Cameco

CAMECO RESOURCES
Corporate Office
2020 Carey Avenue
Suite 600
Cheyenne, WY
82001 USA

Tel: (307) 316-7600
Fax: (307) 635-9949
www.cameco.com

October 22, 2010

ATTN: Document Control Desk
Deputy Director
Decommissioning and Uranium Recovery Licensing Directorate
Division of Waste Management and Environmental Protection
Office of Federal and State Materials and Environmental Management Programs
Mailstop T8-F5
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Replacement pages and response to NRC letters dated November 12, 2009 and March 24, 2010, Open Issues, North Trend Expansion Area License Amendment, Crow Butte Resources, Inc., Crawford Nebraska, License SUA-1534 (TAC J00555)

Document Control Desk:

By letters dated November 12, 2009 and March 24, 2010, the U.S. Nuclear Regulatory Commission identified open issues associated with the North Trend Expansion Area License Amendment. Attached please find responses to the open issues, replacement pages, and redline-strikeout replacement pages to assist NRC review.

Cameco has also attached four additional copies for Mr. Ron Burrows, the NRC Project Manager, for his use during review.

If you or your staff has any questions, please contact John Schmuck at (307) 316-7587.

Sincerely,

William Paul Goranson,
President, Cameco Resources

Attachments: As stated.

CC:	Ron Burrows, NRC,	4 copies w/ attachments		
	Larry Teahon, CBR	w/ attachments	CR file	w/ attachments
	John Schmuck, CR	w/o attachments	Josh Leftwich, CR	w/o attachments
	Jim Stokey, CBR	w/o attachments		

NMSS01

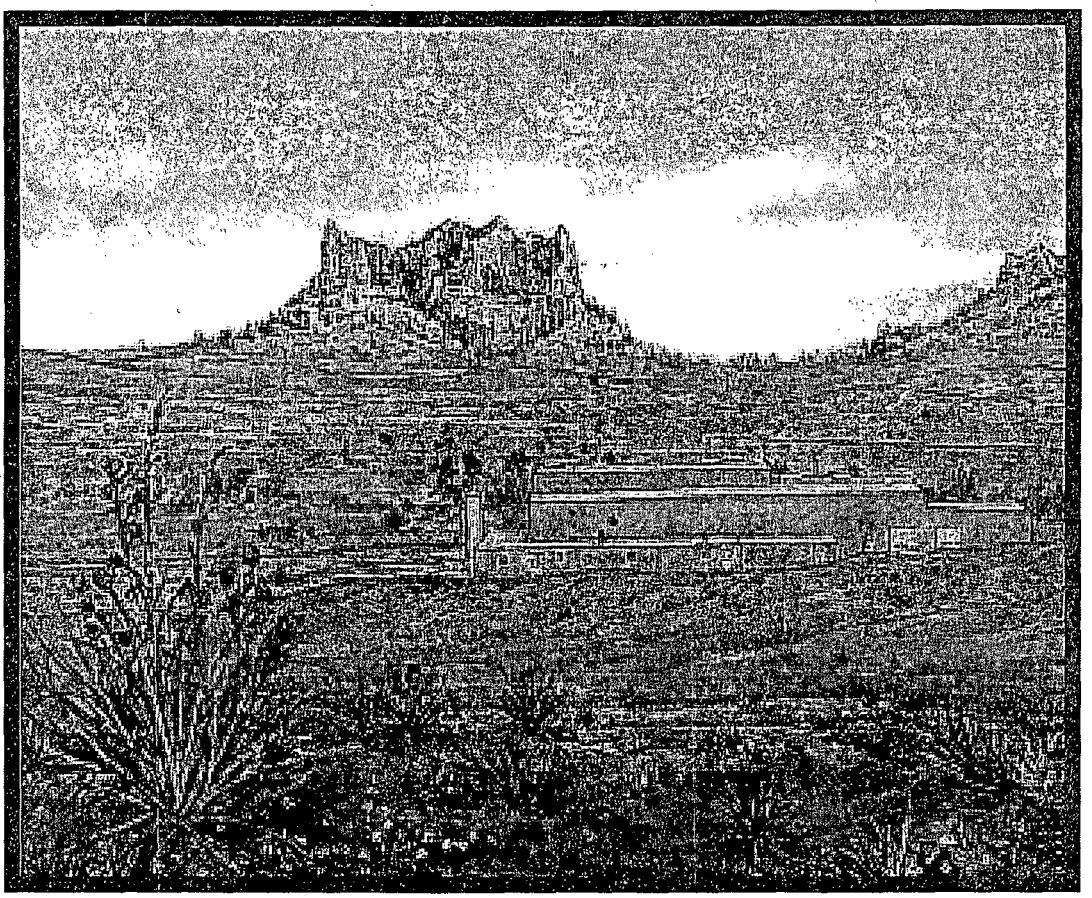
Crow Butte Resources, Inc.

Responses to NRC Open Issues

North Trend Expansion Area License Amendment Request

Source Material License SUA-1534

TAC J00523



Prepared by
Crow Butte Resources, Inc.
86 Crow Butte Road
Crawford, Nebraska 69339

October 2010

CROW BUTTE RESOURCES, INC.

Nuclear Regulatory Commission

Responses to NRC Open Issues (TAC J00523)

North Trend Expansion Area License Amendment Request

Source Material License SUA-1534

October 22, 2010

Responses to NRC Open Issues

North Trend Expansion Area License Amendment Request

Crow Butte Resources, Inc.

License SUA-1534 (TAC J00523)

Dated November 12, 2009

Open Issues

I. Meteorology

1. Justification of why Crow butte data is representative of North Trend Expansion Area.

Background: Section 2.5 of the Technical Report (TR) describe meteorological data collected from an onsite monitoring station "near the Crow Butte facility." In Section 2.5.5 of the TR (Winds), the applicant discusses why the Crow Butte data should be considered valid.

Needed: We are looking for an analysis of why the Crow Butte data, in particular the wind data, is representative of the North Trend Expansion Area, not why it was the best data from the options presented. It would be helpful to include the location of the Crow Butte onsite monitoring station.

***Response**: At the outset of operations, CBR will install, and for one year will operate a meteorological tower at the NTEA to verify the representativeness of the historic Crow Butte Central Processing Plant (CPP) data used in the NTEA license amendment application. This commitment is now reflected in Section 2.5.5. The location of the CPP monitoring station will be added to Figure 2.5-7.*

2. No concurrent data from National Weather Service station to demonstrate data represents long-term trends.

Background: RG 3.63 recommends comparing a concurrent period of meteorological data from a National Weather Service (NWS) station with the long-term meteorological data from that NWS station. The NWS station selected for this comparison should be in a similar geographical and topographical location and be reasonably close (preferably within 50 miles of the site).

Needed: The applicant should determine if the period of meteorological data collection is representative of long-term meteorological conditions in the site vicinity, including a justification for the selection of the NWS station.

***Response:** At the completion of the one year of NTEA meteorological data collection described above, CBR will compile and compare the concurrent data from the NWS station at Chadron Nebraska with the long term data collected at Chadron to determine if the one year data collection period is representative of long-term conditions. The Chadron NWS station is within 50 miles, and is in a similar geographical and topographical location.*

3. No information related to siting of meteorological instruments.

Background: RG 3.63 provides recommendations on the siting of meteorological instruments. The applicant did not furnish any information of this type for its meteorological instruments used to collect onsite data.

Needed: The applicant should provide this information.

***Response:** At this time the location is uncertain. CBR will locate the NTEA meteorological station consistent with RG3.63.*

4. No discussion on method used to calculate atmospheric stability or what type of instrumentation was used.

Background: Referring to RG 3.63, the applicant did not discuss which method was used to calculate atmospheric stability and what type of instrumentation was used in the calculations.

Needed: Applicant should address this issue.

***Response:** A discussion of the atmospheric stability calculation is presented in Section 2.5.5.*

5. No data on mixing layer height.

Background: The applicant did not provide information related to annual average mixing layer

height which is used in MILDOS calculations.

Needed: Applicant should address this issue.

Response: Information regarding annual average mixing layer height is presented in Section 2.5.5.

6. Lack of description of the types and specifications for the meteorological instruments used to collect relevant data.

Background: RG 3.63 provides recommendations regarding meteorological system accuracy and instrumentation specifications. The applicant did not provide a complete description of the types (e.g., wind instrumentation) and specifications for the meteorological instruments used to collect relevant data.

Needed: Applicant should address this issue.

Response: *CBR will select instrumentation for the NTEA meteorological station consistent with the recommendations of RG 3.63.*

Note: No #7.

8. Lack of data on system calibration and maintenance.

Background: RG 3.63 provides recommendations on meteorological system calibration and maintenance. The applicant did not provide any data on systems calibration or maintenance.

Needed: Applicant should address this issue.

Response: *CBR will calibrate and maintain the NTEA meteorological station consistent with RG 3.63.*

9. No recovery rates provided for meteorological data.

Background: RG 3.63 provides recommendations on meteorological data recovery. The applicant did not provide this data.

Needed: Applicant should address this issue.

Response: *Consistent with RG 3.63, CBR has modified Section 2.5.5 of the TR to recognize the data recovery requirements.*

II. Radiological Issues

1. Justification for AM-6 as background control location.

Background: Figure 2.6-1 describes the preoperational and operational air monitoring locations. The applicant stated that monitoring location AM-6 represents the background control location for the North Trend Expansion Area, as well as the current licensed operation.

RG 4.14 provides guidance for selecting control sampling sites. In general, this location should be in the least prevalent wind direction and unaffected by milling operations. Based on wind data presented by the applicant (see Section 2.5 of the TR) and no additional discussion by the applicant, it is not clear why AM-6 was chosen as the background control location for the North Trend Expansion Area.

The least prevalent wind direction appears to be towards the west. While this wind pattern would appear to make AM-6 suitable as a background location for current operations, a more westerly monitoring location would seem to be more appropriate. Table 7.3-1 of the TR appears to confirm this as westerly receptor points generally result in lower estimated doses.

Needed: A discussion which provides justification for selecting AM-6 as the background control location for the North Trend Expansion Area which addresses RG 4.14 guidance criteria.

Response: *Section 2.9.2.1.2 now includes sampling Station AM-26. AM-26 is located west of the satellite facility and will be used to collect background data.*

2. Criteria for placement of pre-operational radon monitors.

Background: in Section 2.9.2.1 of the TR, the applicant described the positioning of the air monitoring locations for the North Trend Expansion Area, AM-9 through AM-14 (see Figure 2.9-2 of the TR). It appears that the nearest residents and the locations of the proposed license boundaries were taken into consideration. However, referring to Figure 2.5-6 and Table 7.3-1 of the TR, the applicant did not appear to take into account the three different downwind sectors with the highest predicted radionuclide airborne concentrations during milling operations as recommended by RG 4.14.

Needed: The applicant should provide justification for placement of preoperational radon monitors which address RG 4.14 recommendations or sufficient justification for an alternate proposal.

Response: *Section 2.9.2.1.2 now includes sampling Station AM-26. AM-26 is located west of the satellite facility and will be used to collect background data. Additional justification for the placement of air monitoring stations has been provided in Sections 2.9.2.1.1 and 2.9.2.1.2.*

3. Justification for a lack of pre-operational airborne particulate monitoring program.

Background: In Section 2.9.2.3 of the TR, the applicant described its preoperational air particulate monitoring program. According to the applicant, since all drying and packaging operations will be performed at the current CPP, there are no operations that could cause a release of airborne particulate radionuclides. However, air particulate samples were taken at air monitoring location AM-10. These results, and those of the control location (AM-6), are presented in Table 2.9-3.

In evaluating the applicant's preoperational air particulate monitoring program, NRC staff notes that other source terms that could lead to a release of airborne particulate radionuclides exist. These include ongoing radon releases leading to particulate radon daughter (e.g., Pb-210) production and pregnant lixiviant field spills.

Needed: An analysis of airborne radionuclide particulate source terms and an evaluation of a preoperational air particulate monitoring program consistent with RG 4.14.

Response: *Section 2.9.2.3.2 now includes preoperational airborne particulate monitoring.*

4. Insufficient justification for not sampling for airborne Th-230.

Background: In selecting which radionuclides to include in its preoperational air particulate monitoring program, the applicant stated that Th-230 was not selected for analysis as recommended in RG 4.14 based on the current NRC-approved Crow Butte operational air particulate monitoring program and because Th-230 is not typically released through the in situ leach process and is not a radionuclide of concern.

In evaluating these reasons, NRC staff notes that the decision to end Th-230 monitoring was made only after evaluating the measurement of Th-230 levels in the environment following seven years of commercial operation at the currently licensed facility (ML071520242). Further, the applicant has not demonstrated that conditions at the North Trend Expansion Area would lead to identical results obtained at its currently licensed facility. Lastly, the applicant did not provide data to substantiate that Th-230 is "not a radionuclide of concern."

Needed: Either provide a preoperational air particulate monitoring program consistent with RG 4.14 or sufficient justification for not including Th-230.

Response: *CBR has agreed to conduct pre-operational monitoring that includes Th-230. The data will be collected to manage CBR environmental risks during operations and to provide a baseline that will*

facilitate decommissioning. CBR remains unconvinced that this sampling is required from either a scientific or a regulatory basis.

The NTEA is a nearby extension of the same ore body that will be mined and processed using identical methods. No scientific basis has been offered to suggest the results will be different. In fact, a strong scientific basis exists which supports operating the NTEA as an extension of the CPP under the existing, NRC-approved and validated, CPP license requirements. Those license requirements do not currently require Th-230 operational sampling.

CBR is extremely concerned with the implications of this comment, particularly the need to demonstrate "that conditions at the North Trend Expansion Area would lead to ***identical*** *results obtained at its currently licensed facility" (emphasis added). The demand of an identical result would impede the exercise of sound professional scientific judgment and from that, appropriate regulatory discretion. It is essential that issues of this kind are objectively evaluated and where appropriate, prior determinations upheld and applied. As time goes on and ISR experience grows, the use and application of the publicly-available data and prior regulatory determinations across the entire ISR industry will promote consistent regulatory interpretation and enforcement, and expedite the licensing process.*

5. Justification for not monitoring radon flux.

Needed: No further action required.

Response: *None required.*

6. Proposed vegetation sampling program not consistent with RG 4.14.

Background: The applicant has committed to perform vegetation sampling during the 2009 growing season. Proposed sample locations are presented in Figure 2.9-4 of the TR. According to the applicant, the sampling protocol in RG 4.14 is based on air particulates from the processing facility and since few particulates will be generated this approach does not appear to be meaningful. Instead, the applicant proposed locations that are representative of wellfield locations and that could be potentially impacted due to spills during cleanup operations.

NRC staff notes that the sampling protocol in RG 4.14 includes radon daughters that are generated from radon in the wellfield and that radon releases can lead to radionuclide foliar deposition and uptake by vegetation of these radon daughter products.

Staff also does not agree with the applicant regarding the definition of milling operations as stated in the applicant's February 27, 2009 response to NRC staff's November 17, 2008 request for additional information. As defined in 10 CFR 40.4, uranium milling "means any activity that result in the production of byproduct material...."

Needed: The applicant should evaluate all of its activities and then propose a vegetation sampling protocol based on this evaluation that is consistent with the recommendations in RG 4.14 or justification for an alternate proposal.

Response: *Consistent with the revisions to Section 2.9.5.2, additional preoperational vegetation sampling will be collected.*

7. Crop sampling not addressed.

Background: The applicant did not address preoperational crop samples. As indicated in Section 2.2.2.2 of the TR, the primary land use in the North Trend Expansion Area is cropland.

Needed: The applicant should evaluate preoperational crop sampling consistent with the recommendations in RG 4.14 or provide justification for an alternate proposal.

Response: *Preoperational crop sampling is now included in the revised Section 2.9.6.*

8. Livestock sampling not addressed.

Background: In Section 2.2.2.2 of the TR, the applicant stated that within the North Trend Expansion Area and the surrounding 2.25-mile review area the primary land use is raising livestock. The applicant did not address preoperational livestock samples.

Needed: The applicant should evaluate preoperational livestock sampling consistent with the recommendations in RG 4.14 or provide justification for an alternate proposal.

Response: *Preoperational livestock sampling is now included in the revised Section 2.9.6.*

9. Fish sampling not addressed.

Background: In Section 7.2.7.10 of the TR, the applicant identified portions of Spring Creek and the White River, both of which cross the proposed site boundary, as suitable habitats for fish. The applicant did not address preoperational fish samples.

Needed: The applicant should evaluate preoperational fish sampling consistent with the recommendations in RG 4.14 or provide justification for an alternate proposal.

Response: *Preoperational fish sampling in the White River is now included in the revised Section 2.9.7.2. Spring Creek is an ephemeral drainage that does not contain fish.*

10. Justification for using exposure rate correlation data developed from currently licensed facility for North Trend Expansion Area direct radiation readings.

Background: As described in Section 2.9.8.2 of the TR, the applicant performed direct gamma radiation measurements at the proposed satellite processing area in May 2004 using a Ludlum Model 44-10 sodium iodide detector and associated electronics. A total of 422 measurements were collected and are presented in Figure 2.9-6 of the TR. In addition, exposure rate measurement were collected at each satellite processing area soil sample location described in Section 2.9.8.2 of the TR using a Ludlum Model 19 [IR meter. Summary data for the gamma direct gamma radiation measurements are presented in Table 2.9-12 of the TR.

NRC staff notes that the gamma exposure rate values in Table 2.9-12 were derived using the exposure rate vs. count rate correlation data derived from the currently licensed facility (see note to Table 2.9-12). The applicant has not provided justification for applying a correlation derived from another land area and applying it to the North Trend Expansion Area. Moreover, in its February 27, 2009 response to NRC staff's November 17, 2008 request for additional information, the applicant stated that it is unlikely that a meaningful correlation exists for this site.

Needed: The applicant should provide a technical justification for using correlation data from an unrelated land area or provide preoperational gamma measurements consistent with RG 4.14.

Response: *As described in Section 2.9.10.2.1, correlation between soil samples, sodium iodide readings and energy independent exposure rate measurements will be performed during preoperational soil sampling and gamma surveys if areas of the site exhibit significantly different gamma count rates.*

11. Same as #10. See above response

12. Justification for location of soil sampling at air monitoring stations – see item #2 above.

Background: As described in Section 2.9.6 of the TR, in 2006, soil samples were obtained from each of the air monitoring locations (AM-9 through AM-14) and analyzed for natural uranium, radium-226, and lead-210. However, as previously discussed, the applicant has not provided sufficient justification to ensure that the locations of the air monitoring stations are consistent

with RG 4.14.

Needed: The applicant should provide justification for placement of air monitoring stations which address RG 4.14 recommendations.

Response: *Additional justification for the placement of air monitoring stations has been provided in revisions to Sections 2.9.2.1.1 and 2.9.2.1.2.*

13. Insufficient justification for not sampling for Th-230 in soil at airborne monitoring stations.

Background: RG 4.14 recommends analyzing surface soil samples at air monitoring stations for Th-230. As indicated on open issue #14, the applicant did not analyze for this radionuclide nor did it provide justification for not doing so.

As discussed for preoperational air sampling, the decision to end Th-230 monitoring was made only after evaluating the measurement of Th-230 levels in the environment following seven years of commercial operation at the currently licensed facility (ML071520242). Additionally, the decision was only applied to airborne particulates and stream sediment samples. Further, the applicant has not demonstrated that conditions at the North Trend Expansion Area would lead to identical results obtained at its currently licensed facility. Lastly, the applicant did not provide data to substantiate that Th-230 is "not a radionuclide of concern."

Needed: Either provide a preoperational soil monitoring program consistent with RG 4.14 or sufficient justification for not including Th-230.

Response: *Please see the response to #4 above. Section 2.9.8.2 now includes Th-230 as an analyte for preoperational soil sampling at airborne monitoring stations. As noted above, requiring "identical results" is without scientific or regulatory basis.*

14. Preoperational sediment sampling from White River not consistent with RG 4.14.

Background: RG 4.14 recommends sampling for sediments twice, once following spring runoff and late summer, preferably following an extended period of low flow. In addition, it recommends that several samples should be collected and composited for a representative sample and analyzed for natural uranium, Ra-226, Th-230, and Pb-210.

In evaluating the applicant's preoperational sediment sampling program, NRC staff notes that the following aspects are not consistent with RG 4.14:

1. The sediment samples were taken in November and December of 2004 and 2006 respectively,
2. There was no discussion on sediment sampling techniques (e.g., how many samples obtained at each location), and
3. Th-230 was not included in the applicant's analysis.

The applicant stated that analysis of Th-230 in sediments was discontinued in 1998 with the concurrence of the NRC. As was previously discussed in open issue #5, the decision to end Th-230 monitoring was made only after evaluating the measurement of Th-230 levels in the environment following seven years of commercial operation at the currently licensed facility (ML071520242). Further, the applicant has not demonstrated that conditions at the North Trend Expansion Area would lead to identical results obtained at its currently licensed facility.

Needed: Provide a preoperational sediment monitoring program consistent with RG 4.14 or sufficient justification for an alternate program.

Response: *Additional preoperational sediment sampling is discussed in Section 2.9.9.2, and Th-230 is included as an analyte. Also please see the Acceptance Criteria for Section 5.7.8.3, (1) enumerated on page 5-39 of NUREG-1569 as regards analysis of Th-230 in natural waters. From this, there does not appear to be a fate and transport mechanism that would lead to deposition of Th-230 in the*

White River. Regardless, CBR will include Th-230 as an analyte during pre-operational sediment monitoring. Also note that Th-230 was non-detect in the six White River samples where Th-230 was analyzed (see Table 2.9-6). As noted above, requiring "identical results" is without scientific or regulatory basis.

15. No preoperational sediment sampling evaluation for Spring and Unnamed Creeks and Hall Canal.

Background: RG 4.14 recommends sampling from drainage systems that cross the site boundary and that may be impacted from contaminated areas.

In Section 2.7.1 of the TR, the applicant identified two ephemeral creeks (Spring and Unnamed) and a historic canal (Hall Canal) that pass through the proposed North Trend Expansion Area (see Figure 2.7-1 of the TR). The applicant did not analyze these drainage systems for potential impacts from their operations.

Needed: Provide a preoperational sediment monitoring program consistent with RG 4.14 or sufficient justification for an alternate program.

Response: *Preoperational sediment sampling for the White River, Spring Creek, Unnamed Creek (at south end of boundary) and Hall Canal is discussed in revised Section 2.9.9.2.*

16. Preoperational surface water sampled for 5 quarters instead of at least 12 months. Only 3 quarters had the complete suite of radionuclides analyzed consistent with Regulatory Guide 4.14.

