1.4.2 of the LRA. The NRC Staff found the Crow Butte processes to be consistent with the previous license renewal applications and with the previously approved restoration plan for Mine Unit 1. The NRC Staff found its prior findings to remain valid and did not further reexamine the issue. The NRC Staff observed that the restoration of a typical mine unit at Crow Butte consists of a variable number of pore volumes of ground water sweep, 6 pore volumes of ground water treatment, and 2 pore volumes of ground water recirculation.

We understand that the pore volume estimates in the SER are based on Crow Butte's approved Surety Estimate for the mine, which includes 9 pore volumes for treatment (3 pore volumes for IX treatment and 6 pore volumes for RO treatment) and 2 pore volumes for recirculation. As we will discuss in more detail later in our testimony, these estimates are based on actual data from Crow Butte indicating that, based on the MBRP, restoration of remaining mine units will be completed with approximately 11 pore volumes (6-9 pore volumes of ground water treatment and 2 pore volumes of ground water recirculation).

C. ***Consumptive Water Use During Restoration***

Q29. What did the NRC Staff conclude in the final EA about consumptive water use in operations?

A29. (All) The NRC Staff addressed ground water impacts in Section 4.6.2 of the EA. As discussed above, Section 4.6.2.2.1 addresses quantity impacts from consumptive use during operations. The Crow Butte facility is licensed to process 9,000 gallons per minute (gpm), but the NRC observed an operating flow in 2011 of 6,760 gpm. Part of the operating flow is utilized as bleed to maintain an inward gradient in the wellfields to contain process fluids and protect surrounding groundwater. The NRC Staff reported that the consumptive use from the bleed has been about 0.5 percent to 1.5 percent. At a processing rate of 7,000 gpm this results in a consumptive use between 35 gpm and 105 gpm. This small consumptive use will remain the same in the renewal period.

Q30. What did the NRC Staff conclude in the final EA about consumptive water use in restoration?

A30. (All) As discussed above, the EA addressed aquifer restoration impacts in EA Section 4.6.2.3. The NRC Staff concluded, "based on the restoration analogues in the most recently approved license application and representations by [Crow Butte]," restoration of a mine unit will need at least eleven pore volumes to achieve compliance with the ground water protection standards in 10 C.F.R. Part 40, Appendix A, Criterion 5B(5). The NRC Staff also assumed, presumably based on historical results for Mine Units 1-3, that the restoration schedule may extend beyond the schedule proposed by Crow Butte and may require more than eleven pore volumes for all mine units. Therefore, the NRC Staff concluded that the short-term impact from consumptive use in restoration may be MODERATE. However, the NRC Staff also concluded that water levels would eventually recover after aquifer restoration, resulting in an overall SMALL impact from consumptive water use.

Q31. Do you have a position on the consumptive water use during restoration?

A31. (All) Yes. Impacts on ground water quantity during aquifer restoration are related to ground water consumptive use. The potential environmental impacts to ground water quantity during aquifer restoration are the same as those for operations, except ground water consumption is increased (as the NRC Staff concluded). This is particularly true during the sweep phase, when a greater amount of ground water is generally withdrawn from the production aquifer. During the sweep phase, ground water is not reinjected into the production aquifer and all withdrawals are considered consumptive. The intervenors' primary claim appears to be that eleven pore volumes (or more) is too few and that Crow Butte must account for potential of a lot more. However, we believe that the NRC Staff conclusions are appropriate and, more likely, conservative or bounding. Based on the most recent methods applied at Crow Butte based on the MBRP and the results achieved to date, the short term consumptive impacts of restoration will be less than assumed by the Staff and will not be more than MODERATE. The impact, however, will not have long term effects as the confined aquifer recovers.

Q32. What is the Model-Based Restoration Plan or MBRP?

A32. (All) Crow Butte began restoration of Mine Unit 2 in 1996 and Mine Unit 3 in 1999. Initial groundwater restoration of these units was relatively inefficient, resulting in an excessive number of pore volumes being treated to achieve the restoration results needed. Crow Butte retained Worley Parsons to develop a site groundwater flow model to optimize flow rates and patterns (Exh. CBR-041). This work was continued by Aqui-Ver and now AquiferTek. This has led to significant improvements in restoration efficiency for Mine Units 2, 3, 4, and 5 to date. Aqui-Ver documented the results for restoration activities completed in Mine Units 2 and 3 in April 2013 (Exh. CBR-038). The analytic results for Mine Units 2 and 3 were submitted to the NRC in separate correspondence dated May 9, 2013 (Exhs. CBR-039 and CBR-040)

(RL) I have been responsible for assisting Crow Butte with wellfield restoration through all of my employers from 2009 to the present. With respect to the MBRP my role has been to complete the study, develop a site-wide groundwater flow model to improve the restoration efficiency and results, prepare a MBRP for Mine Units 2-5, and assess pore volume restoration requirements. The MBRP has been refined and expanded since 2009 as restoration has progressed, and it is currently be utilized to refine the restoration plan for Mine Unit 6.