Background: RG 4.14 recommends sampling at least monthly from streams that cross the site boundary.

In Section 2.9.4 of the TR, the applicant stated that surface water was sampled from W1 and W-2 on a quarterly basis during 2004 and 2005 for a total of five quarters. In a note to Table 2.9-6 of the TR, some of the quarterly samples were not analyzed for Th230, Pb-210 and Po-210 due to a chain of custody error. Therefore, only 3 quarters of complete data are available versus 12 months recommended by RG 4.14. It is not clear how many samples were actually taken as the applicant discusses nine quarterly sampling periods while only five are shown on Table 2.9-6 of the TR.

Based on sample results, it is the opinion of the applicant that the results presented in Table 2.9-6 of the TR appear to be representative of the White River at W-1 and W-2.

This opinion is not sufficient justification to demonstrate consistency with RG 4.14.

Needed: 1) Clarification on the number of surface water samples evaluated; and 2) provide a preoperational surface water monitoring program consistent with RG 4.14 or sufficient justification for an alternate program.

Response: *Additional preoperational surface water sampling is discussed in Section 2.9.4.2.*

17. Missing radionuclide constituents from some quarterly samples.

Background: As discussed in open issue #20, some of the quarterly samples were not analyzed for Th-230, Pb-210 and Po-210 due to a chain of custody error. This is inconsistent with RG 4.14.

Also discussed in open issue #20, it is the opinion of the applicant that the results presented in Table 2.9-6 of the TR appear to be representative of the White River at W-1 and W-2.

This opinion is not sufficient justification to demonstrate consistency with RG 4.14.

Needed: Provide a preoperational surface water monitoring program consistent with RG 4.14 or sufficient justification for an alternate program.

Response: *Additional preoperational surface water sampling is discussed in Section 2.9.4.2.*

18. Preoperational surface water results do not delineate between suspended and dissolved radionuclides.

Background: Staff also notes that the applicant did not delineate between suspended and dissolved radionuclides as recommended by RG 4.14.

Needed: Provide a preoperational surface water monitoring program consistent with RG 4.14 or sufficient justification for an alternate program.

Response: *Additional preoperational surface water sampling is discussed in Section 2.9.4.2, including analysis for both suspended and dissolved radionuclides.*

19. No preoperational surface water sampling evaluation for Spring and Unnamed Creeks and Hall Canal.

Background: RG 4.14 also recommends sampling from drainage systems that cross the site boundary and that may be impacted from contaminated areas. Any stream beds that are dry part of the year should be sampled when water is flowing.

As discussed in open issue #18, the applicant identified two ephemeral creeks (Spring and Unnamed) and a historic canal (Hall Canal) that pass through the proposed North Trend Expansion Area (see Figure 2.6-4). The sources of water include runoff flow and occasional springs.

The applicant did not evaluate these drainage systems for surface water sampling

Needed: Provide a preoperational surface water monitoring program consistent with RG 4.14 or sufficient justification for an alternate program.

Response: *Additional preoperational surface water sampling is discussed in Section 2.9.4.2, including provisions for sampling ephemeral drainages when flows are present.*

20. Analytical results for preoperational surface soil sampling not included in Technical Report (Confirmatory).

Background: In Section 2.9.6 of the TR, the applicant has proposed collecting soil samples to a depth of 5 cm at 300 meter intervals to a distance of 1500 meters, where feasible, in eight meteorological sectors from the center of the proposed North Trend Satellite Facility (see Figure 2.6-2).

Samples will be analyzed for Ra-226 and 10 percent of the samples for natural uranium, Th-230, and Pb-210. However, the analytical results for surface soil sampling are not incorporated into the TR.

Needed: The applicant should incorporate the analytical results for surface soil sampling into the TR.

Response: *The preoperational sampling will be collected and documented pursuant to a license condition and submitted under separate cover prior to operations.*

21. Analytical results for subsurface soil sampling not included in the Technical Report (Confirmatory).

Background: The applicant has also proposed collecting five subsurface soil samples at a center reference location (North Trend Satellite Facility) and at distances of 750 meters in each of four directions from the center point. All samples will be analyzed for Ra-226 and ones set of samples for natural uranium, Th-230, and Pb-210.

However, the analytical results for subsurface soil sampling are not incorporated into the TR.

Needed: The applicant should incorporate the analytical results for surface soil sampling into the

TR.

Response: *The preoperational sampling will be collected and documented pursuant to a license condition and submitted under separate cover prior to operations.*

22. Insufficient justification for not monitoring radon effluent.

Background: The applicant discussed radon effluents in Section 5.7.7 of the TR. Based on the expected inconsistent radon flow rate and its interpretation of RG 8.37 regarding the practicality of monitoring for airborne radioactive effluents, the applicant decided not to perform any radon effluent monitoring.

NRC staff evaluated the applicant's rationale for not monitoring radon effluent and does not agree with it for the following reasons:

1. The applicant has not presented data on technologies evaluated and its potential application to its operations for NRC staff to make a complete determination on practicality;

2. RG 8.37 recommends that unmonitored effluents should not exceed 30 percent of the total estimated effluent releases;

3. RG 4.14 recommends operational sampling for Pb-210 on a semiannual basis under "other" stacks; and

4. It is not clear if the applicant has made an effort to identify the member of the public likely to receive the highest dose from licensed operations in accordance with 10 CFR 20.1301 which includes the entire Permit Area.

Needed: Applicant should propose an effluent monitoring program for gaseous effluents that addresses the requirements in 10 CFR 1302(a), 10 CFR 40, Appendix A, Criterion 7 and 8, and 10 CFR 40.65 and is consistent with RGs 4.14 and 8.37.

Response #1: *The Lost Creek ISR project provided the following discussion in its April 22, 2010 RAI responses (ML102100241).*

> *"LC ISR, LLC and it health physics contractor have made a concerted effort to identify detection equipment that is capable of measuring radon in stack effluent. While at least one instrument has been identified that is designed for radon sampling in stacks, its detection range precludes its use, as currently designed, at an ISR facility. Therefore, LC ISR, LLC contends that it is not technically feasible to measure radon effluent from the stacks.*
>
> *10 CFR 20.1302 requires the licensee to measure or calculate the maximum total effective dose equivalent to the individual likely to receive the highest dose. 10 CFR 40.65 is worded differently but has the same goal, "...to establish maximum potential annual radiation doses to the public..." LC ISR, LLC intends to comply with these regulations by measuring radon as described in TR Section 5.7.7. In the past, NRC has approved this type of monitoring at ISR facilities and most if not all such facilities currently comply with 10 CFR 40.65 in this manner. Specifically, MILDOS modeling is used to calculate the dose to members of the public before operations begin. Once operations are initiated, alpha track etch detectors are used to measure potential exposure to members of the public.*
>
> *LC ISR, LLC believes that with respect to 10 CFR 40.65, the intent of the regulation is to determine dose to members of the public and not to determine the total number of curies of radon released. Finally, the concentration of radon within the stack is not directly relevant to public safety since the public does not have access to the stacks. What is relevant is the actual exposure members of the public may receive".*

The rationale provided by the Lost Creek ISR project is applicable to the NTEA.

Response #2: *RG 8.37 states: "(w)*hen **practicable**, unmonitored effluents should not exceed 30% of the total estimated effluent releases *RG 8.37 recommends that unmonitored effluents should not exceed 30 percent of the total estimated effluent releases" (emphasis added). Regarding practicability, please see response #1, immediately above. Please also revisit the CBR response dated February 27, 2009 to NRC RAIs dated November 17, 2008 (ML090750429), specifically page 42 of the responses to comments.*

Response #3: *The presence of "stacks" at modern ISR facilities is a misnomer. Since the advent of vacumm dryers traditional "stacks" have been replaced by building ventilation systems which include discharge points in a variety of configurations with inconsistent, intermittent release dependant on ongoing activities. In fact, facility doors will sometimes contribute to overall ventilation of the facility. Will doors now become "other stacks"? CBR believes this is an example of inappropriate, rigid application of dated regulatory guidance that was written for an entirely different type of uranium operation. More important, there will be no vacuum dryer at the NTEA.*

Response #4: *Please revisit the MILDOS Area simulation presented in Section 7.3.3. A resident located in a downwind direction to the northeast of the proposed satellite facility was identified as the member of the public likely to receive the highest dose. Section 5.7.7 cross-references the Section 7.3.3 results.*

23. Insufficient justification for not having an operational environmental air particulate monitoring program.

Background: In Section 2.9.2.3 of the TR, the applicant stated that it does not propose to perform any operational air particulate monitoring due to the absence of proposed operations that could be a source of airborne radioactive particulates.

NRC staff notes, however, that pregnant lixiviant field spills and transportation accidents have been shown (NUREG/CR-6733) to have the ability to result in a significant release of licensed material. In addition, radon daughters from operations can accumulate in soil, vegetation, and surface waters from airborne deposition.

Needed: The applicant should provide an operational environmental air particulate monitoring program consistent with RG 4.14 or sufficient justification for an alternate program.

Response: *The current Crow Butte CPP license only requires particulate monitoring when the dryer is operating. It Is critical to recognize that in the absence of a dryer, particulate-generating activities will not occur at the NTEA. As a satellite facility only wet resin will be produced.*

The nearly 20 years of CBR environmental air particulate monitoring at the nearby CPF has documented the radiological contribution from lixiviant field spills. No increasing trend has been identified, in part because most spills occur on the pressurized side of the process when reinjecting stripped lixiviant. Spills of pregnant lixiviant are rare. Please refer to the CBR response to Crow Butte License Renewal Open Issues, G.1, on pages 6, 7 and 8 of 9 (ML102640195) for a summary of those results. Also note the conservatism built into the MILDOS AREA simulation and the resulting higher dose estimate.

The extensive data and MILDOS Area simulation from the nearby CPF include the contribution of a vacuum dryer and yellowcake handling. These sources will not be present at the satellite facilities further reducing the potential dose. As noted above, that data demonstrates the conservatism built into the MILDOS Area simulation. For that reason, operational particulate monitoring will not be conducted and CBR will rely exclusively on the MILDOS Area simulation to estimate dose.

As an adjunct to this approach, CBR will survey, remove and dispose field spill soils at levels greater than the 10 CFR Part 40, Appendix A, Criterion 6(6), with the unity rule applied where appropriate.

This approach will reduce CBR decommissioning obligations and further mitigate the already limited contribution from field spills to offsite soil, vegetation and surface water contamination. The language incorporating this commitment is now found in Section 5.7.1.3.

End of Agenda Issues

1. Criteria for the placement of operation environmental radon monitor (See #2 above).

Background: In Section 2.9.2.1 of the TR, the applicant described the positioning of the air monitoring locations for the North Trend Expansion Area, AM-9 through AM-14 (see Figure 2.9-2 of the TR). It appears that the nearest residents and the locations of the proposed license boundaries were taken into consideration. However, referring to Figure 2.5-6 and Table 7.3-1 of the TR, the applicant did not appear to take into account the three different downwind sectors with the highest predicted radionuclide airborne concentrations during milling operations as recommended by RG 4.14.

Needed: The applicant should provide justification for placement of preoperational radon monitors which address RG 4.14 recommendations or sufficient justification for an alternate proposal.

Response: *Section 2.9.2.1.2 now includes sampling Station AM-26. AM-26 is located west of the satellite facility and will be used to collect background data. Additional justification for the placement of air monitoring stations has been provided in Sections 2.9.2.1.1 and 2.9.2.1.2.*

2. No LLD specified for operational environmental radon measurements.

Background: Monitoring will be performed using Track-Etch radon cups on a semiannual basis. The applicant referred to "the required lower limit of detection (LLD)" but did not specify the value of the LLD. RG 4.14 recommends that the LLD for Rn-222 should be 2×10^{-10} µCi/ml.

Needed: The applicant should specify an LLD for radon measurements that is consistent with RG 4.14 or provide sufficient justification for an alternate value.

Response: *The LLD for Rn-222 is now presented in Section 5.7.7.1.*

3. No justification for not performing operational environmental soil sampling.

Background: RG 4.14, Table 2, suggests that soil sampling be conducted in five or more locations that are the same as for air particulate sampling. It suggests collecting annual grab samples and analyzing for natural uranium, Ra-226, and Pb-210.

The applicant did not propose to perform routine soil sampling during operations. Instead, the applicant stated that surface soil samples will be taken at the monitoring locations (AM-9 through AM-14, see Figure 5.7.7-2) following conclusion of operations and will be compared to the results of the preoperational monitoring program.

NRC staff notes that pregnant lixiviant field spills and transportation accidents have been shown to have the ability to result in a significant release of licensed material. In addition, radon daughters from operations can accumulate in soil, vegetation, and surface waters from airborne deposition.

Needed: The applicant should provide an operational soil monitoring program consistent with RG 4.14 or sufficient justification for an alternate program.

Response: *Please see the response to II. Radiological Issues, #23, above. The absence of "dry" activities at the NTEA satellite facility combined with the CBR commitment to remove field spill soil above 10 CFR Part 40 Appendix A release criteria obviates any need for operational environmental soil sampling. As stated in Section 5.7.7, "operational surface soil samples will be taken following*

conclusion of operations and will be compared to the results of the preoperational monitoring program."

4. No justification for not analyzing White River sediments for Th-230.

Background: RG 4.14, Table 2, suggests that sediment sampling be conducted as an annual grab sample from each water body identified for surface water sampling. The sediment samples should be analyzed for natural uranium, Th-230, Ra-226, and Pb-210.

The applicant stated that upstream and downstream sediment samples from the White River will be collected annually and analyzed for natural uranium, Ra-226 and Pb-210. The applicant did not provide justification for not including Th-230 in its analysis of sediment.

As discussed in open issues #17, the decision to end Th-230 monitoring in sediments at the main facility was made only after evaluating the measurement of Th-230 levels in the environment following seven years of commercial operation at the currently licensed facility (ML071520242). Further, the applicant has not demonstrated that conditions at the North Trend Expansion Area would lead to identical results obtained at its currently licensed facility.

Needed: Provide an operational sediment monitoring program consistent with RG 4.14 or sufficient justification for an alternate program.

Response: *The NRC previously determined that Th-230 sampling was not required as part of environmental airborne particulate monitoring at the CPF. The data which support that determination are directly applicable to analysis of Th-230 in NTEA environmental samples. For that reason, CBR has not included analysis of Th-230 for operational sediment samples.*

Please see the response to II. Radiological Issues, #4, and #14 above. Specifically,the Acceptance Criteria for Section 5.7.8.3, (1) enumerated on page 5-39 of NUREG-1569 as regards analysis of Th-230 in natural waters. From this, there does not appear to be a fate and transport mechanism that would lead to deposition of Th-230 in the White River. Also note that Th-230 was non-detect in the six White River samples where Th-230 was analyzed (see Table 2.9-6).

5. No operational sediment sampling evaluation for Spring and Unnamed Creeks and Hall Canal.

Background: RG 4.14 recommends sampling from drainage systems that cross the site boundary and that may be impacted from contaminated areas.

In Section 2.7.1 of the TR, the applicant identified two ephemeral creeks (Spring and Unnamed) and a historic canal (Hall Canal) that pass through the proposed North Trend Expansion Area (see Figure 2.7-1 of the TR).

The applicant did not analyze these drainage systems for potential impacts from their operations.

Needed: Provide an operational sediment monitoring program consistent with RG 4.14 or sufficient justification for an alternate program.

Response: *Operational sediment sampling is now included for Spring Creek, Unnamed Creek and Hall Canal. See Figure 2.9-5. Th-230 is not included as an analyte.*

6. Insufficient justification for not having an operational vegetation sampling program.

Background: Where a significant pathway to man is identified, RG 4.14 suggests analyzing three of each type of crop, livestock, etc., raised within 3 km of the mill site.

The applicant did not propose to perform any vegetation, food or fish sampling during operations.

In Section 5.7.7 of the TR, the applicant stated that the vegetation pathway was evaluated and discussed in Section 7.3 of the TR. NRC staff notes that while the applicant discusses source terms and dose pathways in general, there is no comparison of the expected dose associated with the

vegetation pathway to that of the "important" exposure pathways recommended in RG 4.14.

Needed: Provide an operational vegetation sampling program consistent with RG 4.14 or sufficient justification for an alternate program.

Response: *As noted in the application, operational vegetation sampling was discontinued for the CPF with the NRC approval of the 1998 license renewal. Unlike the CPF, the NTEA will not include the "dry" activities conducted at the CPF. The data which supported that determination remain relevant, as the NTEA is nearby and will extract from the same groundwater unit. Please also see the text in Section 5.7.7 enumerating the footnote to Regulatory Guide 4.14 that is relevant to this issue.*

7. No justification for not having an operational crop sampling program.

Background: In Section 2.2.2.2 of the TR the applicant stated that the primary land use in the North Trend Expansion Area is cropland, primarily for the production of wheat with a small amount of land being used for the production of alfalfa.

Needed: The applicant should provide an operational crop sampling program consistent with RG 4.14 or sufficient justification for an alternate program

Response: *Please see the CBR response immediately above. Operational crop sampling is not anticipated.*

8. No justification for not having an operational livestock sampling program.

Background: In Section 2.2.2.2 of the TR, the applicant identified that raising livestock is the primary land use within the North Trend Expansion Area and the surrounding 2.25-mile review area.

Needed: The applicant should provide an operational livestock sampling program consistent with RG 4.14 or sufficient justification for an alternate program.

Response: *Please see the CBR responses 5 and 6, immediately above. Operational livestock sampling is not anticipated.*

9. No justification for not having an operational fish sampling program.

Background: In Section 7.2.7.10 of the TR, the applicant identified portions of Spring Creek and the White River, both of which cross the proposed site boundary, as suitable habitats for fish. NRC staff notes that fish sampling for the current licensed facility (ML080940310) did not appear to address either of these areas.

Needed: The applicant should provide an operational fish sampling program consistent with RG 4.14 or sufficient justification for an alternate program.

Response: *Please see the CBR responses 5, 6 and 7, immediately above. Operational fish sampling is not anticipated.*

10. Insufficient justification for placement of operational direct radiation monitoring devices.

Background: RG 4.14, Table 2, suggest five or more passive integrating radiation devices at the same locations as air particulate sampling. The passive integrating radiation devices should be changed out on a quarterly basis and measured for gamma exposure rate.

The applicant proposed to monitor environmental gamma radiation levels continuously at the air monitoring stations (AM-9 through AM-14) with dosimeters that will be exchanged on a quarterly basis.

As noted in Section 2.6.1 of this SER, the applicant did not appear to take into account the three different downwind sectors with the highest predicted radionuclide airborne concentrations during milling operations as recommended by RG 4.14 when determining air sampling locations.

Needed: The applicant should provide an operational direct radiation monitoring program consistent with RG 4.14 or sufficient justification for an alternate program.

Response: *The revised locations for operational direct radiation monitoring devices are discussed in Section 5.7.7.2.*

Hydrogeologic Issues

1. Recent stream flow data and comparative assessment to past data.

Background: In Section 2.7.1.2 of the TR, the applicant assessed stream flow in the White River, using various published data from 1992 through 2004. The applicant should assess more recent stream flow data and assess whether or not the recent data is comparable to past data. In this manner, a trend in stream flow may be identified. NRC staff noted that the USGS has published recent provisional stream flow data on its website.

Needed: Recent stream flow data and comparative assessment to past data.

Response: *Consistent with the license renewal application, Table 2.7-2 has been updated to include more recent data. Based upon that data, the existing language in Section 2.7.1.2 remains valid: "(t)he recent data for the White River is comparable to the steam flow data shown in Table 2.7-1."*

2. Safety considerations and measures for potential flood impacts in Section 34.

Background: In Section 2.7.1.4 of the TR, the applicant states, "the portion of the proposed North Trend Expansion Area where the greatest flooding potential related to the White River exists is the southeast part of Section 34. The White River elevation in that area varies from 3,645 feet AMSL on the western portion of the southern permit boundary, to 3,622 feet AMSL to the northeast. Because of lower elevation and proximity to the White River, final wellfield layout in Section 34 may necessitate consideration of potential flood impacts (e.g., below a surface elevation of 3,657 feet on the west, and 3,634 feet to the northeast)."

Needed: Noting potential flood impacts in Section 34, what are the applicant's considerations for the final wellfield layout in that section? Other than the operational controls, use of dikes and berms, and daily wellfield inspections, what other design features and/or mitigation measures may be considered?

Response: *Please also revisit the CBR response dated February 27, 2009 to NRC RAIs dated November 17, 2008 (ML090750429), specifically page 9 of the responses to comments. No other design features or mitigation measures are contemplated.*

3. Justification and formal request for the 3-year alternate restoration schedule.

Background: In Section 3.1.3 of the TR, the applicant provides a production and restoration schedule. Considering the applicant's current experience with wellfield restoration, NRC staff noted that the restoration timeline appears too short. Also, as specified in 10 CFR 40.42, the

applicant's restoration schedule is considered to be an "Alternate Restoration Schedule." In accordance with these regulations, the applicant must formally request an alternate restoration schedule in its application and deviations from this schedule require a license amendment.

Needed: Provide all requested information.

Response: *For now, CBR has recognized the two year limit enumerated in 10 CFR §40.42(h)(1) in Section 3.1.3. In reality, the duration of restoration will vary and in large part will be depend on the pore volume of the particular mine unit. CBR would like to discuss administrative options in the context of a 10 CFR §40.42(h)(2)(i) alternate schedule. Specifically, administrative processes are in place for the NDEQ to track restoration progress. Perhaps these processes could satisfy NRC oversight needs and operate in lieu of an artificial cycle of proposed schedules and extensions that do not reflect the reality of ISR restoration.*

4. Further assess the cause of the Basal Chadron's increased hydraulic gradient parallel to the monocline fold axis.

Needed: This issue has been resolved internally with NRC staff. No other action required.

Response: *None required.*

5. Short-term stability analysis, construction, drawings, and associated monitoring wells for evaporation ponds.

Needed: As stated.

Response: *Resolved through subsequent discussion. Please see the NRC summary of the March 8, 2010) teleconference, Process and Restoration, Open Issues, #1 (ML100680217).*

6. Justification for baseline indicators, silver, gross alpha and gross beta.

Background: Within Section 2.7.3 of the TR, the applicant's list of baseline indicators is tailored from the list provided in NUREG 1569 to exclude silver, gross alpha, and gross beta. Consistent with NUREG-1569, the applicant may propose a list of baseline indicators tailored to a particular location with a sufficient technical basis.

Needed: A technical bases for excluding silver, gross alpha, and gross beta from the baseline indicators should be provided.

Response: *Exclusion of gross alpha and gross beta is justified in the fourth full paragraph in Section 2.7.3. Although silver is listed as a "typical" constituent for evaluation in NUREG 1569, in 20-plus years of monitoring at Crow Butte, silver has never been included as a contaminant of concern, nor has it been suggested for inclusion by NDEQ or NRC reviewers.*

7. Justification for one overlying monitoring well per five acres and one baseline restoration well per four acres.

Background: In Sections 7.5.3.1 and 6.1.3.1, the applicant proposes one overlying monitoring well per five acres and one baseline restoration well per four acres. Justification for the proposed well spacings was not provided.

Needed: Sufficient technical basis for the proposed well spacings.

Response: *Regarding the baseline restoration well sampling, please see the CBR response to the NRC summary of the March 8, 2010 teleconference, Process and Restoration, Open Issues, #2, below.*

Regarding overlying monitoring wells, CBR will correct the application to confirm sampling density of at least six total samples (to ensure an adequate statistical population) and at least one well per five acres. In addition, CBR will make this commitment in Section 6.1.3.1.

8. Clarify the penetration of screened interval.

Background: In Section 3.1.2.2 of the TR, the applicant states, "The method consists of drilling a hole, geophysically logging the hole to define the desired screen interval, and reaming the hole, if necessary, to the desired depth and diameter.

Needed: Penetration of screened interval of monitoring and production wells and associated justification.

Response: *Please revisit the CBR response dated February 27, 2009 to NRC RAIs dated November 17, 2008 (ML090750429), specifically page 13, Section 3.1, #1 of the responses to comments. Additional justification was provided in Section 3.1.2.2.*

9. NRC must be notified within seven days of excursion in verification

Background: In Section 5.7.8.2 of the TR, the applicant states, "Upon verification of the excursion, the USNRC Project Manager is notified by telephone or email within 48 hours and notified in writing within thirty (30) days."

Needed: Revise written notification from 30 days to 7 days.

Response: *Section 5.7.8.2 has been revised from 30 day to 7 days.*

CROW BUTTE RESOURCES, INC.

Responses to NRC Open Issues

North Trend Expansion Area License Amendment Request

Crow Butte Resources, Inc.

License SUA-1534 (TAC J00523)

Dated March 24, 2009

Process and Restoration

I. Open Issues

1. Confirmation of backup disposal capacity

Background: In Section 3.1.5 of the Technical Report (TR), CBR stated that the production bleed waste stream will be managed by a combination of evaporation pond and deep disposal well injection, both of which will be constructed at the North Trend Satellite Plant. However, in Section 4.2.1.1.2 of the TR, CBR stated that pond design and specifications are currently not available and will be submitted to the NRC in a license amendment application prior to pond construction. Based on this statement, NRC staff is uncertain whether ponds or a backup disposal capacity will be operational at the initiation of the production.

CBR stated that the exact number and capacity of the ponds will depend upon the results of the determination of the performance of the deep disposal well as far as waste water disposal rate. In addition, final pond design cannot be completed until completion of the site geotechnical assessment, which is currently not available.

Needed: To backup deep well disposal, confirm that additional liquid disposal capacity (e.g., evaporation ponds) will be operational at the commencement of production.

Response: *CBR confirms that sufficient liquid disposal capacity (e.g., evaporation ponds and/or deep disposal wells) will be operational prior to the commencement of production.*

2. Confirm that a minimum of six sample locations will be used to establish baseline values for a wellfield.

Background: In Section 6.1.3.1 of the TR, CBR indicated that baseline restoration wells in a mine unit will be minimally one well per four acres. Section 5.7.8.3 of NUREG-1569 guidance states that an acceptable set should include at least one well per acre. However, for large wellfields, it may not be practical to sample one well per acre but the sampling density should be sufficient to provide an adequate statistical population. As a general guidance, at least six samples are required to achieve a specific degree of confidence and in no case should the sampling density be less than one well per four acres. The staff is uncertain about the number of samples to be collected for the baseline restoration well network for a mine unit because CBR did not provide that information directly.

Needed: CBR needs to confirm that the proposed set of samples will provide statistically significant data.

Response: *CBR will correct the application to confirm sampling density of at least six total samples (to ensure an adequate statistical population) and at least one well per four acres.*

3. Reporting for excursion corrective actions

Consistent with Section 5.7.8.3 of NUREG-1569, if wells are still on excursion status when an excursion corrective action report is submitted, the report must also contain a schedule for submittal of future reports, which describe the excursion event, corrective actions taken, and results obtained. In the case of a vertical excursion, the report must contain a projected date when characterization of the extent of the vertical excursion would be completed. CBR has not provided sufficient information consistent with the above-referenced guidance.

Needed: CBR should commit to the above-referenced reporting for excursion corrective actions consistent with NUREG-1569, Section 5.7.8.3, or provide justification for an alternate proposal. Section 5.7.8.3 of NUREG-1569 requires that excursion report include corrective action schedule. Applicant needs to commit to referenced reporting requirement.

Response: *Section 6.1.6 of the application will be revised to reflect these requirements.*

4. Confirm that the liquid disposal capacity is adequate

Background: CBR provided conflicting or lacking information on rates of liquid waste effluent generated during restoration and the corresponding disposal capacity. CBR estimated that the maximum bleed during operations was 1.5 percent of the proposed production capacity of 4,500 gallons per minute (gpm) yielding 67.5 gpm of fluids that may require disposal. In Section 4 of the application, CBR indicated that the brine from the treatment steps will require disposal but that the only consumptive use would be the bleed. On page 3.1-20 of the application, CBR used an average rate of 50 gpm to determine the long-term drawdown. This value is lower than the bleed during operations and likely does not include consumptive use during restoration. CBR did not provide rates attributed to restoration. Consequently, staff cannot determine whether or not the liquid disposal capacity is sufficient for waste generated during restoration treatment in accordance with guidance in NUREG-1569, Section 6.1.2.

Needed: CBR needs to provide staff with estimates of the liquid effluent rates during restoration.

Response: *Analogous to response #1 above, CBR confirms that sufficient liquid disposal capacity (e.g., evaporation ponds and/or deep disposal wells) will be operational prior to the commencement of restoration.*

5. Justification for not including the complete list of parameters from NUREG-1569 in restoration plan.

Background: CBR proposed a list of parameters to be included in the baseline water quality analyses based on NDEQ restoration standards. The list is fairly comprehensive but does not include all typical baseline indicators listed in NUREG-1569. Staff notes that sufficient justification is not provided for the absence of boron, chromium, alkalinity, and specific conductivity. Staff is aware that the proposed list is derived from that used at the existing facility. However, CBR did not provide a justification for the reduced list.

Needed: CBR should provide a justification for not including the selected parameters in the baseline water quality analyses.

Response: *Chromium is already listed in Table 6.1-1 of the application. It should be noted that Table 2.7.3-1 in NUREG-1569 is referenced in Section 2 - Site Characterization and Section 5 - Operations, but it is not referenced in Section 6 which relates to groundwater restoration. At some sites, boron, alkalinity and specific conductivity may be useful during operations, but In the absence of NDEQ or NRC UMTRCA water quality/restoration standards there is no basis to require analysis for these constituents during restoration.*

6. Acknowledge that any proposed ACL must be approved by NRC and not through the SERP process.

Background: In Section 6.1.3.2, CBR included an analysis for determining the NDEQ groundwater restoration standard for a mine unit. Furthermore, CBR stated that the SERP process will be used to establish restoration standards. The staff notes that the NDEQ analysis is not a substitute for an analysis of an ACL. The analysis for an ACL must consider factors listed under Criterion 5B(6) of Appendix A, 10 CFR Part 40. Furthermore, establishment of an ACL cannot be accomplished through the SERP process, but requires consideration and approval by NRC in accordance with Criterion 5B(5)(c) of Appendix A, 10 CFR Part 40.

Needed: CBR needs to acknowledge that secondary restoration goals will be an ACL and that NRC needs to approve any ACL.

Response: *Section 6.1.3.2 has been revised to reflect correct process for establishing ACLs.*

7. Commit to hydraulic control from start of production to stabilization

Background: CBR committed to maintaining a hydrologic bleed during extraction and until restoration is complete to prevent the lateral migration of lixiviant. The intent is consistent with staff's goal, but to clarify the understanding, the staff requests that CBR includes a statement that the hydraulic control will be maintained should the mine unit be placed on standby status (no production) after the first injection of lixiviant until stabilization and that the control will be sufficient to maintain an inward gradient at all times.

Needed: CBR needs to include a statement in the TR that the hydraulic control will be maintained throughout the life of the wellfield.

Response: *Section 6.1.4.1 will be revised to include the word "standby" in the sentence regarding hydrologic bleed.*

8. Confirm that the stabilization period will be sufficient to determine restoration success

Background: CBR stated that the existing facility's Class III permit requires a minimum 6-month period for stability monitoring to demonstrate the success of restoration activities. Based on historical data, CBR noted that the 6 months may not be sufficient time to assure stability for all monitored constituents and that the monitoring may continue beyond the proposed 6 months. CBR stated that the stability monitoring will conclude when the restoration goals on a mine unit average for the monitored constituents are met and there is an absence of significant increasing trends. At the end of the stabilization process, a request will be made to NDEQ for acceptance. NDEQ would accept the restoration, extend the stabilization period or require further restoration. CBR proposed monthly sampling for 6 months for all restoration parameters at the designated restoration wells and any monitoring wells which had been on excursion status during operations.

NUREG-1569 does not provide specific guidance on the requirements for a stability monitoring program. NUREG-1569 does state that the purpose of a stability monitoring program is to ensure that chemical species of concern do not increase in concentration subsequent to restoration and that CBR should specify the length of time that stability monitoring will be conducted, the number of wells to be monitored, the chemical indicators to be monitored, and the monitoring frequency. CBR has provided the latter information, but NUREG-1569 indicates that staff's review should evaluate the ability of the post-reclamation stability monitoring program to verify successful restoration.

The staff's evaluation indicates that the information provided is not sufficient. While the proposed monthly sampling may provide an adequate number of samples for a statistically significant trend analysis, the proposed length of time for the stability monitoring may not be sufficient as noted by CBR. Based on staff's review of historical stability monitoring data for various ISR facilities, a minimum of four quarterly samples is required to verify a successful restoration.

Needed: CBR needs to provide sufficient information for the staff to conclude that the stability monitoring program is sufficient to demonstrate a successful restoration.

Response: *Section 6.1.5 has been revised to reflect sampling every other month (bi-monthly) for four quarters to verify successful restoration.*

9. Include corrective actions during stabilization

Background: CBR did not describe how it will address corrective action at wells that are on excursion during the restoration and restoration stability monitoring period. This requirement is similar to guidance in Section 5.7.8.3 (5) of NUREG-1569 for corrective actions in the excursion

monitoring operational procedures.

Needed: CBR needs to document corrective actions for excursions during restoration and stabilization.

Response: *It is difficult for CamecoCBR to envision how a well would go on excursion during the stability monitoring period when no pumping or injection is occurring. Regardless, CBR has revised Section 6.1.6 to cross reference the excursion monitoring process presented in Section 5.7.8.2. It should be noted that CBR will not remove production or monitoring wells until the stability monitoring is concluded. In that way, these wells could be used to correct an excursion.*

10. Provide techniques for statistical trend analysis of stability data

Background: CBR stated that restoration will be deemed complete if the restoration values for all wells are maintained during the stabilization period with no significant increasing trends. CBR did not provide a description of how stability trends will be evaluated statistically or otherwise, or describe what actions would be taken if trends are determined to be significantly increasing. NRC staff requests that CBR provide this information. In addition, the staff notes that the statistically significant analyses should not only be applicable to trend analysis, but also an analysis of hot spots should the wellfield average be used to determine that restoration has been accomplished.

Needed: CBR needs to document statistical analyses that may be used to establish statistically significant trends.

Response: *CBR will analyze the data by the Cumulative Sum Control Chart (CUSUM), which is a sequential analysis technique.*

11. Correct pore volume calculations; provide flare factors

Background: CBR provided an estimate of the volume of water associated with the total pore volume (PV) of all wellfields within the proposed licensed area. The total reported PV is 133,268,000 gallons based on a calculated aerial extent of the wellfields of 30,636,400 square feet, thickness of 15 feet, and a porosity of 29 percent. Source or location of the information to verify the estimates was not identified in the application. In addition, the information may be in error. For example, the unit of gallons for the reported total PV is incorrect as the unit should be cubic feet (30,636,400 feet^2 x 15 feet x 0.29). In addition, CBR did not address any flare factors in the application and whether or not the proposed restoration methods are based on flare factors.

Needed: CBR needs to correct the PV estimate, provide sources of the data, and provide an estimate of the PV for at least the first mine unit.

Response: *Flare factors exhibit a linear relationship which decreases as the size of the wellfield increases. It is not possible to estimate pore volume or flare factor for the first mine unit without additional exploratory drilling. CBR will utilize a pore volume estimate that includes flare factors when the surety obligation is calculated for activities in the first mine unit. In addition, the total pore volume in gallons has been corrected to 997,000,000 gallons.*

12. Comment on the applicability of restoration analogues to the proposed larger wellfields

Background: Using the values listed in the application and the proposed nine mine units, the average area per mine unit is estimated at approximately 78 acres. The staff notes that the approved restoration analogue in the application was for a mine unit that was only 9.3 acres. The staff is concerned about the applicability of the restoration analogue to a much larger mine unit. In addition, the large mine units have large PVs, which has implications on the schedule and liquid waste disposal capacity (see Sections 6.1.9 and 6.1.10).

Needed: CBR needs to comment on the size of the proposed mine units and applicability of the

analogue to those units.

Response: *The discussion is offered for historical purposes and to highlight the intense technical review and approval process that was conducted. Consistent with Section 6.1.6, restoration approval will be requested for a mine unit or group of mine units on a case by case basis. The restoration schedule is discussed in the CBR response to the NRC North Trend Expansion Areas Open Issues, November 12, 2009, Hydrogeologic issue #3 and associated text revisions. Similarly, CBR has confirmed that adequate disposal capacity will be available prior to commencement of operations in the response found at Process and Restoration I.1.*

13. Document sampling procedures/analysis to establish that restoration goals are met

Background: CBR reported that monitoring will be performed daily, weekly, and monthly at selected wells to track the restoration progress. CBR proposes to sample all monitoring wells at the end of the active restoration phase for parameters listed in Table 6.1-1 of the application. CBR did not provide a description of the monitoring procedures to be used during restoration, including sampling density, parameters, and frequency to substantiate that restoration progress. NUREG-1569 guidance suggests that CBR may reduce the parameter list and monitoring wells to monitor restoration progress. However, without any information on the proposed plan, the staff cannot fully evaluate whether or not the program is adequate.

Needed: CBR needs to document the monitoring program during restoration.

Response: *Section 6.1.3 will be revised to cross reference the operational groundwater monitoring program described in Sections 5.7.8 and 5.7.9. Consistent with the Class III UIC permit, the specifics of the restoration monitoring are provided in a restoration plan for each mine unit or group of mine units for submission to the NDEQ.*

14. Acknowledge that NRC will not use the restoration goal of average plus two standard deviations

NRC Response: Stated that the language is in the license in 10.3C. The open issue has been resolved and will be deleted.

Radiological

I. Open Issues

1. Justification for radon release rates from the wellfield, resin transfer and venting, and plant vent

Background: In CBR's submittal dated November 20, 2009, *Missing Attachments to the North Trend License Amendment,* the following assumptions are made regarding calculations for radon released to the environment:

- Resin transfer and venting, 10% released
- Wellfield, 25% released
- Plant vent, 10% released

These assumptions are found in Tables 4.12.2(A)-4 and 7-3(A)-4, Calculation of Annual Radon Emissions Crow Butte Project – North Trend Satellite Area.

Needed: Please provide more details on the origin of these assumptions.

Response: *These assumptions have been applied to MILDSOS Area simulations conducted for all Crow Butte ISR license applications and renewals. The conservatism of these assumptions has been demonstrated at the Crow Butte Central Processing Plant (CPP). Please see the CBR response to NRC License Renewal Open Issues, D.1., ML102640195).*

The 10% release factor for resin transfer and venting has been applied wherever pressurized upflow resin columns are employed, as this ALARA-design only releases during resin transfer, venting and maintenance activities. The 10% release factor was also used and accepted in the Moore Ranch license application (see ML072851268, page 7-36).

The 25% wellfield release factor is also over-conservative, in light the 10% wellfield release factor found acceptable by the NRC in its approval of the Moore Ranch permit application.

2. Please provide details on how radon progeny will be factored into determining compliance with 10 CFR 20.1301/1302 during operations.

Background: In Section 5.7.7 of the TR, CBR describes its radon air sampling program. However, there is no discussion of how radon progeny will be factored into analyzing potential public doses. This open issue is related to the open issue on the LLD for environmental radon measurements transmitted to CBR in NRC's letter dated November 12, 2009 (ML093060326) providing meeting minutes for the October 5, 2009, public meeting (issue 2 on page 13 of the letter). The concentration values given in 10 CFR 20, Appendix B, Table 2, are based on radionuclide concentrations inhaled or ingested. NRC staff has determined that the correct evaluation of radon-222 exposures to the public must include the dose from radon-222 and an assessment of radon progeny. The radon progeny, if present, will be the principal contributor to radiation dose in most practical radon exposure situations and need to be considered in any dose assessment.

Needed: Details on how radon progeny will be factored into determining compliance with 10 CFR 20.1301/1302 during operations.

Response: *Please refer to the CBR response to Crow Butte License Renewal Open Issues, H.1, on page 8 of 9 (ML102640195).*

At the NTEA, CBR will use the results of environmental monitoring for direct radiation (see Section 5.7.7.8), air particulates (see Sections 5.7.7.2) and radon (see Section 5.7.7.1) to estimate occupational exposure and dose to the public from licensed operations. A summary is presented in Table 5.7-1. The monitoring results are used to calculate the TEDE for nearby residents. The monitoring and resulting Dose to Public TEDE includes the dose from uranium, radium-226, lead-210, radon-222 and gamma from the diverse, albeit limited sources in and around the plant, and provides consideration of radon and its progeny.

3. The applicant has not addressed the potential for beta exposure and surveys for beta radioactivity resulting from spills or maintenance activities.

Background: The description in Section 5.7.2.1 has not adequately addressed surveys following spills or maintenance. CBR has not addressed the potential for exposure to beta radiation from the residual radioactivity that contains uranium and short-lived progeny that is in secular equilibrium with uranium. Alpha surveys will not detect the presence of the short-lived progeny because Th-234 and Pa-234m are beta-gamma emitters.

Needed: Provide justification for not conducting beta surveys.

Response: *The CBR contamination control program relies primarily on alpha surveys. Please refer to the CBR response to Crow Butte License Renewal Open Issues, D.1. , on page 5 of 9 (ML102640195). Specifically, "it should be recognized that there are no mechanisms by which the beta emitters Thorium-234 or Proactinium-234 can be separated from their alpha emitting uranium parents. For that reason there cannot be contamination in the absence of detectable alpha." Any beta exposure that does occur will be quantified using the personnel dosimetry program.*

4. The applicant has not addressed the potential for beta exposure and surveys for beta radioactivity resulting from spills or maintenance activities.

Duplicate of #3.

5. CBR has not provided sufficient technical basis for using Class D for natural U as an inhalation class.

   Background: Sections 4.1.2.1, 5.7.3.1, and 5.7.4.1 state the DAC for soluble natural U is 5×10^{-10} µCi/ml in accordance with 10 CFR 20, Appendix B.

   Needed: Provide justification for inhalation classification.

Response: *Please refer to the CBR response to Crow Butte License Renewal Open Issues, C.1. , on page 1 of 9 (ML102640195). The DAC for soluble natural U presented in the application is correct.*

Miscellaneous Issues

I. Open Issues

Quality Assurance: Non-Radiological Monitoring

1. Confirm non-radiological quality assurance program (Refer to Regulatory Guide 3.46 section on non-radiological requirements (same as for radiological issues?).

Background: It follows from UMTRCA Section 205 (a), that a quality assurance (QA) program should be provided for ISR monitoring programs that generate data used to assess non-radiological hazards. It also follows that the quality assurance plan for non-radiological monitoring activities will have the same basic requirements as the radiological QA program. Regulatory Guide 3.46 entitled, "Standard Format and Content of License Applications for In Situ Uranium Solution Mining," indicates that a description of the quality assurance programs for all radiological and non-radiological in-plant, effluent, and environmental monitoring programs that include groundwater monitoring should be provided.

In Section 5.7.9 of the TR, CBR stated that a quality assurance program is in place at the main facility for all relevant operational monitoring and analytical procedures. NRC staff is uncertain if this statement refers to both the radiological and non-radiological monitoring programs. Staff also notes that CBR's statement did not include non-radiological pre- and post-operational monitoring activities.

Needed: CBR should confirm that a non-radiological QA program exists for monitoring activities that generate non-radiological data.

Response: *The Quality Assurance Program described in Section 5.7.9 of the license application is applicable to activities that generate both radiological and non-radiological data.*

2. Document the organizational structure and responsibilities of managerial and operational staff for the non-radiological QA/QC program.

Background: In Section 5.7.9 of the TR, CBR stated that a quality assurance program is in place that includes the formal delineation of organizational structure and management responsibilities. Responsibility for both review/approval of written procedures and monitoring data/reports is provided. NRC staff notes that management responsibilities and the responsibility for both review/approval of written procedures and monitoring data/reports do not appear to be provided for the non-radiological QA program.

Needed: CBR should describe the management responsibilities for the non-radiological QA/QC program.

Response: *The management responsibilities for both radiological and non-radiological programs are*

outlined in Section 5.2.1. The CBR QA/QC program is embodied in the Safety Health Environment and Quality Management System (SHEQ MS). The SHEQ MS has been subject to NRC review during inspections at the Crow Butte and no deficiencies have been noted.

3. Confirm specifications of personnel qualifications

Background: In Section 5.7.9 of the TR, CBR stated that a quality assurance program is in place that includes minimum qualifications and training programs for individuals performing radiological monitoring and those individuals associated with the QA program. NRC staff notes that details of the specifications of personnel qualifications for the non-radiological QA program were not provided in the TR.