My work specifically included development of a three-dimensional groundwater flow and transport model for the site using MODFLOW2000, a three-dimensional groundwater flow model developed by the United States Geological Survey. This model was then used in the MBRP to optimize restoration well locations, injection and extraction rates, and the overall sequence of treatment activities for each mine unit. The flow and transport model and the MBRP greatly improved restoration efficiency by strategically focusing on water that needs to be treated and minimizing water that is treated multiple times. The MBPR was implemented in May 2009 with full-scale restoration of Mine Unit 2, followed by full-scale restoration of Unit 3 in December 2009. *See* Pore Volume Restoration Analysis at 1-2 (Exh. CBR-038)

Q33. Was the groundwater flow model calibrated?

A33. (RL) Yes. The 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. Initial estimates of aquifer properties and boundary water levels were adjusted slightly as part of the model calibration process in order to achieve the best possible match between observed and simulated water levels. The calibrated groundwater flow model is currently being used to optimize restoration in Mine Units 4-6, now undergoing restoration. The plan is adjusted given certain practical limitations on treatment rates, disposal capacity, and existing well injection and extraction rates. The model is also re-calibrated periodically to reflect current mine conditions.

Q34. What have been the results to date using this model?

A34. (All) As discussed in the April 2013 Pore Volume Restoration Analysis (Exh. CBR-038) groundwater in Mine Unit 2 was restored in January 2010 after nine months of groundwater treatment. After March 2010 restoration was limited to spot treatment of certain areas with somewhat elevated concentrations of arsenic and/or vanadium. Restoration of Mine Unit 3 was completed in October 2011, again with limited spot treatment of specific areas after that date.

Q35. More germane to Contention 6, what was the impact on pore volumes used in the treatment phase of restoration?

A35. (All) The Pore Volume Restoration Analysis (Exh. CBR-038) discusses the pore volume modeling for Mine Units 2 and 3. The pore volumes calculated by the MBRP are for full-scale groundwater treatment (RO + IX + reductant) and does not include groundwater sweep, IX treatment only, water transfer, or recirculation phases of restoration. But, after implementation of the MBRP, restoration of Mine Units 2 and 3 was achieved after 2.25 and 1.71 pore volumes of groundwater treatment, respectively. The report also addresses pore volume restoration requirements for other mine units. We concluded that the theoretical number of pore volumes of groundwater treatment needed to restore a mine unit ranges from 1.54 to 3.00 pore volumes. Then, using Cameco's historical affected pore volume ("APV") calculations that reflect restoration inefficiencies, deviations from model assumptions, and uncertainty, rather than the theoretical APV calculated by our model, the total amount of full-scale groundwater treatment needed for complete restoration is approximately 3.63 to 5.96 pore volumes. Therefore, we conclude that restoration of the remaining mine units can be achieved in 3.6 to 6.0 pore volumes of full-scale groundwater treatment. This suggests that NRC Staff's EA is, if anything, conservative in its assumptions and conclusions with respect to pore volume estimates for future restorations.

Q36. The Intervenors mentioned in their contention that Mine Unit 1 was the smallest mine on the site and that the restoration of the larger mine units will consume much greater quantities. Can you respond?

A36. (All) Yes. This is simply not the case. Mine Unit 1 was surrounded by production wellfields, which complicated the restoration process for that unit. In addition, since embarking on restoration for Mine Unit 1, Crow Butte has greatly improved restoration planning (*i.e.*, through use of the MBRP). Crow Butte has also heavily invested in restoration infrastructure, including doubling the capacity of the reverse osmosis circuit and adding an additional wellfield circuit (to separate the commercial and restoration circuits).

Q37. Going forward, do you have pore volume projections for Mine Units 4 and 5?

A37. (All) We currently expect to complete restoration of Mine Unit 4 in a total of about 12 pore volumes and Mine Unit 5 in 11 pore volumes. These numbers are in line with the EA assumptions.

Q38. Can you summarize the past and projected data for groundwater consumed in the restoration stage at Crow Butte?

A38. (LT) Yes. As discussed above, restoration consists of four possible activities: groundwater transfer; groundwater sweep, groundwater treatment (IX + RO); and wellfield recirculation. The most consumptive groundwater use has been and will be in the treatment processes. Since implementation of the MBRP model we have achieved and will achieve results consistent with the Surety Estimate.