Needed: CBR should describe personnel training, qualifications, and maintenance of proficiency in the principles and techniques of non-radiological monitoring activities and QA/QC support functions.

Response: *All facets of both non-radiological environmental monitoring and radiological monitoring are addressed using the CBR SHEQ MS described in Section 5.2.1.*

4. Document written procedures for the non-radiological monitoring program activities.

Background: The TR did not adequately describe written procedures for all activities that generate non-radiological data, such sample collection, sample management and chain of custody, sample preparation and analysis, data reduction and recording, and data assessment and reporting. A description of written procedures is also needed for addressing support functions, such as the preparation of quality control samples, corrective actions, audits, and records.

Needed: CBR should describe written procedures for the non-radiological QA/QC program.

Response: *All facets of both non-radiological environmental monitoring and radiological monitoring are addressed using the CBR SHEQ MS described in Section 5.2.1.*

5. Document records management

Background: In Section 5.2.1 of the TR, CBR described its environment, health and safety management system and record keeping and retention. Records containing information pertinent to decommissioning and reclamation such as descriptions of spills, excursions, contamination events, etc., as well as information related to site and aquifer characterization will be maintained on site until license termination. Section 5.2.1 also stated that the SHEQ MS Program Volume II, *Management Procedures,* provides specific instructions for the proper maintenance, control, and retention of records associated with implementation of the program. NRC staff notes that a description of the non-radiological monitoring records management is not provided in the report.

Needed: CBR should describe the proposed system that produces records which document environmental monitoring activities. CBR should also describe how records are maintained and establish a retention time(s) for the records.

Response: *All facets of both non-radiological environmental monitoring and radiological monitoring are addressed using the CBR SHEQ MS described in Section 5.2.1. Recordkeeping and retention is specifically addressed in Section 5.2.1.3.*

6. Document quality control program

Background: In Section 5.7.9 of the TR, CBR indicated that quality control (QC) exists for laboratory methods. Procedures cover statistical data evaluation, instrument calibration, duplicate sample programs, and spike sample programs. Outside laboratory QA/QC programs are included.

CBR has not adequately described the quality control program for non-radiological data (e.g., data quality objectives, field and laboratory QA/QC practices, proper maintenance, calibration, and use of equipment, and proper sample handling, custody, and shipping of samples).

Needed: CBR should adequately describe the quality control program for the non-radiological monitoring program.

Response: *All facets of both non-radiological environmental monitoring and radiological monitoring are addressed using the CBR SHEQ MS described in Section 5.2.1.*

7. Document non-radiological data verification and validation

Background: In Section 5.7.9 of the TR, CBR stated that the QA program provides assurance to both regulatory agencies and the public that the monitoring results are valid. CBR has not adequately described the procedures and qualified individuals for the routine verification and validation of non-radiological data to ensure data quality is sufficient to meet data needs. NRC staff notes that a description of the non-radiological monitoring records management is not provided in the report.

Needed: CBR should adequately describe the procedure and qualified individuals for the routine data verification and validation.

Response: *All facets of both non-radiological environmental monitoring and radiological monitoring are addressed using the CBR SHEQ MS described in Section 5.2.1.*

8. Document QA/QC program assessments and audits

Background: In Section 5.7.9 of the TR, CBR stated that the QA program addresses provisions for periodic management audits to verify that the QA program is effectively implemented and to verify compliance with applicable rules, regulations, and license requirements. The NRC staff notes that a description of the QA/QC program assessments and audits for the non-radiological QA program was not provided.

Needed: CBR should describe the assessment and auditing of the QA/QC program practices and procedures.

Response: *All facets of both non-radiological environmental monitoring and radiological monitoring are addressed using the CBR SHEQ MS described in Section 5.2.1.*

9. Document QA/QC preventive and corrective actions

Background: In Section 5.7.9 of the TR, CBR stated that a quality assurance program is in place at the main facility for all relevant operational monitoring and analytical procedures. The objective of the program is to identify any deficiencies in the sampling techniques and measurement processes so that corrective action can be taken and to obtain a level of confidence in the results of the monitoring programs. CBR has not discussed or demonstrated a corrective action program at the site that integrates components of the Quality Assurance program.

Needed: CBR should describe the components of a QA program that include identifying areas for improvement, defining performance or programmatic deficiencies, and initiating appropriate corrective or preventive actions.

Response: *All facets of both non-radiological environmental monitoring and radiological monitoring are addressed using the CBR SHEQ MS described in Section 5.2.1.*

Management Programs

1. Delegation of survey responsibilities to designated personnel

Background: Regulatory Guide 8.31, Section 2.6, states that the RSO and radiation safety office personnel are responsible for performing routine and special radiation surveys, and License Condition 9.12 requires that CBR conform to Regulatory Guide 8.31. However, in Sections 5.1.8 and 5.7.6 of the application, CBR stated that health physics technician may delegate radiation survey requirements to trained personnel.

Needed: Please demonstrate how delegating survey responsibilities conforms with Regulatory Guide 8.31, as required by License Condition 9.12.

Response: *Consistent with the CBR response to the Crow Butte License Renewal Open Issues, F.2. , on page 6 of 9 (ML102640195), the text has been clarified as to the qualifications of personnel releasing items for unrestricted use.*

2. Weekly inspections

Background: License Condition 9.12 requires CBR to comply with Regulatory Guide 8.31, and Section 2.3.1 of this regulatory guide states that the RSO and facility foreman should conduct weekly inspections. CBR stated that the General Manager and the Lead Operator would perform these inspections in the absence of the RSO and Operations Superintendent. This statement does not appear to comply with Regulatory Guide 8.31.

Needed: Please explain how CBR will comply with Regulatory Guide 8.31 regarding the personnel to conduct the weekly inspections.

Response: *Regulatory Guide 8.31 does not preclude occasional delegation of weekly inspections, and acceptable alternative methods are specifically recognized. Delegation is an acceptable alternative method that has been used at the Crow Butte CPP. This alternative method has been acceptable to NRC inspectors, and was not identified as an issue during the license renewal review process.*

Regulatory Guide 8.31 is entitled "Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Reasonably Achievable". Consistent with Reg. Guide 8.31, the weekly inspections are an opportunity for the RSO to interact with facility personnel with direct operational authority where actual radiological activities occur, providing an opportunity to observe, and to review any changes in procedures or equipment. It is reasonable, on an occasional basis, for knowledgeable management designees that are familiar with the radiation protection procedures to substitute in that role. CBR believes that the occasional substitution promotes management involvement in the ALARA program. In fact, rigid application of the Regulatory Guide 8.31 language would artificially restrain participation by management personnel critical to continual improvement.

In most circumstances, the RSO would first delegate responsibility for the inspection to an HPT, and if an HPT is not available, the General Manager will conduct the inspection. Section 5.3.1.2 has been revised accordingly.

Accidents

1. Actions and equipment to stop major tank or pipe failure

Background: CBR specified that tank failures will likely occur as small leaks, the repair of which would occur by emptying the tank and patching the leak. However, CBR did not explain the actions and equipment used to stop a major pipe or tank rupture in the plant.

Needed: CBR should provide the staff information regarding the manner in which major piping/tank ruptures will be stopped and also the capacity of the sumps/bermed areas. As an

alternative, the NRC staff will include a license condition requiring that this information be provided and approved before operations start.

Response: *CBR will provide information prior to the start of operations.*

2. Procedures in the event of wildfire encroachment

Background: On July 31, 2006, CBR notified the NRC Emergency Operations Center and the NRC project manager of the potential evacuation of the main facility due to encroaching wildfires. Although the fires did not approach close enough to warrant an evacuation, the potential for wildfires exists.

Needed: CBR should describe the procedures to be followed in the event of an evacuation, and should describe the potential radiological health effects.

Response: *Evacuation procedures in Section 9 (Evacuations) and Section 3.3 (Range Fire) of the SHEQ MS, Volume III, Emergency Manual, were successfully implemented during the July 2006 fire.*

II. Confirmatory

Management Programs

1. Health Physics training for designated personnel

Background: CBR identified the Lead Operator as the "designated person" who will perform daily inspections in the occasional absence of the RSO or Health Physics Technician. License Condition 9.12 will be amended to require that any designated person will have health physics training, and such training program will be specified by CBR and submitted to the staff prior to starting operations at the North Trend facility. Furthermore, License Condition 9.12 will be modified to state that the Lead Operator may perform daily inspections no more than 2 days per week, and those reports will be reviewed by health physics staff within 48 hours completing the report. CBR will also have a health physics staff member available by telephone while the Lead Operator is performing the daily inspections.

Needed: Concurrence with the license condition.

Response: *CBR requests a license condition that reflects "two days per calendar week except Thanksgiving, Christmas and New Years' where four days, three days, and three days per calendar week, respectively, may be allowed". A member of the Crow Butte Radiation Safety Office staff will be accessible by phone during these periods.*

End of Agenda Items – Begin Additional Issues

Radiological (Open Issues)

1. CBR has not adequately addressed the RAI 5.7.2, 3(a).

Background: In the letter dated November 10, 2008, the NRC staff requested an analysis of public doses for visitors for compliance with 10 CFR 20.1302 (b) and 10 CFR 20.1301 (b). CBR estimated the highest total effective dose equivalent for a downwind receptor near the NTEA as 5.8 mrem/year based on an occupancy factor of 100% (8,760 hours/year). CBR stated that a visitor onsite for 2,000 hours per year would receive an annual dose of 1.2 mrem/year, much less than the 100 mrem public dose limit. CBR has not explained if the downwind point is arbitrary. In terms of public dose, it is not clear that CBR determined who or what group receives the highest exposure consistent with NUREG-1736.

Needed: Provide a more detailed explanation that CBR has met the requirements in 10 CFR 20.1301(b) and 1302(b).

Response: *Section 2.5.4 states: "the predominant air pollutant dispersion would be towards the north*

to north east. The next most common directions would be towards southwest to south-southwest". Figure 7.3-2 shows that receptor #31, a residence, is located north northwest of the proposed plant site and receptor #34 is located south southwest. From this, the point in not arbitrary and a resident located to the north to northeast would receive the highest dose.

2. Applicant needs to identify survey equipment available to measure gamma doses in excess of 5 mrem/hour.

Background: In section 5.7.2.1, CBR indicated that the external gamma survey meters will have a detection range "Lowest range not to exceed 100 microRoentgens per hour (μR/hr) fullscale with the highest range to read at least 5 milliRoentgens per hour (mR per hour) full scale". It is not clear if CBR will have sufficient instrumentation to measure gamma dose rates in excess of 5 mrem per hour sufficient for expected dose rates during operations.

Needed: Provide survey instrumentation sufficient to measure expected gamma dose rates during operations.

Response: *The survey instruments identified in the third full paragraph of Section 5.7.2.1 will read well over 5 milliRoentgens per hour full scale.*

3. Recordkeeping and Reporting Requirements

CBR must provide a description of the records and reporting criteria in Sections 5.7.2, 5.7.3, 5.7.5, and 5.7.6. to meet the requirements of 10 CFR 20, Subpart L, which specifies record keeping requirements and 10 CFR 20, Subpart M which defines reporting requirements.

Needed: A description of how CBR will incorporate the record and reporting requirements specified in 10 CFR 20, Subpart L, and Subpart M.

Response: *A description of Recordkeeping and Reporting is provided in Section 5.2.1.3. For additional detail please refer to the CBR response to Crow Butte License Renewal NRC Request for Additional Information, NRC Comment Section 5.4, May 12, 2009, pages 9 through 11, (ML091470119).*

4. CBR has not sufficiently demonstrated that the requirements for mixed radionuclides in Section 20.1204(e), (f) and (g) are met.

Background: In Section 5.7.3.1 of the TR, CBR indicated that measurement of airborne uranium will be performed by gross alpha counting of the glass fiber air filters for uranium air particulates using an alpha scaler. CBR also stated that Ra-226 may be present in a lesser amount and that the DAC for Ra-226 is 3 x 10^{-10} μCi/ml. Gross alpha counting of the air filters will not be able to differentiate specific radionuclides. CBR has not described how the inhalation of mixed radionuclides will be calculated in exposure doses.

Needed: Demonstration of how CBR will meet regulatory requirements for monitoring and inhalation exposure to mixed radionuclides in Sections 5.7.3.1 and 5.7.4.

This includes an analysis of all uranium alpha- and beta-emitting daughters.

Response: *Please refer to the CBR response to Crow Butte License Renewal Open Issues, C.2. , on pages 3, 4 and 5 of 9 (ML102640195), justifying application of 10 CFR §20.1204(g).*

5. Specify method for determining the lower limit of detection (LLD) for the alpha scaler used to measure air samples in Section 5.7.3 in the TR.

Background: CBR stated that LLD will be able to detect 10% of DAC, but does not describe method used to determine LLD.

Applicant needs to provide method for determining LLC.

Response: *The text in Section 5.7.3.1 was modified to reflect the language in the License Renewal*

application.

6. Justification that urinalysis is acceptable for bioassay in Section 5.7.5.

Background: CBR has not sufficiently justified using inhalation class D for the uranium in its facility. Regulatory Guide 8.22 recommends in vivo lung counts for exposures to Class W or Y materials.

Needed: Provide justification for bioassay type.

Response: *Please refer to the CBR response to Crow Butte License Renewal Open Issues, C.1 , on pages 1, 2 and 3 of 9 (ML102640195), justifying use of 100% inhalation Class D.*

7. CBR has not provided a description of how bioassay results will be used to confirm results derived from its airborne radiation monitoring program and used in exposure calculations. In addition, CBR does not describe actions to be taken in the event action levels are exceeded in Section 5.7.5.

Background: There is no discussion on CBR's methods for evaluating bioassay data that result in calculated intakes in Section 5.7.4 or 5.7.5. CBR stated that action levels are established based on Table 1 in RG 8.22, but does not describe CBR's actions in the event that a positive bioassay (urinalysis) result is confirmed, such as determining whether internal exposure for an individual should be determined based on bioassay results or monitoring data. Exposure calculations discuss inhalation based on air monitoring results in 5.7.4.

Needed: Provide a technical basis for how the uptake will be converted to a dose and assigned to the individual in accordance with 10 CFR 20 Subpart C, which include the limit specified in Section 20.1201(e)

Response: *The text in Section 5.7.5 has been revised to refer the reader to SHEQ MS, Health Physics Manual Volume IV, Section 8.5.6, (discussing action limits and corrective actions) and Section 8.5.7 regarding use of bioassay results for exposure calculations.*

8. CBR has not provided sufficient information on releasing items to unrestricted areas during operations in Section 5.7.6.

Background: CBR should clarify what beta-gamma surface contamination limits will be used for releasing items for unrestricted use consistent with License Condition 9.8 of License SUA-1534. License Condition 9.8 requires CBR to comply with Enclosure 2 of Policy and Guidance Directive FC 83-23 (the Guidelines), or an NRC-approved suitable alternative procedure for releasing equipment, materials, or packages from the restricted area. According to the Guidelines, the limit for beta-gamma-emitting radionuclides should be applied independently from alpha-emitting radionuclides. In addition, CBR has not provided information on how its ALARA program will be implemented with respect to license condition 9.8 in License SUA-1534. The guidelines state, "The licensee shall make a reasonable effort to eliminate residual contamination."

Needed: Description of how requirements in license condition will be met for releasing potentially contaminated items for unrestricted use.

Response: *The text has been revised for consistency with the language in the License Renewal application and the CBR response to Crow Butte License Renewal Open Issues, F.1 , on page 6 of 9 (ML102640195).*

9. Beta-gamma surface contamination limits for releasing items for unrestricted use during facility decommissioning.

Background: Regarding facility decommissioning, CBR must clarify what beta-gamma surface contamination limits will be used for releasing items for unrestricted use pursuant to License

Condition 9.8 of License SUA-1534. License Condition 9.8 requires CBR to comply with Enclosure 2 of Policy and Guidance Directive FC 83-23 (the Guidelines), or an NRC-approved suitable alternative procedure for releasing equipment, materials, or packages from the restricted area.

Section 6.3.2.1 of the TR indicates that separate beta-gamma surface contamination limits will not be applied for releasing items for unrestricted use. According to the Guidelines, the limit for beta-gamma-emitting radionuclides should be applied independently from alpha-emitting radionuclides.

Needed: Description of how requirements will be met.

Response: *The text in Section 6.3.2.1 will be modified for consistency with Section 5.7.6. Section 5.7.6 provides independent application of the limit for beta-gamma-emitting radionuclides.*

10. CBR did not address personnel or surface contamination monitoring for beta-gamma-emitting radionuclides.

Background: CBR stated in Section 5.7.6 that personnel leaving the restricted area will be required to perform gross alpha contamination monitoring. Any gross alpha contamination on the skin or clothing will be considered removable and is subject to a limit of 1000 dpm/100 cm^2, which is consistent with Table 2 of Regulatory Guide 8.30 for removable natural uranium contamination. However, CBR did not address the potential for personnel contaminated with beta-gamma-emitting radionuclides, taking into account the full scope of operations including spills and maintenance. In addition, monitoring for the presence of beta-gamma-emitting radionuclides is not addressed.

10 CFR 20.1501 requires, among other things, that surveys be made to evaluate potential radiological hazards.

Needed: Description of how the CBR's personnel and surface contamination monitoring program will comply with relevant regulatory requirements regarding the potential for the presence of beta-gamma-emitting radionuclides

Response: *Please refer to the CBR response to Crow Butte License Renewal Open Issues, D.1. , on page 5 of 9 (ML102640195).*

11. No description of the quality of samples or error and precision requirements in Section 5.7.9.

Background: NUREG-1569 acceptance criteria states the quality assurance plan should be consistent with guidance provided in RG 4.14 Sections 3 and 6, and RG 4.15. Section 3, Quality of Samples, and Section 6, Precision and Accuracy of Results, describe objectives to be met to ensure the quality of effluent and environmental monitoring samples. RG 4.15 describes quality assurance throughout a sampling and analysis program. CBR described calibration and instrument standards in Section 3.3 and quality control of bioassay analysis in Section 5.7.5. However, no discussion of error is discussed

Needed: Description of how CBR's quality assurance program is consistent with recommendations in RG 4.15 and Sections 3 and 6 of RG 4.14 regarding samples related to the radiological monitoring program.

Response: *Regulatory Guide 4.15 has been referenced in Section 5.7.9. Consistent with Regulatory Guide 4.14, when performing isotopic analysis of environmental samples, measurement uncertainty is reported to CBR by the laboratory.*

12. Demonstrate that calculations converting gross alpha measurements of air samples to U concentrations are acceptable to use in exposure calculations in Section 5.7.4.

Background: In Sections 5.7.3.1 and 5.7.3.2 of the TR, CBR states that air samples analyzed for alpha activity will be used to determine airborne uranium and radon progeny exposure, respectively. CBR does not explain how the gross alpha counts are used to differentiate the type of exposure. CBR did not include information on the efficiency of the detector, the probe used, or if the lower limit of detection meets NRC criteria to demonstrate how the gross alpha counts are converted to U or Rn progeny concentrations to use in the exposure calculations.

Needed: A description of detailed calculations converting gross alpha counts to U or Rn progeny concentrations in Section 5.7.4.

Response: *As stated in Sections 5.7.4.1 and 5.7.4.2, CBR reflects the same dose calculation method as that applied at the CPP. Please refer to Sections 5.8.4.1 and 5.8.4.2 of the License Renewal Application for additional detail (ML091470119).*

13. CBR has not demonstrated how gamma exposure readings will correlate to uranium and Ra-226 that may be present in soils at NTEA.

Background: CBR states that 17,900 cpm as determined with a Ludlum Model 44-190/2221 NaI detection system or equivalent held at 18 inches above ground surface will be used as an action level for gamma radiation. CBR states that this action level was based on an evaluation between gamma count rates and Ra-226 concentrations at the main plant area.

Needed: CBR should provide technical justification for using correlation data derived from an unrelated land area and applying this data to NTEA

Response: *Please see the CBR response to the NRC North Trend Expansion Areas Open Issues, November 12, 2009, II. Radiological Issues #10.*

14. Please specify radiological monitoring that CBR will perform during operations to confirm its licensing basis and the validity of calculations used for estimating public and occupational exposures for all aspects of its operations.

Background: Although calculations are allowed in meeting the requirements of 10 CFR 1301/1302, the NRC staff expects that CBR will perform monitoring to such an extent as to be able to confirm its licensing basis and the validity of calculations used for estimating effluent concentrations and calculating dose for compliance with 20.1301/1302. This concept applies to point sources as well as diffuse sources such as radon released in the wellfield. Compliance with 10 CFR 20.1501 in regards to occupational dose should be approached in the same manner.

Monitoring proposed by CBR does not appear to take into account all sources of potential exposure to workers and members of the public. Examples include effluent discharged from the facility, header houses, and wellfields. More specifically, it is not clear that occupational exposures due to radon and its progeny are considered for all aspects of its operations throughout the permit area.

Needed: A more detailed description of CBR's radiological monitoring program that can be used to confirm its licensing basis and the validity of calculations used for estimating public and occupational exposures for all aspects of its operations.

Response: *Please see the CBR response to an identical comment, Crow Butte License Renewal Open Issues, G.1,, on pages 6 and 7 of 9 (ML102640195). As a "Satellite Plant" the North Trend Expansion Area will be operated pursuant to the same SHEQ Management System.*

15. More details needed on CBR's ALARA program.

Background: ALARA requirements relevant to ISR facilities are codified in 10 CFR 20.1101 and 10 CFR 40, Appendix A, Criterion 8.

License Condition 9.12 of SUA-1534 requires CBR to follow the guidance in Regulatory Guide 8.31, *Information Relevant to Ensuring that Occupational Radiation Exposure at Uranium Recovery Facilities Will Be As Low As Is Reasonably Achievable*. Regulatory Guide 8.31 specifically recommends that the annual radiation protection and ALARA audit should address trends in personnel exposure and recommendations on ways to further reduce personnel exposure from uranium and its daughters.

Further, Regulatory Guide 8.10, *Operating Philosophy for Maintaining Occupational Radiation Exposures As Low As Is Reasonably Achievable*, recommends that the RSO and radiation protection staff know the origins of radiation exposures and that they look for ways to reduce exposure.

Section 5.3 of the CBR's TR describes its management and inspection program. This program includes an annual ALARA audit. However, it is not clear how the CBR's ALARA program is consistent with the principles recommended in Regulatory Guides 8.31 and 8.10. Although CBR does apply good ALARA practices in its occupational airborne monitoring program described in Section 5.7.3 of its TR (e.g., setting action levels at 25% of the DAC), there are other areas of its radiation protection program that do not address ALARA principles.

Specific examples that NRC staff is requesting clarification on include the following:

- Reliance in Section 5.7.6 of the TR on maximum limits for personnel monitoring
- No discussion in Section 5.7.6 of the TR on reducing surface contamination from items to be release for unrestricted use. CBR appears to rely on maximum release limits here as well
- Lack of demonstration that CBR accounts for all sources (e.g., effluents from the facility, wellfield and header houses) of occupational exposure.
- No ALARA goals stated in the TR.
- CBR has not demonstrated that it has a radiological monitoring program that can be used to confirm its licensing basis and the validity of calculations used for estimating public and occupational exposures for all aspects of its operations.

Needed: A detailed description of CBR's ALARA program that addresses the points above and how the program is consistent with recommendations in Regulatory Guides 8.31 and 8.10.

Response: *Throughout the license application and license renewal process and during inspections, the NRC has repeatedly reviewed the CBR Crow Butte CPP ALARA program and determined it to be adequate. An identical program has been proposed for the North Trend Expansion Area.*

This comment is very general and is best addressed by a thorough review of the license application in light of the CBR responses to open issues.

<u>Miscellaneous (Confrimatory)</u>

Spill Prevention

Background: Contamination from spills would be isolated from surface water due to the construction of berms around the wellfields (Section 7.2.6.2, CBR, 2007). Furthermore, CBR will prepare and implement a Spill Prevention, Control, and Countermeasures (SPCC) plan to remediate soil contamination by spills. CBR also cites Section VIII of its Emergency Manual for spill response procedures, as well. However, it is not clear what is included in the term "surface water features.

Needed: CBR should clarify that the berms would prevent surface spills from entering all surface water bodies and drainages that connect to surface water bodies and that the berms serve to eliminate public dose and contaminant pathways to surface water.

Response: *The suggested clarification has been included.*

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Add replacement pages:

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2.5 METEOROLOGY

2.5.1 Introduction

This section describes the meteorological conditions in the region surrounding the Crow Butte Project and the North Trend Expansion Area. The data presented in this section were used to determine the effect of the local climate on the development area. The joint frequency data can be used to assess the atmospheric dispersion characteristics present in the region.

Data sources for the meteorological conditions used for this report come from the High Plains Regional Climatic Center (HPRCC) for a site located in Chadron, Nebraska (HPRCC 2004) and from an on-site monitoring station near the Crow Butte facility. The period of record for the HPRCC data covers 56 years of observation between 1948 and 2003. The on-site monitoring data were collected between May 1982 and April 1984, and include temperature, precipitation, evaporation, wind speed, and wind direction. Data are also included from the National Weather Service Stations in Scottsbluff, Nebraska and Rapid City, South Dakota.

The North Trend Expansion Area is located in Dawes County (in the north central portion of the Nebraska panhandle), which shares its northern border with South Dakota. The weather patterns are typical of a semi-arid, continental climate. This climate is characterized by warm summers, cold winters, light precipitation, and frequent changes in the weather.

The Rocky Mountains, located to the west of the site, and the Black Hills, located to the north, effectively block moisture from these directions, while moisture from the south is directed eastward by a plateau south of the region. As a result of this topography, the project area is generally drier than the rest of the panhandle.

The HPRCC data were collected at the Chadron 1 NW site (latitude 42° 50' north, longitude 103° 01' west with a ground elevation of 1021 m [3350 ft] above mean sea level). The monitor is 1.4 km (0.9 miles) west northwest of Chadron, 37 km (23 miles) east northeast of Crawford, and 35 km (22 miles) east northeast of the proposed license area.

2.5.2 Temperature

Table 2.5-1 shows the mean daily maximum and minimum temperatures as well as the mean monthly temperatures. The months of November through March all have mean daily minimum temperatures below freezing, with January as the coldest month. December, January, and February all have monthly mean temperatures below freezing.

TABLE 2.5-1
MEAN DAILY MAXIMUM AND MINIMUM AND MEAN MONTHLY TEMPERATURE DATA FOR CHADRON, NEBRASKA

Month	Mean Daily Maximum	Mean Daily Minimum	Mean Monthly	Record High		Record Low	
	(°C)	(°C)	(°C)	(°C)	Year	(°C)	Year
Jan	2.0	-11.8	-4.9	21.1	1989	-33.9	1949
Feb	5.0	-9.2	-2.1	24.4	1982	-32.8	1982
Mar	8.9	-5.4	1.8	28.3	1967	-32.2	1989
Apr	15.1	0.2	7.7	33.9	1989	-23.9	1975
May	20.9	6.3	13.6	36.7	1969	-8.9	1954
June	27.1	11.6	19.3	41.7	1989	-3.3	1969
July	31.8	15.2	23.5	43.3	1954	3.3	1971
Aug	31.3	14.3	22.8	42.2	1980	2.2	1962
Sept	25.3	8.1	16.7	40.0	1978	-8.3	1984
Oct	18.2	1.3	9.7	34.4	1953	-21.7	1991
Nov	8.9	-5.4	1.8	27.2	1999	-27.8	1959
Dec	3.6	-10.1	-3.3	22.2	1980	-40.0	1989
Year	16.5	1.2	8.9	43.3	Jul-54	-40.0	Dec-89

Source: HPRCC

The warmest months are July and August. The mean yearly temperature is 8.9°C (48.0°F).

The temperature extremes for the period of record are also given in Table 2.5-1, along with the year of occurrence. These data show that temperatures can exceed 100°F (38°C), and freezing or near-freezing temperatures can occur throughout the year.

Table 2.5-1 summarizes Mean Daily Maximum and Minimum and Mean Monthly Temperature Data for Chadron, Nebraska (From 1948 to 2003).

Table 2.5-2 lists the mean number of days per month with temperatures above or below selected values.

The average date of the last yearly 0°C (32°F) temperature is May 18 while the first fall freeze is expected on September 18. The average growing season is 120 to 130 days long (USDA 1981). These are average values, and the exact occurrence of freezing temperatures depends on exposure.

The temperature in Chadron, Nebraska is comparable to the temperature in Crawford, Nebraska. To demonstrate this trend, high and low temperature data for both locations for April to August 1999 are displayed in Figure 2.5-1. The source for Chadron and Crawford temperature data is from Weather Underground (WUG 2009) and the National Climatic Data Center (NCDC 2009) operated by NOAA (NCDC), respectively. Figure 2.5-1 shows that the temperature data from the two weather stations is consistent.

The Weather Underground website uses temperature data from the Chadron weather station for prediction of weather in both Crawford and Chadron. 1999 was selected for comparison because 1999 was the most recent year for which actual Crawford temperature data was available. Since complete meteorological data from Crawford is not available and the temperature data from Chadron is consistent with Crawford, the Chadron data would be the best option for usage in air emission modeling and evaluation.

2.5.3 Precipitation

Precipitation in the region is generally light, with the heaviest occurrences in the spring and summer. Table 2.5-3 lists the monthly precipitation totals for the period of record. May has the heaviest precipitation, with good precipitation occurring through July. The driest months are November through February. The mean yearly precipitation is 40.79 cm (16.06 in). The maximum 24-hour precipitation events are also listed in Table 2.5-3.

The monthly mean and maximum snowfalls for the period of record are listed in Table 2.5-3. The mean annual snowfall is 107.44 cm (42.30 in). July and August are the only two months without a reported snowfall. The maximum mean monthly snowfall occurred in March.

TABLE 2.5-2
TEMPERATURE OCCURRENCES FOR CHADRON, NEBRASKA
(FROM 1948 TO 2003)

Month	Mean Number of Days with Maximum Temperatures		Mean Number of Days with Minimum Temperatures	
	> 32.2°C	< 0°C	< 0°C	< -17.8°C
Jan	0.0	11.4	30.1	7.5
Feb	0.0	7.8	26.7	4.3
Mar	0.0	4.7	26.2	1.7
Apr	0.1	0.8	15.4	0.0
May	0.9	0.0	2.9	0.0
June	6.0	0.0	0.1	0.0
July	15.9	0.0	0.0	0.0
Aug	15.6	0.0	0.0	0.0
Sept	5.6	0.0	1.9	0.0
Oct	0.3	0.5	12.4	0.1
Nov	0.0	4.5	25.6	1.0
Dec	0.0	9.1	29.6	4.7
Year	44.3	38.7	170.8	19.3

Source: HPRCC

TABLE 2.5-3
MEAN AND MAXIMUM PRECIPITATION DATA FOR CHADRON, NEBRASKA (FROM 1948 TO 2003)

Month	Water Equivalent		Snow Fall	
	Mean	Maximum 24-Hour	Mean	Maximum Monthly
	(cm)	(cm)	(cm)	(cm)
Jan	1.12	2.72	16.51	88.14
Feb	1.17	3.81	16.51	59.69
Mar	2.16	3.51	21.84	88.14
Apr	4.47	6.22	13.21	49.28
May	7.52	6.50	1.52	23.62
June	7.14	5.38	0.00	3.05
July	5.41	5.08	0.00	0.00
Aug	3.48	4.62	0.00	0.00
Sept	3.66	11.18	0.76	25.40
Oct	2.36	3.81	5.59	28.45
Nov	1.24	1.78	13.21	42.93
Dec	1.04	1.80	17.78	46.99
Year	40.79	11.18	107.44	196.85

Source: HPRCC

Precipitation data from the National Oceanic and Atmospheric Administration (NOAA) was also reviewed. The site in Scottsbluff, Nebraska is 98 km (60.9 mi) south of the license area and the site in Rapid City, South Dakota is 158 km (98.2 mi) north of the license area. These data indicate that precipitation in excess of 0.03 cm (.01 in) can be expected on an average of 91 and 96 days per year, respectively. These data are listed in Table 2.5-4.

Tornadoes are rare. In the USNRC, "Draft Generic Environmental Impact Statement on Uranium Milling", (USNRC 1979) the authors calculated a mean annual frequency of 0.6 for tornadoes in intensity Category I at Rapid City. The annual probability of occurrence at this location is 4.8×10^{-4}. A tornado in intensity Category I has a rotational speed of 134 meters per second (m/s) and a translational speed of 26 m/s.

For comparison of rainfall in Chadron and Crawford, rainfall data collected at the two locations was compared for April of 1999 to August of 1999. The source for rainfall data for both locations was the NCDC. Figure 2.5-2 shows a bar graph of daily rainfall measured at the two locations. While the rainfall was not found to be exactly the same on a daily basis, the trend does show that rainfall events are typically logged in both locations. Table 2.5-5 shows monthly and seasonal rainfall totals of the data in Figure 2.5-2. The total rainfall for the spring and summer seasons are consistent.

2.5.4 Humidity

Relative percent humidity at the Scottsbluff and Rapid City weather stations is given in Table 2.5-6. The humidity at 0500, 1100, 1700, and 2300 hours is listed. Both locations have about the same humidity during the night; but in the early morning, Scottsbluff is slightly more humid. By noon and throughout the afternoon, Scottsbluff becomes less humid than Rapid City. These data indicate that humidity differences are slight and the humidity at the license area can be expected to be similar to these locations.

While Rapid City, South Dakota and Scottsbluff, Nebraska are greater than 50 miles from Crawford, Nebraska, the humidity is comparable and the best estimate for available data. To illustrate this point, 2006 humidity data for weather stations at Rapid City and Scottsbluff and also for Chadron, Nebraska (within 50 miles of Crawford) was obtained from the Weather Underground website (WUG 2009). Humidity data for Crawford was not available.

Figure 2.5-3 of this document shows the average daily humidity for 2006 for all three locations with available data. The solid trend lines on the graph show the moving 30 day average humidity for each of the three locations. Overall, the humidity in Chadron is slightly higher than in either Rapid City or Scottsbluff. The average humidity for 2006

TABLE 2.5-4
PRECIPITATION EVENTS (1982 - 1990)

Month	Mean Number of Days with Precipitation	
	Scottsbluff, NE	Rapid City SD
January	5.4	5.4
February	5.4	6.2
March	7.3	9.2
April	9.2	8.0
May	12.0	10.8
June	9.2	11.3
July	8.6	8.3
August	8.2	8.6
September	8.0	8.3
October	5.3	6.6
November	6.6	6.2
December	6.2	6.8
Year	91.4	95.7
Period of Record (years)	9	9

Source: NOAA 1993

Table 2.5-5. Rainfall for Spring and Summer at Towns of Crawford and Chadron 1999

1999	Total Rainfall (inches)	
	Crawford	Chadron
April	5.07	3.97
May	1.86	3.5
June	4.31	4.24
July	2.7	1.56
August	0.99	1.42
Total (April to August)	**14.93**	**14.69**

TABLE 2.5-6
PERCENT RELATIVE HUMIDITY DATA (FROM 1982 - 1990)

Month	0500 Hours		1100 Hours		1700 Hours		2300 Hours	
	NE[a]	SD[b]	NE	SD	NE	SD	NE	SD
January	72.0	67.7	54.3	55.7	53.4	61.0	68.3	67.0
February	75.0	71.0	52.6	54.8	47.6	56.1	70.0	70.0
March	76.0	76.2	50.9	56.3	44.1	54.9	68.4	73.7
April	75.3	70.6	42.9	44.9	39.1	43.2	65.0	65.1
May	80.3	75.4	44.4	49.2	41.2	47.5	68.8	70.8
June	80.0	77.0	43.0	49.8	38.4	46.1	66.8	71.3
July	81.1	72.3	40.7	41.3	35.1	37.8	65.4	62.8
August	82.6	73.4	42.6	41.3	37.2	36.8	69.2	64.7
September	79.5	71.9	42.7	44.1	37.8	42.0	68.0	65.8
October	76.6	69.7	43.4	45.2	40.9	48.2	67.6	66.4
November	76.2	72.3	51.2	54.3	53.9	60.5	71.3	70.9
December	76.1	69.1	57.4	56.6	59.6	63.3	73.4	68.1
Year	77.6	72.2	47.2	49.5	44.0	49.8	68.5	68.1
Period of Record (years)	9	9	9	9	9	9	9	9

Source: NOAA 1993
a Scottsbluff, NE
b Rapid City, SD

for Chadron, Scottsbluff, and Rapid City were 61.6 %, 57.5 %, and 56.8 %, respectively. While Chadron may be slightly closer in distance to the project location in Crawford, the elevation of Crawford (3,679 ft.) is more consistent with the average elevation of Scottsbluff and Rapid City (average elevation of 3,565 ft.) in comparison to Chadron (3,369 ft.). The higher elevation of Crawford may make the humidity slightly lower than Chadron and consistent with the data provided in the original report.

While the differences in humidity are slight for the three weather stations discussed above, the use of slightly lower humidity data would be more conservative from an air emissions modeling standpoint. A lower humidity would predict impacts at a greater distance from the emission source. It is noted that humidity data are not expected to be required as an input parameter into modeling at North Trend (i.e., MILDOS and RESRAD). However, if modeling is needed that requires humidity input, an average of values for Scottsbluff and Rapid City (lower than Chadron) would be used, resulting in a more conservative number for air modeling.

Data from Scottsbluff, Nebraska and Rapid City, South Dakota were used because those cities have near-by weather stations that monitor many meteorological parameters hourly

and provide complete, hourly data to the public. Crawford, Nebraska does not have a local weather station to provide that type of complete data.

2.5.5 Winds

Figure 2.5-4 and Figure 2.5-5 are the wind roses for Scottsbluff, Nebraska and Rapid City, South Dakota, respectively. These figures show predominant wind patterns that are similar; however, the finer details are greatly influenced by the local topography. Rapid City has a predominant wind from the north-northwest while Scottsbluff has a slightly bimodal distribution with the predominant winds from the west-northwest and the east-southeast. The least prevalent wind direction at Scottsbluff and Rapid City is from the southwest.

As shown by the wind rose for the license area in Figure 2.5-6, the predominant air pollutant dispersion would be towards the north to northeast. The next most common directions would be towards the southwest to south-southwest.

Local terrain will have a significant influence on the wind patterns in a given area. Because of this, a meteorological station was installed on the current Crow Butte project site (Figure 2.5-7). This station was capable of measuring wind speed, direction, and the standard deviation of the wind direction. Joint frequency data was compiled from this information. Figure 2.5-6 exhibits the wind rose that was identified for the site and Table 2.5-7 through Table 2.5-13 shows the frequency of winds by direction and speed for the six stability classes. Table 2.5-14 shows the annual relative joint frequency distribution. As shown on Figure 2.5-6, the predominant wind direction of the site is from a south-southwest direction approximately 45 percent of the time.

The nearest national weather station to NTEA that reports mixing height values is located at North Platte, Nebraska. This station is located approximately 170 miles southeast of the City of Crawford. Due to the distance, the data are not considered representative of the NTEA. Mixing height data were not available for the CBR meteorological station, since the type of data needed was not collected (i.e., upper air wind measurements). Since the NRC MILDOS modeling requires mixing height data as input into the model, CBR utilized a mixing height default value. The NRC MILDOS modeling program, a computer program for calculating radiation doses from uranium recovery operations, allows for the use of a default value of 100 meters (NRC NUREG/CR-2011). This default value was used for the NTEA MILDOS modeling.

A description of how the stability classes were calculated could not be found in CBR's archived records. However, based on the type of meteorological data collected onsite, it may be assumed the stability classes were calculated using the Sigma Theta Method. This method was the most common method historically used to calculate stability class, because all you needed were wind speed and wind direction. This is the method that was used in a number of standard air modeling programs (e.g., Industrial Source Complex (ISC) model and Screen3 model). It is very likely that the CBR stability class data

generated historically was calculated this way since there was not a lot of other data available beyond wind speed and wind direction. This method using the standard deviation of horizontal wind speed and direction is an atmospheric classification system recommended by the NRC. Limits of sigma theta are given in NRC Reg. Guide 1.23.

As discussed later in this section, CBR will install and operate a new meteorological tower at the outset of operations at NTEA that will allow for the collection of one-year of onsite data that can be used to calculate onsite stability classes. These new data can then be compared to the historic CPF data.

Wind patterns at a specific site do not change significantly from year to year, but will change significantly for different locations. Unlike some other meteorological parameters, wind patterns are notably influenced by local topography. This is the case for the Crawford area.

The wind rose diagram in Figure 2.5-4 shows the wind direction for Scottsbluff, Nebraska for 1984 to 1990. A comparison of this wind rose to the monthly wind roses located on the Natural Resources Conservation Service (NRCS) website (NRCS 2009) for 1961 to 2003 for Scottsbluff, Nebraska shows consistent wind direction trends. The same comparison and conclusion was made for Figure 2.5-5 (wind rose for Rapid City, South Dakota, 1984 to 1990) and the wind roses on the NRCS website (NRCS 2009) for 1961 to 2003 for Rapid City, South Dakota. This shows that over time the wind patterns for a specific location remain consistent. However, a comparison of Figure 2.5-4 and 2.5-5 to Figure 2.5-6 (NTEA) show that Scottsbluff and Rapid City have different predominant wind patterns than the project site. Because of the differences among the sites discussed above, Rapid City, and Scottsbluff, the two-year Crow Butte site wind record is considered the most representative.

CBR recognizes the importance of capturing local wind patterns since this data is used to determine the predominant air pollutant dispersion direction. The 1982 to 1984 meteorological data from the Crow Butte Project station was used to show the trends in wind patterns for the project site. This older data is the only data available from the onsite monitoring station. For evaluation of wind patterns, older data from the actual site is more representative than recent data from available off-site weather stations. The wind patterns are largely impacted by local terrain, and these 1982 to 1984 data should be considered to still be climatologically valid, and hence, appropriate for regulatory purposes.

At the outset of operations, CBR will install, and for one year will operate a meteorological tower at the NTEA to verify the representativeness of the historic CPF data used in the NTEA license amendment application. In addition CBR will compare the data collected at the North Trend site to concurrent data collected that National Weather Service station at Chadron Nebraska to determine if the data collection period is representative of long term conditions. The meteorological tower will be operated to collect data to meet the NRC Regulatory Guide 3.63 requirements for data recovery.