Q39. The NRC Staff in the EA concludes aquifer levels will eventually be restored naturally (*e.g.*, natural movement of inflowing groundwater from regional groundwater flow). Do you agree?

A39. (RL) Yes. The Basal Chadron aquifer is a highly pressurized confined aquifer. The mining and restoration process does not de-water the aquifer pore space or desaturate the aquifer skeleton; it merely depressurizes the system temporarily. After uranium production and aquifer restoration are completed and ground water withdrawals are terminated, the ground water levels in the aquifer will recover relatively quickly with time. Confined aquifers recover quickly compared to unconfined aquifers because they do not require resaturation of the aquifer. Instead the elastic expansion of the aquifer skeleton (repressurization) is a rapid process.

A comparison of recent water levels to the limited 1982-1983 Basal Chadron aquifer water level data depicting static (pre-operational) potentiometric surface was described in Section 3.1.3.5.6 of the SER. Drawdown within the mine units over this time period is estimated to be approximately 14.3 m (47 feet). Although the potentiometric surface of the Basal Chadron Aquifer has been lowered, water levels measured in wells screened within the Basal Chadron aquifer still would rise to approximately the level of the pre-operational potentiometric surface upon termination of mining and restoration. The Basal Chadron aquifer would remain saturated at all locations throughout mining operations. Recovery rates of confined aquifers, such as the Basal Chadron aquifer, are generally far more rapid than those observed in shallow water-table aquifers. The NDEQ UIC permit limits the number of wellfields in restoration at any one time (Exh. CBR-017). This further limits potential cumulative impacts on ground water quality and quantity during restoration.

Q40. Overall, how would you characterize the impacts on ground water consumption due to restoration?

A40. (All) Generally, in its NEPA evaluations the NRC Staff categorizes the potential environmental impacts of a proposed action as follows:

> 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.

MODERATE is conservative with respect to the short term impacts of drawdown during restoration. SMALL is appropriate for longer term impacts given that the aquifer recovers relatively quickly once restoration is complete and natural flow patterns are re-established.

Q41. How does this compare to the conclusions in the NRC's Generic Environmental Impact Statement for In-Situ Leach Uranium Milling facilities?

A41. (All) The conclusions are comparable. The NRC's Generic Environmental Impact Statement for In-Situ Leach Uranium Milling facilities is NUREG-1910, published in May 2009. With respect to the title, note that the NRC treats ISR facilities as underground "mills" since they are separating the uranium from the host rock. The NUREG addresses groundwater impacts in Section 4.4.4.2. The Staff concluded that potential environmental impacts will be affected by the restoration techniques, the severity and extent of contamination, and current and future use of the production and surrounding aquifers in the vicinity of the facility. But the impacts of groundwater consumptive use during restoration could range from SMALL to MODERATE. The most heavily contaminated groundwater is disposed through the wastewater treatment system with SMALL impacts. Underground injection in accordance with an EPA or state permit (as at crow Butte) would be SMALL. The NRC also notes that aquifer restoration continues until NRC and state requirements for groundwater quality are met. Nothing in the NUREG supports the assertion that groundwater quality standards cannot be met or that restoration activities to achieve acceptable levels will require consumptive use beyond the range already identified in the report.

D. <u>Groundwater Impacts During Restoration and Mitigation Measures</u>

Q42. How does Crow Butte address the potential for spills and leaks that might affect groundwater quality?

A42. (LT, DP) A network of buried pipelines is used during ISR operation and restoration for transporting fluids between the pump house and the satellite or processing facility. Although the liquids carried in these pipes during restoration are less hazardous than those used during the operation phase, the failure of pipeline fittings or valves, or failures of well mechanical integrity, could result in leaks or spills of these fluids, which could impact ground water quality. Similarly, the waste storage ponds continue to operate during restoration, and any leaks would impact shallow ground water. Accordingly, as described in the LRA (Exh. CBR-011), Section 3.3, Crow Butte maintains continuous real-time monitoring and control systems to detect and mitigate potential spills and leaks that would impact groundwater. The monitoring and mitigation activities for ground water aquifers during operations are also described in EA Section 4.6.2.2 (Exh. NRC-010). These measures will continue in effect during the restoration phase.

Q43. What are the monitoring activities during operations?

A43. (DP, LT) Crow Butte maintains an extensive water sampling program to identify any potential impacts to water resources in the area. The groundwater monitoring program is described in Section 5.8.8.2 of the LRA (Exh. CBR-011) and Section 5.7.9.3.1 of the SER (Exh. NRC-009). Operational monitoring for all mine units includes sampling of monitoring wells and private wells within and surrounding the license area to establish pre-mining baseline water quality and to identify excursions into the ore zone aquifer outside of the wellfield and into the overlying water bearing strata. If limits are exceeded in a monitor well in 2 of three values or if one value is exceeded by 20 percent, the well is resampled with 48 hours and analyzed for excursion indicators. If an exceedance verified, the well in question is to be placed in excursion status and the NRC is to be notified. Corrective actions are initiated as described in the LRA (at 5-124). Sampling frequency of the monitor well in question is also increased. CBR's excursion monitoring and corrective action program (as reflected in in EA Section 4.6.2.2.4) ensures the protection of water quality in the aquifers surrounding the production zone.