TABLE 2.5-7 FREQUENCY OF WINDS BY DIRECTION AND SPEED (STABILITY A)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	0.98	8.63	2.62	0.11	0.00	0.00	12.34	4.90
NNE	2.61	8.74	2.95	0.11	0.00	0.00	14.31	4.60
NE	1.64	8.52	1.31	0.00	0.00	0.00	11.47	4.50
ENE	0.66	4.37	0.55	0.00	0.00	0.00	5.58	4.40
E	1.20	1.97	0.77	0.00	0.00	0.00	3.94	4.40
ESE	0.33	0.87	0.22	0.00	0.00	0.00	1.42	4.00
SE	0.98	1.75	1.64	0.00	0.00	0.00	4.37	5.10
SSE	0.44	2.61	1.64	0.11	0.00	0.00	4.70	5.30
S	0.98	3.72	1.53	0.00	0.00	0.00	6.23	5.00
SSW	0.55	1.97	2.08	0.22	0.00	0.00	4.82	6.00
SW	0.77	3.72	1.53	0.00	0.00	0.00	6.02	5.00
WSW	0.66	2.08	1.53	0.00	0.00	0.00	4.27	5.30
W	0.66	1.75	1.75	0.11	0.00	0.00	4.27	5.50
WNW	0.77	1.42	0.98	0.44	0.00	0.00	3.61	5.70
NW	0.66	2.30	1.53	0.11	0.00	0.00	4.60	5.50
NNW	1.53	3.93	1.86	0.44	0.00	0.00	7.76	5.30
ALL	15.32	58.25	24.49	1.65	0.00	0.00	99.71	5.00

Stability Class A
Data Recorded between May 1982 and April 1984
Crow Butte Uranium Project Site, Nebraska
Calm (less than one knot) = 0.3%
Period mean wind speed = 5.0 knots
Percent occurrence for A stability class = 5.6%

TABLE 2.5-8
FREQUENCY OF WINDS BY DIRECTION AND SPEED
(STABILITY B)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	1.01	2.68	5.53	0.67	0.00	0.00	9.89	6.40
NNE	1.34	3.52	3.77	0.34	0.00	0.00	8.97	5.70
NE	0.92	5.28	5.45	0.50	0.00	0.00	12.15	6.00
ENE	0.84	1.76	2.85	0.25	0.00	0.00	5.70	6.00
E	0.17	0.84	0.75	0.08	0.00	0.00	1.84	6.00
ESE	0.59	0.59	1.09	0.00	0.00	0.00	2.27	5.80
SE	0.08	1.26	2.26	0.25	0.00	0.00	3.85	6.90
SSE	0.67	1.17	2.43	0.50	0.00	0.00	4.77	6.50
S	1.09	1.01	4.02	0.92	0.00	0.00	7.04	7.00
SSW	1.01	2.01	2.26	0.75	0.00	0.00	6.03	6.30
SW	0.92	3.19	2.61	0.59	0.00	0.00	7.21	6.10
WSW	0.59	2.01	2.60	0.84	0.08	0.00	6.12	6.90
W	0.42	1.34	2.35	0.42	0.08	0.00	4.61	7.20
WNW	0.67	1.09	2.10	0.34	0.00	0.00	4.20	6.60
NW	0.25	1.09	4.02	1.09	0.08	0.00	6.53	7.80
NNW	0.42	1.51	4.95	1.68	0.08	0.00	8.64	7.80
ALL	10.99	30.35	48.94	9.22	0.32	0.00	99.82	6.60

Stability Class B
Data Recorded between May 1982 and April 1984
Crow Butte Uranium Project Site, Nebraska
Calm (less than one knot) = 0.2%
Period mean wind speed = 6.5 knots
Percent occurrence for B stability class = 7.4%

TABLE 2.5-9
FREQUENCY OF WINDS BY DIRECTION AND SPEED\
(STABILITY C)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	0.74	1.54	2.68	0.74	0.00	0.00	5.70	6.70
NNE	0.63	2.62	2.90	0.85	0.00	0.00	7.00	6.60
NE	0.91	2.28	5.69	1.20	0.00	0.00	10.08	7.00
ENE	0.46	1.03	2.96	0.97	0.00	0.00	5.42	7.30
E	0.00	0.57	0.74	0.28	0.00	0.00	1.59	7.60
ESE	0.23	0.34	0.91	0.23	0.00	0.00	1.71	7.00
SE	0.17	0.68	1.82	0.74	0.00	0.00	3.41	7.70
SSE	0.46	0.74	2.22	1.48	0.00	0.00	4.90	8.00
S	0.97	1.65	5.30	2.28	0.00	0.00	10.20	7.70
SSW	1.14	3.02	3.93	0.97	0.00	0.00	9.06	6.60
SW	1.03	3.36	4.67	1.14	0.11	0.00	10.31	6.80
WSW	0.97	3.02	3.59	1.14	0.06	0.06	8.84	6.80
W	0.11	0.91	1.99	1.03	0.11	0.00	4.15	8.40
WNW	0.17	0.51	1.03	1.25	0.06	0.00	3.02	9.10
NW	0.40	0.74	3.70	2.22	0.06	0.00	7.12	8.70
NNW	0.40	1.42	3.42	2.11	0.00	0.00	7.35	8.20
ALL	8.79	24.43	47.55	18.63	0.40	0.06	99.86	7.40

Stability Class C
Data Recorded between May 1982 and April 1984
Crow Butte Uranium Project Site, Nebraska
Calm (less than one knot) = 0.2%
Period mean wind speed = 7.4 knots
Percent occurrence for C stability class = 10.8%

TABLE 2.5-10
FREQUENCY OF WINDS BY DIRECTION AND SPEED
(STABILITY D)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	0.17	0.52	1.14	0.83	0.20	0.02	2.88	9.20
NNE	0.16	1.12	2.34	2.90	0.89	0.19	7.60	10.70
NE	0.13	1.53	2.65	2.72	0.46	0.08	7.47	9.80
ENE	0.04	0.47	0.79	0.50	0.06	0.00	1.86	8.30
E	0.02	0.06	0.28	0.22	0.04	0.00	0.62	9.50
ESE	0.01	0.25	0.35	0.13	0.00	0.00	0.74	7.40
SE	0.06	0.42	0.71	0.52	0.18	0.01	1.90	9.50
SSE	0.13	1.78	1.50	2.60	1.21	0.34	7.56	11.10
S	0.34	1.67	3.58	7.77	3.57	0.58	17.51	12.40
SSW	0.22	1.37	3.82	3.60	0.76	0.12	9.89	10.00
SW	0.17	2.11	5.80	3.80	0.29	0.02	12.19	8.80
WSW	0.17	0.61	2.28	2.74	0.54	0.16	6.50	10.70
W	0.10	0.20	0.64	1.03	0.47	0.19	2.63	12.60
WNW	0.05	0.17	0.91	1.39	0.66	0.28	3.46	13.20
NW	0.05	0.31	1.60	5.13	2.68	1.55	11.32	15.00
NNW	0.04	0.49	1.80	2.34	0.90	0.20	5.77	11.90
ALL	1.86	13.08	30.09	38.22	12.91	3.74	99.90	11.20

Stability Class D
Data Recorded between May 1982 and April 1984
Crow Butte Uranium Project Site, Nebraska
Calm (less than one knot) = 0.1%
Period mean wind speed = 11.2 knots
Percent occurrence for D stability class = 51.3%

TABLE 2.5-11
FREQUENCY OF WINDS BY DIRECTION AND SPEED
(STABILITY E)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	0.85	2.92	0.65	0.04	0.00	0.00	4.46	4.60
NNE	0.97	2.80	1.82	0.00	0.00	0.00	5.59	5.20
NE	0.97	3.32	1.90	0.08	0.00	0.00	6.27	5.10
ENE	0.45	1.26	0.73	0.00	0.00	0.00	2.44	5.10
E	0.16	0.73	0.20	0.00	0.00	0.00	1.09	4.70
ESE	0.28	0.65	0.45	0.00	0.00	0.00	1.38	4.80
SE	0.49	1.82	0.85	0.12	0.00	0.00	3.28	5:10
SSE	1.70	7.62	1.05	0.08	0.00	0.00	10.45	4.40
S	2.23	11.06	4.34	0.16	0.00	0.00	17.79	5.00
SSW	2.11	10.53	2.80	0.04	0.00	0.00	15.48	4.70
SW	1.78	8.18	5.67	0.12	0.04	0.00	15.79	5.50
WSW	1.05	2.88	2.47	0.04	0.00	0.00	6.44	5.40
W	0.65	0.97	0.36	0.04	0.00	0.00	2.02	4.30
WNW	0.36	0.97	0.81	0.00	0.00	0.00	2.14	5.50
NW	0.45	1.18	0.85	0.20	0.00	0.00	2.68	5.70
NNW	0.61	1.34	0.49	0.00	0.00	0.00	2.44	4.50
ALL	15.11	58.23	25.44	0.92	0.04	0.00	99.74	5.00

Stability Class E
Data Recorded between May 1982 and April 1984
Crow Butte Uranium Project Site, Nebraska
Calm (less than one knot) = 0.2%
Period mean wind speed = 5.0 knots
Percent occurrence for E stability class = 15.2%

TABLE 2.5-12
FREQUENCY OF WINDS BY DIRECTION AND SPEED
(STABILITY F)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	3.30	1.65	0.00	0.00	0.00	0.00	4.95	2.80
NNE	1.65	1.33	0.00	0.00	0.00	0.00	2.98	3.00
NE	0.95	1.40	0.00	0.00	0.00	0.00	2.35	3.10
ENE	1.40	0.76	0.00	0.00	0.00	0.00	2.16	2.80
E	1.27	0.44	0.00	0.00	0.00	0.00	1.71	2.80
ESE	1.78	1.02	0.00	0.00	0.00	0.00	2.80	2.60
SE	1.72	1.78	0.00	0.00	0.00	0.00	3.50	3.00
SSE	3.75	4.76	0.00	0.00	0.00	0.00	8.51	3.10
S	7.50	12.07	0.00	0.00	0.00	0.00	19.57	3.30
SSW	7.24	13.15	0.00	0.00	0.00	0.00	20.39	3.30
SW	6.48	8.01	0.00	0.00	0.00	0.00	14.49	3.20
WSW	2.73	2.60	0.00	0.00	0.00	0.00	5.33	3.00
W	1.78	1.46	0.00	0.00	0.00	0.00	3.24	2.90
WNW	0.83	0.95	0.00	0.00	0.00	0.00	1.78	3.00
NW	1.33	1.21	0.00	0.00	0.00	0.00	2.64	3.00
NNW	1.33	0.51	0.00	0.00	0.00	0.00	1.84	2.60
ALL	45.04	53.10	0.00	0.00	0.00	0.00	98.14	3.10

Stability Class F
Data Recorded between May 1982 and April 1984
Crow Butte Uranium Project Site, Nebraska
Calm (less than one knot) = 1.8%
Period mean wind speed = 3.1 knots
Percent occurrence for F stability class = 9.7%

TABLE 2.5-13
FREQUENCY OF WINDS BY DIRECTION AND SPEED
(ALL STABILITIES)

Wind Direction	Speed Class Intervals (Knots)							
	1 – 3	3 – 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	0.75	1.72	1.53	0.57	0.10	0.01	4.68	6.50
NNE	0.70	2.16	2.24	1.61	0.46	0.10	7.27	8.20
NE	0.57	2.64	2.69	1.57	0.23	0.04	7.64	7.70
ENE	0.37	0.99	1.08	0.38	0.03	0.00	2.85	6.50
E	0.24	0.42	0.35	0.15	0.02	0.00	1.18	6.20
ESE	0.31	0.46	0.44	0.09	0.00	0.00	1.30	5.50
SE	0.35	0.93	0.95	0.38	0.09	0.01	2.71	7.00
SSE	0.81	2.84	1.44	1.55	0.62	0.17	7.43	8.20
S	1.48	4.17	3.45	4.33	1.83	0.30	15.56	9.30
SSW	1.36	4.17	3.09	2.03	0.39	0.06	11.10	7.20
SW	1.21	3.91	4.62	2.13	0.17	0.01	12.05	7.10
WSW	0.70	1.60	2.21	1.60	0.29	0.09	6.49	8.20
W	0.40	0.69	0.87	0.68	0.26	0.10	3.00	8.90
WNW	0.27	0.54	0.91	0.90	0.35	0.14	3.11	10.20
NW	0.32	0.75	1.73	2.99	1.39	0.79	7.97	12.80
NNW	0.40	0.99	1.84	1.58	0.47	0.10	5.38	9.50
ALL	10.24	28.88	29.44	22.64	6.70	1.92	99.72	8.40

Stability Class All
Data Recorded between May 1982 and April 1984
Crow Butte Uranium Project Site, Nebraska
Calm (less than one knot) = 0.3%
Period mean wind speed = 8.4 knots
Percent occurrence for A stability class = 100.0%

TABLE 2.5-14
CBR ONSITE MET STATION JOINT FREQUENCY DISTRIBUTION

Stability Class A					
0.00056	0.00488	0.00148	0.00006	0.00000	0.00000
0.00142	0.00495	0.00167	0.00006	0.00000	0.00000
0.00093	0.00482	0.00074	0.00000	0.00000	0.00000
0.00037	0.00247	0.00031	0.00000	0.00000	0.00000
0.00068	0.00111	0.00043	0.00000	0.00000	0.00000
0.00019	0.00049	0.00012	0.00000	0.00000	0.00000
0.00056	0.00099	0.00093	0.00000	0.00000	0.00000
0.00025	0.00142	0.00093	0.00006	0.00000	0.00000
0.00056	0.00210	0.00087	0.00000	0.00000	0.00000
0.00031	0.00111	0.00117	0.00012	0.00000	0.00000
0.00043	0.00210	0.00087	0.00000	0.00000	0.00000
0.00037	0.00117	0.00087	0.00000	0.00000	0.00000
0.00037	0.00099	0.00099	0.00006	0.00000	0.00000
0.00043	0.00080	0.00056	0.00025	0.00000	0.00000
0.00037	0.00130	0.00087	0.00006	0.00000	0.00000
0.00087	0.00223	0.00105	0.00025	0.00000	0.00000
Stability Class B					
0.00074	0.00198	0.00408	0.00049	0.00000	0.00000
0.00099	0.00260	0.00278	0.00025	0.00000	0.00000
0.00068	0.00389	0.00402	0.00037	0.00000	0.00000
0.00062	0.00130	0.00210	0.00019	0.00000	0.00000
0.00012	0.00062	0.00056	0.00006	0.00000	0.00000
0.00043	0.00043	0.00080	0.00000	0.00000	0.00000
0.00006	0.00093	0.00167	0.00019	0.00000	0.00000
0.00049	0.00087	0.00179	0.00037	0.00000	0.00000
0.00080	0.00074	0.00297	0.00068	0.00000	0.00000
0.00074	0.00148	0.00167	0.00056	0.00000	0.00000
0.00068	0.00235	0.00185	0.00043	0.00000	0.00000
0.00043	0.00148	0.00192	0.00062	0.00006	0.00000
0.00031	0.00099	0.00173	0.00031	0.00006	0.00000
0.00049	0.00080	0.00155	0.00025	0.00000	0.00000
0.00019	0.00080	0.00297	0.00080	0.00006	0.00000
0.00031	0.00111	0.00365	0.00124	0.00006	0.00000

TABLE 2.5-14
CBR ONSITE MET STATION JOINT FREQUENCY DISTRIBUTION

Stability Class C					
0.00080	0.00167	0.00291	0.00080	0.00080	0.00000
0.00068	0.00284	0.00315	0.00093	0.00093	0.00000
0.00099	0.00247	0.00618	0.00130	0.00130	0.00000
0.00049	0.00111	0.00321	0.00105	0.00105	0.00000
0.00000	0.00062	0.00080	0.00031	0.00031	0.00000
0.00025	0.00037	0.00099	0.00025	0.00025	0.00000
0.00019	0.00074	0.00198	0.00080	0.00080	0.00000
0.00049	0.00080	0.00241	0.00161	0.00161	0.00000
0.00105	0.00179	0.00575	0.00080	0.00000	0.00000
0.00124	0.00328	0.00427	0.00093	0.00000	0.00000
0.00111	0.00365	0.00507	0.00130	0.00012	0.00000
0.00105	0.00328	0.00389	0.00105	0.00006	0.00006
0.00012	0.00099	0.00216	0.00031	0.00012	0.00000
0.00019	0.00056	0.00111	0.00025	0.00006	0.00000
0.00043	0.00080	0.00402	0.00080	0.00006	0.00000
0.00043	0.00155	0.00371	0.00161	0.00000	0.00000
Stability Class D					
0.00087	0.00266	0.00587	0.00427	0.00105	0.00012
0.0008	0.00575	0.01205	0.0149	0.00457	0.00099
0.00068	0.00785	0.01311	0.01397	0.00235	0.00043
0.00019	0.00241	0.00408	0.0026	0.00031	0.00000
0.00012	0.00031	0.00142	0.00111	0.00019	0.00000
0.00006	0.0013	0.00179	0.00068	0.00000	0.00000
0.00031	0.00216	0.00365	0.00266	0.00093	0.00006
0.00068	0.00915	0.00773	0.01335	0.00624	0.00173
0.00173	0.00859	0.01842	0.04	0.01836	0.00297
0.00111	0.00705	0.01966	0.01854	0.00389	0.00062
0.00087	0.01088	0.02986	0.01953	0.00148	0.00012
0.00087	0.00315	0.01175	0.01409	0.00278	0.0008
0.00049	0.00105	0.00328	0.00532	0.00241	0.00099
0.00025	0.00087	0.0047	0.00717	0.0034	0.00142
0.00025	0.00161	0.00822	0.0264	0.01379	0.00797
0.00019	0.00253	0.00927	0.01205	0.00464	0.00105

TABLE 2.5-14
CBR ONSITE MET STATION JOINT FREQUENCY DISTRIBUTION

Stability Class E					
0.00130	0.00445	0.00099	0.00006	0.00000	0.00000
0.00148	0.00427	0.00278	0.00000	0.00000	0.00000
0.00148	0.00507	0.00291	0.00012	0.00000	0.00000
0.00068	0.00192	0.00111	0.00000	0.00000	0.00000
0.00025	0.00111	0.00031	0.00000	0.00000	0.00000
0.00043	0.00099	0.00068	0.00000	0.00000	0.00000
0.00074	0.00278	0.00130	0.00019	0.00000	0.00000
0.00260	0.01162	0.00161	0.00012	0.00000	0.00000
0.00340	0.01688	0.00661	0.00025	0.00000	0.00000
0.00321	0.01607	0.00427	0.00006	0.00000	0.00000
0.00272	0.01249	0.00865	0.00019	0.00006	0.00000
0.00161	0.00439	0.00377	0.00006	0.00000	0.00000
0.00099	0.00148	0.00056	0.00006	0.00000	0.00000
0.00056	0.00148	0.00124	0.00000	0.00000	0.00000
0.00068	0.00179	0.00130	0.00031	0.00000	0.00000
0.00093	0.00204	0.00074	0.00000	0.00000	0.00000
Stability Class F					
0.00321	0.00161	0.00000	0.00000	0.00000	0.00000
0.00161	0.00130	0.00000	0.00000	0.00000	0.00000
0.00093	0.00136	0.00000	0.00000	0.00000	0.00000
0.00136	0.00074	0.00000	0.00000	0.00000	0.00000
0.00124	0.00043	0.00000	0.00000	0.00000	0.00000
0.00173	0.00099	0.00000	0.00000	0.00000	0.00000
0.00167	0.00173	0.00000	0.00000	0.00000	0.00000
0.00365	0.00464	0.00000	0.00000	0.00000	0.00000
0.00729	0.01175	0.00000	0.00000	0.00000	0.00000
0.00705	0.01280	0.00000	0.00000	0.00000	0.00000
0.00631	0.00779	0.00000	0.00000	0.00000	0.00000
0.00266	0.00253	0.00000	0.00000	0.00000	0.00000
0.00173	0.00142	0.00000	0.00000	0.00000	0.00000
0.00080	0.00093	0.00000	0.00000	0.00000	0.00000
0.00130	0.00117	0.00000	0.00000	0.00000	0.00000
0.00130	0.00049	0.00000	0.00000	0.00000	0.00000

Note: Joint frequency distribution in this table is a set of data that represents a summary of meteorological conditions at the meteorological station location for a two-year period (May 1982 – April1984). Joint frequency distribution is computed by compiling meteorological data, determined and recorded for each hour, over a designated time interval and computing the frequency of occurrence of each joint frequency category. Each joint frequency category represents a band of wind speeds, directions and stability conditions.

At the outset of operations, CBR will install, and for one year will operate a meteorological tower at the NTEA to verify the representativeness of the historic CPF data used in the NTEA license amendment application. In addition CBR will compare the data collected at the North Trend site to concurrent data collected that National Weather Service station at Chadron Nebraska to determine if the data collection period is representative of long term conditions. The meteorological tower will be operated to collect data to meet the NRC Regulatory Guide 3.63 requirements for data recovery.

2.5.6 Air Quality

Radon gas is expected to be the major radiological emission at the North Trend operations. The air dispersion of radiological particulates during routine operations is not expected to be major issue at the NTEA since there will be no yellowcake drying and packaging operations. These later operations are the major source of radioactive particulates for uranium in situ operations. However, surface spills of pregnant lixiviant could be a source of radiological emissions that could eventually become entrained and airborne. Preoperational ambient atmospheric radon and air particulate monitoring (Uranium, Ra-226 and Pb-210) were collected at designated air monitoring stations (1996-1997 and 2004-2005) Preoperational baseline direct radiation (gamma) measures were also made at the abovementioned air monitoring stations and the proposed North Trend Satellite Facility. In addition preoperational vegetation, soils, surface water and groundwater sampling for the North Trend area were also completed. Additional vegetation, soils and gamma surveys will be completed to better document baseline conditions for site conditions within the NTEA. A description of the completed monitoring programs including the results of monitoring, and planned monitoring activities are presented in Section 2.9.

The primary new emission source of non-radiological pollutants will be tailpipe emissions of nitrogen oxides (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2), non-methane-ethane volatile organic compounds (VOC), and particulate matter with a diameter less than ten micrometers (PM_{10}) resulting from vehicle traffic within the North Trend Expansion Area. Approximately 6-8 vehicle trips per day (VTPD) are anticipated as part of regular operations. These vehicles are expected to be light duty pick-up style trucks. Heavy equipment in the form of drill rigs, equipment haulers, or water trucks will be used as necessary and are anticipated to average less than one VTPD. These emissions are expected to be minor and should not affect the local ambient air quality.

Although there are no ambient air quality monitoring data for these non-radiological pollutants in the license area, PM_{10} concentrations have been measured in Rapid City, South Dakota and Badlands National Park in South Dakota. Both locations are geographically similar to the license area.

The Rapid City data were collected at the National Guard Camp Armory site about 2 miles west of the city. This area is classified as suburban. The Badlands data were collected in an area classified as rural. Because of the degree of urbanization, the air

quality at the license area would probably fall somewhere between the air quality at these two locations. These data were obtained from the United States Environmental Protection Agency (USEPA) air quality monitoring database (USEPA 2007), and are presented in Table 2.5-15.

The National Ambient Air Quality Standards (NAAQS) for PM_{10} are 150 micrograms per cubic meter (24-hour average), and 50 micrograms per cubic meter (annual average). All counties within the 80-km radius or the project are in attainment of NAAQS.

2.5.7 References

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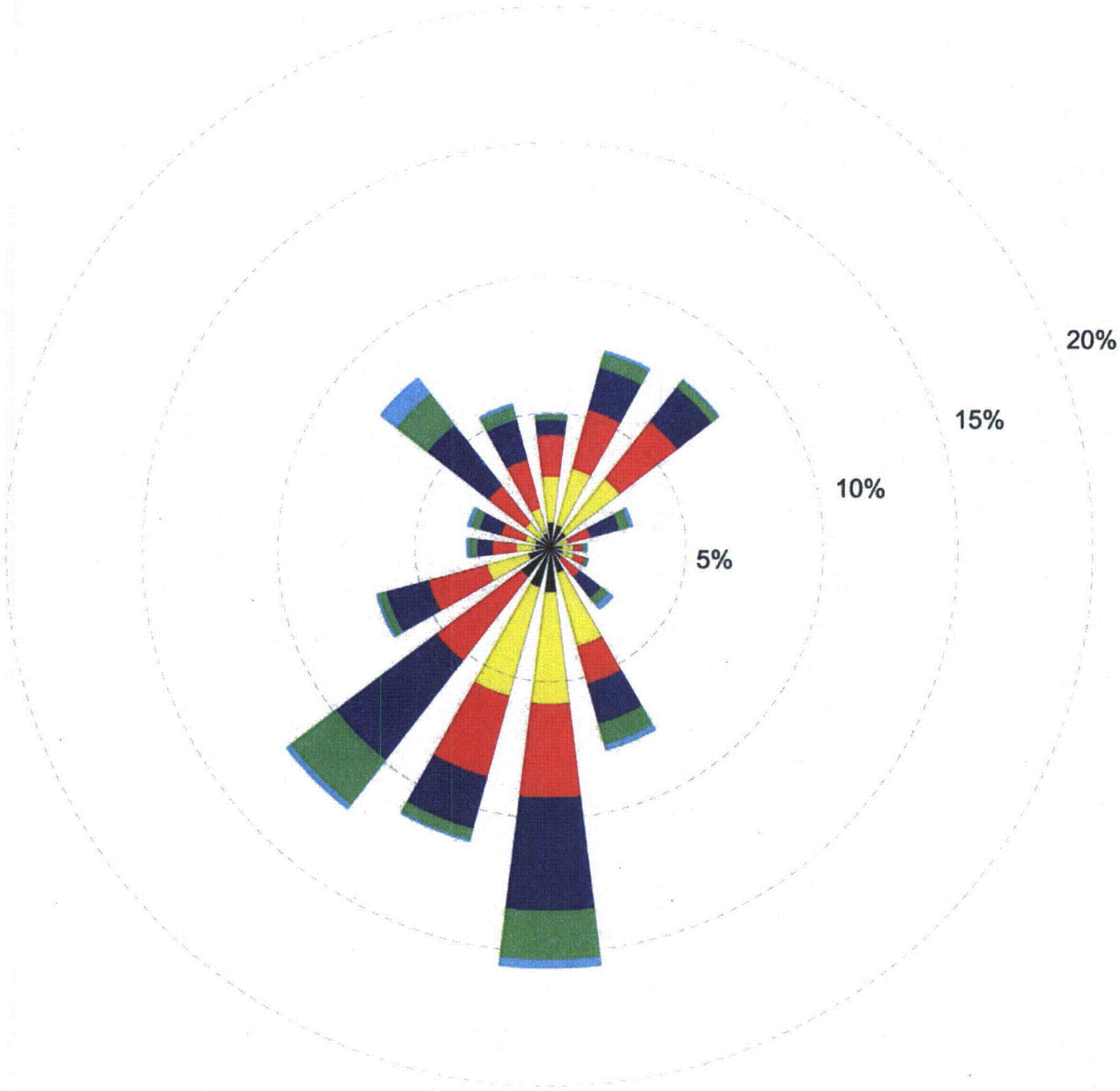


Source: Greystone

Wind Speed (Knots)

- >21
- 17-21
- 11-16
- 7-10
- 4-6
- 1-3

Avg. Wind Speed	8.40	knots
Percent Calm Winds	0.3	percent
Wind Direction	Blowing From	
Years	May 1982 - April 1984	

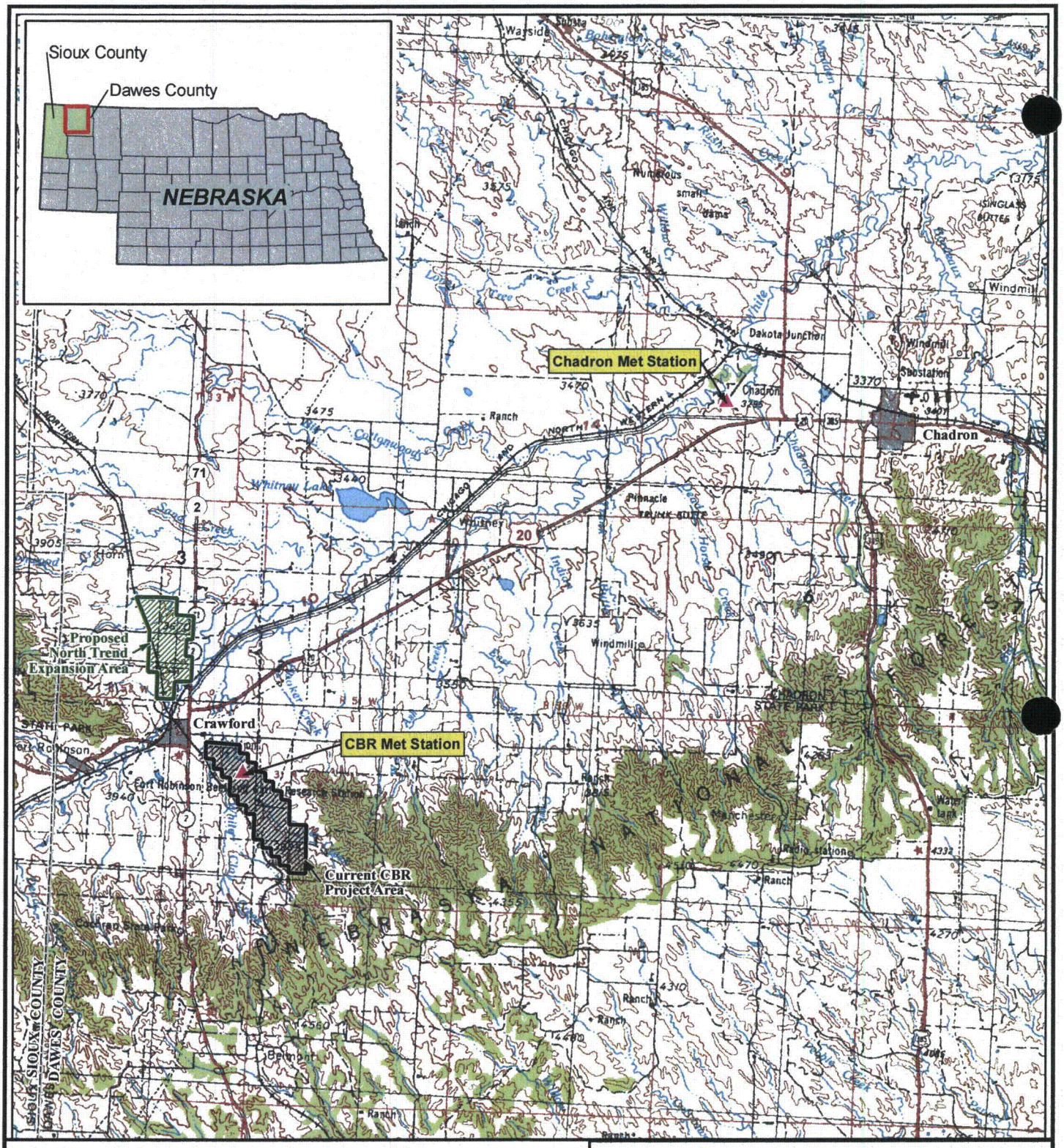
1711-04 cb-wind-rose.dwg

CROW BUTTE PROJECT

DAWES & SIOUX COUNTIES, NEBRASKA

FIGURE 2.5-6
CROW BUTTE
SURFACE WINDS

Date **06/01/04** Drawn **ETC** Fig. **2-5-3**



LEGEND

- Meteorological Station
- Proposed North Trend Expansion Area
- Current CBR Project Area
- County Boundary

0 1.5 3
Miles

PROJECTION:
NAD_1927_STATE_PLANE_
NEBRASKA_NORTH_FIPS_2601

SOURCE: USGS 1:250K DRG - ALLIANCE (1980), NE

N
W — E

CROW BUTTE RESOURCES, INC.

FIGURE 2.5-7
LOCATION OF CBR AND CHADRON METEOROLOGICAL STATIONS

PROJECT: CO001396.00001 MAPPED BY: JC CHECKED BY: JEC

ARCADIS
630 Plaza Drive, Ste. 100
Highlands Ranch, CO 80129
P: 720-344-3500 F: 720-344-3535
www.arcadis-us.com

K:\CBR_Projects\CO001322_NTEA\2_GIS\ArcMaps\0001_TRI\NRC Response TR Fig_2_5-7 Regional Met Stations.mxd - 10/15/2010 @ 1:38:44 PM

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2.5 METEOROLOGY

2.5.1 Introduction

This section describes the meteorological conditions in the region surrounding the Crow Butte Project and the North Trend Expansion Area. The data presented in this section were used to determine the effect of the local climate on the development area. The joint frequency data can be used to assess the atmospheric dispersion characteristics present in the region.

Data sources for the meteorological conditions used for this report come from the High Plains Regional Climatic Center (HPRCC) for a site located in Chadron, Nebraska (HPRCC 2004) and from an on-site monitoring station near the Crow Butte facility. The period of record for the HPRCC data covers 56 years of observation between 1948 and 2003. The on-site monitoring data were collected between May 1982 and April 1984, and include temperature, precipitation, evaporation, wind speed, and wind direction. Data are also included from the National Weather Service Stations in Scottsbluff, Nebraska and Rapid City, South Dakota.

The North Trend Expansion Area is located in Dawes County (in the north central portion of the Nebraska panhandle), which shares its northern border with South Dakota. The weather patterns are typical of a semi-arid, continental climate. This climate is characterized by warm summers, cold winters, light precipitation, and frequent changes in the weather.

The Rocky Mountains, located to the west of the site, and the Black Hills, located to the north, effectively block moisture from these directions, while moisture from the south is directed eastward by a plateau south of the region. As a result of this topography, the project area is generally drier than the rest of the panhandle.

The HPRCC data were collected at the Chadron 1 NW site (latitude 42° 50' north, longitude 103° 01' west with a ground elevation of 1021 m [3350 ft] above mean sea level). The monitor is 1.4 km (0.9 miles) west northwest of Chadron, 37 km (23 miles) east northeast of Crawford, and 35 km (22 miles) east northeast of the proposed license area.

2.5.2 Temperature

Table 2.5-1 shows the mean daily maximum and minimum temperatures as well as the mean monthly temperatures. The months of November through March all have mean daily minimum temperatures below freezing, with January as the coldest month. December, January, and February all have monthly mean temperatures below freezing.

TABLE 2.5-1
MEAN DAILY MAXIMUM AND MINIMUM AND MEAN MONTHLY TEMPERATURE DATA FOR CHADRON, NEBRASKA

Month	Mean Daily Maximum	Mean Daily Minimum	Mean Monthly	Record High		Record Low	
	(°C)	(°C)	(°C)	(°C)	Year	(°C)	Year
Jan	2.0	-11.8	-4.9	21.1	1989	-33.9	1949
Feb	5.0	-9.2	-2.1	24.4	1982	-32.8	1982
Mar	8.9	-5.4	1.8	28.3	1967	-32.2	1989
Apr	15.1	0.2	7.7	33.9	1989	-23.9	1975
May	20.9	6.3	13.6	36.7	1969	-8.9	1954
June	27.1	11.6	19.3	41.7	1989	-3.3	1969
July	31.8	15.2	23.5	43.3	1954	3.3	1971
Aug	31.3	14.3	22.8	42.2	1980	2.2	1962
Sept	25.3	8.1	16.7	40.0	1978	-8.3	1984
Oct	18.2	1.3	9.7	34.4	1953	-21.7	1991
Nov	8.9	-5.4	1.8	27.2	1999	-27.8	1959
Dec	3.6	-10.1	-3.3	22.2	1980	-40.0	1989
Year	16.5	1.2	8.9	43.3	Jul-54	-40.0	Dec-89

Source: HPRCC

The warmest months are July and August. The mean yearly temperature is 8.9°C (48.0°F).

The temperature extremes for the period of record are also given in Table 2.5-1, along with the year of occurrence. These data show that temperatures can exceed 100°F (38°C), and freezing or near-freezing temperatures can occur throughout the year.

Table 2.5-1 summarizes Mean Daily Maximum and Minimum and Mean Monthly Temperature Data for Chadron, Nebraska (From 1948 to 2003).

Table 2.5-2 lists the mean number of days per month with temperatures above or below selected values.

The average date of the last yearly 0°C (32°F) temperature is May 18 while the first fall freeze is expected on September 18. The average growing season is 120 to 130 days long (USDA 1981). These are average values, and the exact occurrence of freezing temperatures depends on exposure.

The temperature in Chadron, Nebraska is comparable to the temperature in Crawford, Nebraska. To demonstrate this trend, high and low temperature data for both locations for April to August 1999 are displayed in Figure 2.5-1. The source for Chadron and Crawford temperature data is from Weather Underground (WUG 2009) and the National Climatic Data Center (NCDC 2009) operated by NOAA (NCDC), respectively. Figure 2.5-1 shows that the temperature data from the two weather stations is consistent.

The Weather Underground website uses temperature data from the Chadron weather station for prediction of weather in both Crawford and Chadron. 1999 was selected for comparison because 1999 was the most recent year for which actual Crawford temperature data was available. Since complete meteorological data from Crawford is not available and the temperature data from Chadron is consistent with Crawford, the Chadron data would be the best option for usage in air emission modeling and evaluation.

2.5.3 ~~2.5.3~~ Precipitation

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Precipitation in the region is generally light, with the heaviest occurrences in the spring and summer. Table 2.5-3 lists the monthly precipitation totals for the period of record. May has the heaviest precipitation, with good precipitation occurring through July. The driest months are November through February. The mean yearly precipitation is 40.79 cm (16.06 in). The maximum 24-hour precipitation events are also listed in Table 2.5-3.

The monthly mean and maximum snowfalls for the period of record are listed in Table 2.5-3. The mean annual snowfall is 107.44 cm (42.30 in). July and August are the only

two months without a reported snowfall. The maximum mean monthly snowfall occurred in March.

TABLE 2.5-2
TEMPERATURE OCCURRENCES FOR CHADRON, NEBRASKA
(FROM 1948 TO 2003)

Month	Mean Number of Days with Maximum Temperatures		Mean Number of Days with Minimum Temperatures	
	> 32.2°C	< 0°C	< 0°C	< -17.8°C
Jan	0.0	11.4	30.1	7.5
Feb	0.0	7.8	26.7	4.3
Mar	0.0	4.7	26.2	1.7
Apr	0.1	0.8	15.4	0.0
May	0.9	0.0	2.9	0.0
June	6.0	0.0	0.1	0.0
July	15.9	0.0	0.0	0.0
Aug	15.6	0.0	0.0	0.0
Sept	5.6	0.0	1.9	0.0
Oct	0.3	0.5	12.4	0.1
Nov	0.0	4.5	25.6	1.0
Dec	0.0	9.1	29.6	4.7
Year	44.3	38.7	170.8	19.3

Source: HPRCC

TABLE 2.5-3
MEAN AND MAXIMUM PRECIPITATION DATA FOR CHADRON, NEBRASKA (FROM 1948 TO 2003)

Month	Water Equivalent		Snow Fall	
	Mean	Maximum 24-Hour	Mean	Maximum Monthly
	(cm)	(cm)	(cm)	(cm)
Jan	1.12	2.72	16.51	88.14
Feb	1.17	3.81	16.51	59.69
Mar	2.16	3.51	21.84	88.14
Apr	4.47	6.22	13.21	49.28
May	7.52	6.50	1.52	23.62
June	7.14	5.38	0.00	3.05
July	5.41	5.08	0.00	0.00
Aug	3.48	4.62	0.00	0.00
Sept	3.66	11.18	0.76	25.40
Oct	2.36	3.81	5.59	28.45
Nov	1.24	1.78	13.21	42.93
Dec	1.04	1.80	17.78	46.99
Year	40.79	11.18	107.44	196.85

Source: HPRCC

Precipitation data from the National Oceanic and Atmospheric Administration (NOAA) was also reviewed. The site in Scottsbluff, Nebraska is 98 km (60.9 mi) south of the license area and the site in Rapid City, South Dakota is 158 km (98.2 mi) north of the license area. These data indicate that precipitation in excess of 0.03 cm (.01 in) can be expected on an average of 91 and 96 days per year, respectively. These data are listed in Table 2.5-4.

Tornadoes are rare. In the USNRC, "Draft Generic Environmental Impact Statement on Uranium Milling", (USNRC 1979) the authors calculated a mean annual frequency of 0.6 for tornadoes in intensity Category I at Rapid City. The annual probability of occurrence at this location is 4.8×10^{-4}. A tornado in intensity Category I has a rotational speed of 134 meters per second (m/s) and a translational speed of 26 m/s.

For comparison of rainfall in Chadron and Crawford, rainfall data collected at the two locations was compared for April of 1999 to August of 1999. The source for rainfall data for both locations was the NCDC. Figure 2.5-2 shows a bar graph of daily rainfall measured at the two locations. While the rainfall was not found to be exactly the same on a daily basis, the trend does show that rainfall events are typically logged in both locations. Table 2.5-5 shows monthly and seasonal rainfall totals of the data in Figure 2.5-2. The total rainfall for the spring and summer seasons are consistent.

~~2.5.3~~2.5.4 Humidity

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Relative percent humidity at the Scottsbluff and Rapid City weather stations is given in Table 2.5-6. The humidity at 0500, 1100, 1700, and 2300 hours is listed. Both locations have about the same humidity during the night; but in the early morning, Scottsbluff is slightly more humid. By noon and throughout the afternoon, Scottsbluff becomes less humid than Rapid City. These data indicate that humidity differences are slight and the humidity at the license area can be expected to be similar to these locations.

While Rapid City, South Dakota and Scottsbluff, Nebraska are greater than 50 miles from Crawford, Nebraska, the humidity is comparable and the best estimate for available data. To illustrate this point, 2006 humidity data for weather stations at Rapid City and Scottsbluff and also for Chadron, Nebraska (within 50 miles of Crawford) was obtained from the Weather Underground website (WUG 2009). Humidity data for Crawford was not available.

Figure 2.5-3 of this document shows the average daily humidity for 2006 for all three locations with available data. The solid trend lines on the graph show the moving 30 day average humidity for each of the three locations. Overall, the humidity in Chadron is slightly higher than in either Rapid City or Scottsbluff. The average humidity for 2006

TABLE 2.5-4
PRECIPITATION EVENTS (1982 - 1990)

Month	Mean Number of Days with Precipitation	
	Scottsbluff, NE	Rapid City SD
January	5.4	5.4
February	5.4	6.2
March	7.3	9.2
April	9.2	8.0
May	12.0	10.8
June	9.2	11.3
July	8.6	8.3
August	8.2	8.6
September	8.0	8.3
October	5.3	6.6
November	6.6	6.2
December	6.2	6.8
Year	91.4	95.7
Period of Record (years)	9	9

Source: NOAA 1993

Table 2.5-5. Rainfall for Spring and Summer at Towns of Crawford and Chadron 1999

1999	Total Rainfall (inches)	
	Crawford	Chadron
April	5.07	3.97
May	1.86	3.5
June	4.31	4.24
July	2.7	1.56
August	0.99	1.42
Total (April to August)	**14.93**	**14.69**

TABLE 2.5-6
PERCENT RELATIVE HUMIDITY DATA (FROM 1982 - 1990)

Month	0500 Hours		1100 Hours		1700 Hours		2300 Hours	
	NE[a]	SD[b]	NE	SD	NE	SD	NE	SD
January	72.0	67.7	54.3	55.7	53.4	61.0	68.3	67.0
February	75.0	71.0	52.6	54.8	47.6	56.1	70.0	70.0
March	76.0	76.2	50.9	56.3	44.1	54.9	68.4	73.7
April	75.3	70.6	42.9	44.9	39.1	43.2	65.0	65.1
May	80.3	75.4	44.4	49.2	41.2	47.5	68.8	70.8
June	80.0	77.0	43.0	49.8	38.4	46.1	66.8	71.3
July	81.1	72.3	40.7	41.3	35.1	37.8	65.4	62.8
August	82.6	73.4	42.6	41.3	37.2	36.8	69.2	64.7
September	79.5	71.9	42.7	44.1	37.8	42.0	68.0	65.8
October	76.6	69.7	43.4	45.2	40.9	48.2	67.6	66.4
November	76.2	72.3	51.2	54.3	53.9	60.5	71.3	70.9
December	76.1	69.1	57.4	56.6	59.6	63.3	73.4	68.1
Year	77.6	72.2	47.2	49.5	44.0	49.8	68.5	68.1
Period of Record (years)	9	9	9	9	9	9	9	9

Source: NOAA 1993
a Scottsbluff, NE
b Rapid City, SD

for Chadron, Scottsbluff, and Rapid City were 61.6 %, 57.5 %, and 56.8 %, respectively. While Chadron may be slightly closer in distance to the project location in Crawford, the elevation of Crawford (3,679 ft.) is more consistent with the average elevation of Scottsbluff and Rapid City (average elevation of 3,565 ft.) in comparison to Chadron (3,369 ft.). The higher elevation of Crawford may make the humidity slightly lower than Chadron and consistent with the data provided in the original report.

While the differences in humidity are slight for the three weather stations discussed above, the use of slightly lower humidity data would be more conservative from an air emissions modeling standpoint. A lower humidity would predict impacts at a greater distance from the emission source. It is noted that humidity data are not expected to be required as an input parameter into modeling at North Trend (i.e., MILDOS and RESRAD). However, if modeling is needed that requires humidity input, an average of values for Scottsbluff and Rapid City (lower than Chadron) would be used, resulting in a more conservative number for air modeling.

Data from Scottsbluff, Nebraska and Rapid City, South Dakota were used because those cities have near-by weather stations that monitor many meteorological parameters hourly

and provide complete, hourly data to the public. Crawford, Nebraska does not have a local weather station to provide that type of complete data.

~~2.5.4~~2.5.5 Winds

Figure 2.5-4 and Figure 2.5-5 are the wind roses for Scottsbluff, Nebraska and Rapid City, South Dakota, respectively. These figures show predominant wind patterns that are similar; however, the finer details are greatly influenced by the local topography. Rapid City has a predominant wind from the north-northwest while Scottsbluff has a slightly bimodal distribution with the predominant winds from the west-northwest and the east-southeast. The least prevalent wind direction at Scottsbluff and Rapid City is from the southwest.

As shown by the wind rose for the license area in Figure 2.5-6, the predominant air pollutant dispersion would be towards the north to northeast. The next most common directions would be towards the southwest to south-southwest.

Local terrain will have a significant influence on the wind patterns in a given area. Because of this, a meteorological station was installed on the current Crow Butte project site (Figure 2.5-7). This station was capable of measuring wind speed, direction, and the standard deviation of the wind direction. Joint frequency data was compiled from this information. Figure 2.5-6 exhibits the wind rose that was identified for the site and Table 2.5-7 through Table 2.5-13 shows the frequency of winds by direction and speed for the six stability classes. Table 2.5-14 shows the annual relative joint frequency distribution. As shown on Figure 2.5-6, the predominant wind direction of the site is from a south-southwest direction approximately 45 percent of the time.