Q44. What is the monitoring during the stabilization phase of restoration?

A44. (All) As discussed above, once restoration is completed for a mine unit, Crow Butte must conduct restoration stability monitoring to ensure that chemical species of concern (*i.e.*, hazardous constituents) do not increase in concentration above the Criterion 5B(5) restoration standards subsequent to restoration. Crow Butte committed in Section 6.1.5 of the LRA (Exh. CBR-011) that once the restoration standards are met for a mine unit, a stability monitoring period of at least six months will be initiated in which monthly samples will be collected from specified ore zone aquifer wells to demonstrate that restoration is stable and that there are no significant increasing trends in any of the constituents of concern. As discussed in the SER (Exh. NRC-009), Section 6.1.4(3), the NRC Staff increased the stability monitoring requirements during the license renewal period. Monitoring must continue until at least the most recent four consecutive quarters of data indicate that constituent concentrations do not demonstrate any statistically significant increasing trend. The NRC Staff imposed a license condition that requires quarterly monitoring of all constituents of concern at the specified ore zone aquifer wells until stability for all constituents of concern is established over at least four quarters.

Based on the restoration plan, Crow Butte will determine the start of the stabilization period through a Safety and Environmental Review Panel ("SERP") process. The SERP has also been used to review and approve field studies to assess the effectiveness of remediation and additional measures that may be employed.

Q45. What additional measures have been implemented during restoration to mitigate groundwater impacts?

A45. (All) As noted previously, Crow Butte has used chemical reductants during the groundwater treatment phase to improve the restoration performance. Chemical reductants change the oxidation/reduction potential of the ground water in the wellfield to induce precipitation of uranium and other constituents to lower their concentration in the groundwater.

(RL) In October 2008 a Crow Butte SERP reviewed and approved a pilot field study using biorestoration to improve restoration performance in Mine Unit 4. Biorestoration is the injection of organic compounds in the groundwater in the wellfield to induce biological reduction to change the oxidation/reduction potential of the ground water in the wellfield to induce precipitation of uranium and other constituents. Although initial laboratory test results indicated that bioreduction had potential, subsequent field testing was not successful. Ultimately, Crow Butte determined that the MBRP provides the most efficient and effective method for completing restoration of mine units.

Q46. Contention 9 alleges inadequate discussion of efforts to mitigate the effect of increased pore volumes and ground water restoration quality and quantity impacts. Do you have any comments on those topics?

A46. (All) As we have discussed, Crow Butte has developed a calibrated groundwater flow model that will be applied to restoration activities going forward. The effectiveness of the model has been demonstrated for Mine Units 2 and 3. Application of the model will minimize the number of pore volumes necessary for restoration, as well as related impacts on consumptive use. With respect to groundwater quality, Crow Butte must restore groundwater quality to levels that satisfy the conditions set in its NDEQ permit and NRC license. Those restoration standards, which are linked to baseline conditions/background concentrations (NDEQ and NRC), class of use (for NDEQ), the maximum values for groundwater protection in Part 40, Appendix A, Table 5C (for NRC), or alternate concentration limits (ACLs) established by the NRC.[2] Restoration to those standards — levels that are either consistent with baseline conditions or, by definition, protective of human health and the environment — will result in SMALL environmental impacts.

CONCLUSIONS

Q47. What are your overall conclusions regarding Contentions 6 and 9?

A47. (All) Contentions 6 and 9 do not present any reason that the NRC Staff's EA is inadequate. The EA addresses consumptive water use during restoration in both the short term and the long term. The EA describes the former as MODERATE and the latter as SMALL. We believe that, based on current and future practices, these characterizations are bounding. The EA, as supplemented by our discussion here, also describes the restoration standards, the restoration process, and reasonable measures to mitigate the impacts of consumptive water use (*e.g.,* the MBRP) and to control and to mitigate impacts on groundwater water quality (*e.g.,* monitoring, treatment, and standards).

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2 ACLs will, as previously discussed, require an additional regulatory approval only that will be granted only after Crow Butte demonstrates, among other requirements, that the limits are "as low as reasonably achievable" and that the constituent "will not pose a substantial present or future hazard to human health or the environment." Part 40, Appendix A, Criterion 5B(6).