The nearest national weather station to NTEA that reports mixing height values is located at North Platte, Nebraska. This station is located approximately 170 miles southeast of the City of Crawford. Due to the distance, the data are not considered representative of the NTEA. Mixing height data were not available for the CBR meteorological station, since the type of data needed was not collected (i.e., upper air wind measurements). Since the NRC MILDOS modeling requires mixing height data as input into the model, CBR utilized a mixing height default value. The NRC MILDOS modeling program, a computer program for calculating radiation doses from uranium recovery operations, allows for the use of a default value of 100 meters (NRC NUREG/CR-2011). This default value was used for the NTEA MILDOS modeling.

A description of how the stability classes were calculated could not be found in CBR's archived records. However, based on the type of meteorological data collected onsite, it may be assumed the stability classes were calculated using the Sigma Theta Method. This method was the most common method historically used to calculate stability class, because all you needed were wind speed and wind direction. This is the method that was used in a number of standard air modeling programs (e.g., Industrial Source Complex

(ISC) model and Screen3 model). It is very likely that the CBR stability class data generated historically was calculated this way since there was not a lot of other data available beyond wind speed and wind direction. This method using the standard deviation of horizontal wind speed and direction is an atmospheric classification system recommended by the NRC. Limits of sigma theta are given in NRC Reg. Guide 1.23.

As discussed later in this section, CBR will install and operate a new meteorological tower at the outset of operations at NTEA that will allow for the collection of one-year of onsite data that can be used to calculate onsite stability classes. These new data can then be compared to the historic CPF data.

Wind patterns at a specific site do not change significantly from year to year, but will change significantly for different locations. Unlike some other meteorological parameters, wind patterns are notably influenced by local topography. This is the case for the Crawford area.

The wind rose diagram in Figure 2.5-4 shows the wind direction for Scottsbluff, Nebraska for 1984 to 1990. A comparison of this wind rose to the monthly wind roses located on the Natural Resources Conservation Service (NRCS) website (NRCS 2009) for 1961 to 2003 for Scottsbluff, Nebraska shows consistent wind direction trends. The same comparison and conclusion was made for Figure 2.5-5 (wind rose for Rapid City, South Dakota, 1984 to 1990) and the wind roses on the NRCS website (NRCS 2009) for 1961 to 2003 for Rapid City, South Dakota. This shows that over time the wind patterns for a specific location remain consistent. However, a comparison of -Figure 2.5-4 and 2.5-5 to Figure 2.5-6 (NTEA) show that Scottsbluff and Rapid City have different predominant wind patterns than the project site. Because of the differences among the

TABLE 2.5-7 FREQUENCY OF WINDS BY DIRECTION AND SPEED (STABILITY A)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	0.98	8.63	2.62	0.11	0.00	0.00	12.34	4.90
NNE	2.61	8.74	2.95	0.11	0.00	0.00	14.31	4.60
NE	1.64	8.52	1.31	0.00	0.00	0.00	11.47	4.50
ENE	0.66	4.37	0.55	0.00	0.00	0.00	5.58	4.40
E	1.20	1.97	0.77	0.00	0.00	0.00	3.94	4.40
ESE	0.33	0.87	0.22	0.00	0.00	0.00	1.42	4.00
SE	0.98	1.75	1.64	0.00	0.00	0.00	4.37	5.10
SSE	0.44	2.61	1.64	0.11	0.00	0.00	4.70	5.30
S	0.98	3.72	1.53	0.00	0.00	0.00	6.23	5.00
SSW	0.55	1.97	2.08	0.22	0.00	0.00	4.82	6.00
SW	0.77	3.72	1.53	0.00	0.00	0.00	6.02	5.00
WSW	0.66	2.08	1.53	0.00	0.00	0.00	4.27	5.30
W	0.66	1.75	1.75	0.11	0.00	0.00	4.27	5.50
WNW	0.77	1.42	0.98	0.44	0.00	0.00	3.61	5.70
NW	0.66	2.30	1.53	0.11	0.00	0.00	4.60	5.50
NNW	1.53	3.93	1.86	0.44	0.00	0.00	7.76	5.30
ALL	15.32	58.25	24.49	1.65	0.00	0.00	99.71	5.00

Stability Class A
Data Recorded between May 1982 and April 1984
Crow Butte Uranium Project Site, Nebraska
Calm (less than one knot) = 0.3%
Period mean wind speed = 5.0 knots
Percent occurrence for A stability class = 5.6%

TABLE 2.5-8
FREQUENCY OF WINDS BY DIRECTION AND SPEED
(STABILITY B)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	1.01	2.68	5.53	0.67	0.00	0.00	9.89	6.40
NNE	1.34	3.52	3.77	0.34	0.00	0.00	8.97	5.70
NE	0.92	5.28	5.45	0.50	0.00	0.00	12.15	6.00
ENE	0.84	1.76	2.85	0.25	0.00	0.00	5.70	6.00
E	0.17	0.84	0.75	0.08	0.00	0.00	1.84	6.00
ESE	0.59	0.59	1.09	0.00	0.00	0.00	2.27	5.80
SE	0.08	1.26	2.26	0.25	0.00	0.00	3.85	6.90
SSE	0.67	1.17	2.43	0.50	0.00	0.00	4.77	6.50
S	1.09	1.01	4.02	0.92	0.00	0.00	7.04	7.00
SSW	1.01	2.01	2.26	0.75	0.00	0.00	6.03	6.30
SW	0.92	3.19	2.61	0.59	0.00	0.00	7.21	6.10
WSW	0.59	2.01	2.60	0.84	0.08	0.00	6.12	6.90
W	0.42	1.34	2.35	0.42	0.08	0.00	4.61	7.20
WNW	0.67	1.09	2.10	0.34	0.00	0.00	4.20	6.60
NW	0.25	1.09	4.02	1.09	0.08	0.00	6.53	7.80
NNW	0.42	1.51	4.95	1.68	0.08	0.00	8.64	7.80
ALL	10.99	30.35	48.94	9.22	0.32	0.00	99.82	6.60

Stability Class B
Data Recorded between May 1982 and April 1984
Crow Butte Uranium Project Site, Nebraska
Calm (less than one knot) = 0.2%
Period mean wind speed = 6.5 knots
Percent occurrence for B stability class = 7.4%

TABLE 2.5-9
FREQUENCY OF WINDS BY DIRECTION AND SPEED\
(STABILITY C)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	0.74	1.54	2.68	0.74	0.00	0.00	5.70	6.70
NNE	0.63	2.62	2.90	0.85	0.00	0.00	7.00	6.60
NE	0.91	2.28	5.69	1.20	0.00	0.00	10.08	7.00
ENE	0.46	1.03	2.96	0.97	0.00	0.00	5.42	7.30
E	0.00	0.57	0.74	0.28	0.00	0.00	1.59	7.60
ESE	0.23	0.34	0.91	0.23	0.00	0.00	1.71	7.00
SE	0.17	0.68	1.82	0.74	0.00	0.00	3.41	7.70
SSE	0.46	0.74	2.22	1.48	0.00	0.00	4.90	8.00
S	0.97	1.65	5.30	2.28	0.00	0.00	10.20	7.70
SSW	1.14	3.02	3.93	0.97	0.00	0.00	9.06	6.60
SW	1.03	3.36	4.67	1.14	0.11	0.00	10.31	6.80
WSW	0.97	3.02	3.59	1.14	0.06	0.06	8.84	6.80
W	0.11	0.91	1.99	1.03	0.11	0.00	4.15	8.40
WNW	0.17	0.51	1.03	1.25	0.06	0.00	3.02	9.10
NW	0.40	0.74	3.70	2.22	0.06	0.00	7.12	8.70
NNW	0.40	1.42	3.42	2.11	0.00	0.00	7.35	8.20
ALL	8.79	24.43	47.55	18.63	0.40	0.06	99.86	7.40

Stability Class C
Data Recorded between May 1982 and April 1984
Crow Butte Uranium Project Site, Nebraska
Calm (less than one knot) = 0.2%
Period mean wind speed = 7.4 knots
Percent occurrence for C stability class = 10.8%

TABLE 2.5-10
FREQUENCY OF WINDS BY DIRECTION AND SPEED
(STABILITY D)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	0.17	0.52	1.14	0.83	0.20	0.02	2.88	9.20
NNE	0.16	1.12	2.34	2.90	0.89	0.19	7.60	10.70
NE	0.13	1.53	2.65	2.72	0.46	0.08	7.47	9.80
ENE	0.04	0.47	0.79	0.50	0.06	0.00	1.86	8.30
E	0.02	0.06	0.28	0.22	0.04	0.00	0.62	9.50
ESE	0.01	0.25	0.35	0.13	0.00	0.00	0.74	7.40
SE	0.06	0.42	0.71	0.52	0.18	0.01	1.90	9.50
SSE	0.13	1.78	1.50	2.60	1.21	0.34	7.56	11.10
S	0.34	1.67	3.58	7.77	3.57	0.58	17.51	12.40
SSW	0.22	1.37	3.82	3.60	0.76	0.12	9.89	10.00
SW	0.17	2.11	5.80	3.80	0.29	0.02	12.19	8.80
WSW	0.17	0.61	2.28	2.74	0.54	0.16	6.50	10.70
W	0.10	0.20	0.64	1.03	0.47	0.19	2.63	12.60
WNW	0.05	0.17	0.91	1.39	0.66	0.28	3.46	13.20
NW	0.05	0.31	1.60	5.13	2.68	1.55	11.32	15.00
NNW	0.04	0.49	1.80	2.34	0.90	0.20	5.77	11.90
ALL	1.86	13.08	30.09	38.22	12.91	3.74	99.90	11.20

Stability Class D
Data Recorded between May 1982 and April 1984
Crow Butte Uranium Project Site, Nebraska
Calm (less than one knot) = 0.1%
Period mean wind speed = 11.2 knots
Percent occurrence for D stability class = 51.3%

TABLE 2.5-11
FREQUENCY OF WINDS BY DIRECTION AND SPEED
(STABILITY E)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	0.85	2.92	0.65	0.04	0.00	0.00	4.46	4.60
NNE	0.97	2.80	1.82	0.00	0.00	0.00	5.59	5.20
NE	0.97	3.32	1.90	0.08	0.00	0.00	6.27	5.10
ENE	0.45	1.26	0.73	0.00	0.00	0.00	2.44	5.10
E	0.16	0.73	0.20	0.00	0.00	0.00	1.09	4.70
ESE	0.28	0.65	0.45	0.00	0.00	0.00	1.38	4.80
SE	0.49	1.82	0.85	0.12	0.00	0.00	3.28	5.10
SSE	1.70	7.62	1.05	0.08	0.00	0.00	10.45	4.40
S	2.23	11.06	4.34	0.16	0.00	0.00	17.79	5.00
SSW	2.11	10.53	2.80	0.04	0.00	0.00	15.48	4.70
SW	1.78	8.18	5.67	0.12	0.04	0.00	15.79	5.50
WSW	1.05	2.88	2.47	0.04	0.00	0.00	6.44	5.40
W	0.65	0.97	0.36	0.04	0.00	0.00	2.02	4.30
WNW	0.36	0.97	0.81	0.00	0.00	0.00	2.14	5.50
NW	0.45	1.18	0.85	0.20	0.00	0.00	2.68	5.70
NNW	0.61	1.34	0.49	0.00	0.00	0.00	2.44	4.50
ALL	15.11	58.23	25.44	0.92	0.04	0.00	99.74	5.00

Stability Class E
Data Recorded between May 1982 and April 1984
Crow Butte Uranium Project Site, Nebraska
Calm (less than one knot) = 0.2%
Period mean wind speed = 5.0 knots
Percent occurrence for E stability class = 15.2%

TABLE 2.5-12
FREQUENCY OF WINDS BY DIRECTION AND SPEED
(STABILITY F)

Wind Direction	Speed Class Intervals (Knots)							
	1 - 3	3 - 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	3.30	1.65	0.00	0.00	0.00	0.00	4.95	2.80
NNE	1.65	1.33	0.00	0.00	0.00	0.00	2.98	3.00
NE	0.95	1.40	0.00	0.00	0.00	0.00	2.35	3.10
ENE	1.40	0.76	0.00	0.00	0.00	0.00	2.16	2.80
E	1.27	0.44	0.00	0.00	0.00	0.00	1.71	2.80
ESE	1.78	1.02	0.00	0.00	0.00	0.00	2.80	2.60
SE	1.72	1.78	0.00	0.00	0.00	0.00	3.50	3.00
SSE	3.75	4.76	0.00	0.00	0.00	0.00	8.51	3.10
S	7.50	12.07	0.00	0.00	0.00	0.00	19.57	3.30
SSW	7.24	13.15	0.00	0.00	0.00	0.00	20.39	3.30
SW	6.48	8.01	0.00	0.00	0.00	0.00	14.49	3.20
WSW	2.73	2.60	0.00	0.00	0.00	0.00	5.33	3.00
W	1.78	1.46	0.00	0.00	0.00	0.00	3.24	2.90
WNW	0.83	0.95	0.00	0.00	0.00	0.00	1.78	3.00
NW	1.33	1.21	0.00	0.00	0.00	0.00	2.64	3.00
NNW	1.33	0.51	0.00	0.00	0.00	0.00	1.84	2.60
ALL	45.04	53.10	0.00	0.00	0.00	0.00	98.14	3.10

Stability Class F
Data Recorded between May 1982 and April 1984
Crow Butte Uranium Project Site, Nebraska
Calm (less than one knot) = 1.8%
Period mean wind speed = 3.1 knots
Percent occurrence for F stability class = 9.7%

TABLE 2.5-13
FREQUENCY OF WINDS BY DIRECTION AND SPEED
(ALL STABILITIES)

Wind Direction	Speed Class Intervals (Knots)							
	1 – 3	3 – 6	6 - 10	10 – 16	16 - 21	>21	All	Mean Speed
N	0.75	1.72	1.53	0.57	0.10	0.01	4.68	6.50
NNE	0.70	2.16	2.24	1.61	0.46	0.10	7.27	8.20
NE	0.57	2.64	2.69	1.57	0.23	0.04	7.64	7.70
ENE	0.37	0.99	1.08	0.38	0.03	0.00	2.85	6.50
E	0.24	0.42	0.35	0.15	0.02	0.00	1.18	6.20
ESE	0.31	0.46	0.44	0.09	0.00	0.00	1.30	5.50
SE	0.35	0.93	0.95	0.38	0.09	0.01	2.71	7.00
SSE	0.81	2.84	1.44	1.55	0.62	0.17	7.43	8.20
S	1.48	4.17	3.45	4.33	1.83	0.30	15.56	9.30
SSW	1.36	4.17	3.09	2.03	0.39	0.06	11.10	7.20
SW	1.21	3.91	4.62	2.13	0.17	0.01	12.05	7.10
WSW	0.70	1.60	2.21	1.60	0.29	0.09	6.49	8.20
W	0.40	0.69	0.87	0.68	0.26	0.10	3.00	8.90
WNW	0.27	0.54	0.91	0.90	0.35	0.14	3.11	10.20
NW	0.32	0.75	1.73	2.99	1.39	0.79	7.97	12.80
NNW	0.40	0.99	1.84	1.58	0.47	0.10	5.38	9.50
ALL	10.24	28.88	29.44	22.64	6.70	1.92	99.72	8.40

Stability Class All
Data Recorded between May 1982 and April 1984
Crow Butte Uranium Project Site, Nebraska
Calm (less than one knot) = 0.3%
Period mean wind speed = 8.4 knots
Percent occurrence for A stability class = 100.0%

~~**Table 2.5-14 Joint Frequency Distribution**~~

		~~**Stability Class A**~~			
~~0.00056~~	~~0.00488~~	~~0.00148~~	~~0.00006~~	~~0.00000~~	~~0.00000~~
~~0.00142~~	~~0.00495~~	~~0.00167~~	~~0.00006~~	~~0.00000~~	~~0.00000~~
~~0.00093~~	~~0.00482~~	~~0.00074~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00037~~	~~0.00247~~	~~0.00031~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00068~~	~~0.00111~~	~~0.00043~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00019~~	~~0.00049~~	~~0.00012~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00056~~	~~0.00099~~	~~0.00093~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00025~~	~~0.00142~~	~~0.00093~~	~~0.00006~~	~~0.00000~~	~~0.00000~~
~~0.00056~~	~~0.00210~~	~~0.00087~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00031~~	~~0.00111~~	~~0.00117~~	~~0.00012~~	~~0.00000~~	~~0.00000~~
~~0.00043~~	~~0.00210~~	~~0.00087~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00037~~	~~0.00117~~	~~0.00087~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00037~~	~~0.00099~~	~~0.00099~~	~~0.00006~~	~~0.00000~~	~~0.00000~~
~~0.00043~~	~~0.00080~~	~~0.00056~~	~~0.00025~~	~~0.00000~~	~~0.00000~~
~~0.00037~~	~~0.00130~~	~~0.00087~~	~~0.00006~~	~~0.00000~~	~~0.00000~~
~~0.00087~~	~~0.00223~~	~~0.00105~~	~~0.00025~~	~~0.00000~~	~~0.00000~~
		~~**Stability Class B**~~			
~~0.00074~~	~~0.00198~~	~~0.00408~~	~~0.00049~~	~~0.00000~~	~~0.00000~~
~~0.00099~~	~~0.00260~~	~~0.00278~~	~~0.00025~~	~~0.00000~~	~~0.00000~~
~~0.00068~~	~~0.00389~~	~~0.00402~~	~~0.00037~~	~~0.00000~~	~~0.00000~~
~~0.00062~~	~~0.00130~~	~~0.00210~~	~~0.00019~~	~~0.00000~~	~~0.00000~~
~~0.00012~~	~~0.00062~~	~~0.00056~~	~~0.00006~~	~~0.00000~~	~~0.00000~~
~~0.00043~~	~~0.00043~~	~~0.00080~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00006~~	~~0.00093~~	~~0.00167~~	~~0.00019~~	~~0.00000~~	~~0.00000~~
~~0.00049~~	~~0.00087~~	~~0.00179~~	~~0.00037~~	~~0.00000~~	~~0.00000~~
~~0.00080~~	~~0.00074~~	~~0.00297~~	~~0.00068~~	~~0.00000~~	~~0.00000~~
~~0.00074~~	~~0.00148~~	~~0.00167~~	~~0.00056~~	~~0.00000~~	~~0.00000~~
~~0.00068~~	~~0.00235~~	~~0.00185~~	~~0.00043~~	~~0.00000~~	~~0.00000~~

~~Table 2.5-14 Joint Frequency Distribution~~

~~0.00043~~	~~0.00148~~	~~0.00192~~	~~0.00062~~	~~0.00006~~	~~0.00000~~
~~0.00031~~	~~0.00099~~	~~0.00173~~	~~0.00031~~	~~0.00006~~	~~0.00000~~
~~0.00049~~	~~0.00080~~	~~0.00155~~	~~0.00025~~	~~0.00000~~	~~0.00000~~
~~0.00019~~	~~0.00080~~	~~0.00297~~	~~0.00080~~	~~0.00006~~	~~0.00000~~
~~0.00031~~	~~0.00111~~	~~0.00365~~	~~0.00124~~	~~0.00006~~	~~0.00000~~
~~Stability Class C~~					
~~0.00080~~	~~0.00167~~	~~0.00291~~	~~0.00080~~	~~0.00080~~	~~0.00000~~
~~0.00068~~	~~0.00284~~	~~0.00315~~	~~0.00093~~	~~0.00093~~	~~0.00000~~
~~0.00099~~	~~0.00247~~	~~0.00618~~	~~0.00130~~	~~0.00130~~	~~0.00000~~
~~0.00049~~	~~0.00111~~	~~0.00321~~	~~0.00105~~	~~0.00105~~	~~0.00000~~
~~0.00000~~	~~0.00062~~	~~0.00080~~	~~0.00031~~	~~0.00031~~	~~0.00000~~
~~0.00025~~	~~0.00037~~	~~0.00099~~	~~0.00025~~	~~0.00025~~	~~0.00000~~
~~0.00019~~	~~0.00074~~	~~0.00198~~	~~0.00080~~	~~0.00080~~	~~0.00000~~
~~0.00049~~	~~0.00080~~	~~0.00241~~	~~0.00161~~	~~0.00161~~	~~0.00000~~
~~0.00105~~	~~0.00179~~	~~0.00575~~	~~0.00080~~	~~0.00000~~	~~0.00000~~
~~0.00124~~	~~0.00328~~	~~0.00427~~	~~0.00093~~	~~0.00000~~	~~0.00000~~
~~0.00111~~	~~0.00365~~	~~0.00507~~	~~0.00130~~	~~0.00012~~	~~0.00000~~
~~0.00105~~	~~0.00328~~	~~0.00389~~	~~0.00105~~	~~0.00006~~	~~0.00006~~
~~0.00012~~	~~0.00099~~	~~0.00216~~	~~0.00031~~	~~0.00012~~	~~0.00000~~
~~0.00019~~	~~0.00056~~	~~0.00111~~	~~0.00025~~	~~0.00006~~	~~0.00000~~
~~0.00043~~	~~0.00080~~	~~0.00402~~	~~0.00080~~	~~0.00006~~	~~0.00000~~
~~0.00043~~	~~0.00155~~	~~0.00371~~	~~0.00161~~	~~0.00000~~	~~0.00000~~
~~Stability Class D~~					
~~0.00087~~	~~0.00266~~	~~0.00587~~	~~0.00427~~	~~0.00105~~	~~0.00012~~
~~0.0008~~	~~0.00575~~	~~0.01205~~	~~0.0149~~	~~0.00457~~	~~0.00099~~
~~0.00068~~	~~0.00785~~	~~0.01311~~	~~0.01397~~	~~0.00235~~	~~0.00043~~
~~0.00019~~	~~0.00241~~	~~0.00408~~	~~0.0026~~	~~0.00031~~	~~0.00000~~
~~0.00012~~	~~0.00031~~	~~0.00142~~	~~0.00111~~	~~0.00019~~	~~0.00000~~
~~0.00006~~	~~0.0013~~	~~0.00179~~	~~0.00068~~	~~0.00000~~	~~0.00000~~

~~**Table 2.5-14 Joint Frequency Distribution**~~

~~0.00031~~	~~0.00216~~	~~0.00365~~	~~0.00266~~	~~0.00093~~	~~0.00006~~
~~0.00068~~	~~0.00915~~	~~0.00773~~	~~0.01335~~	~~0.00624~~	~~0.00173~~
~~0.00173~~	~~0.00859~~	~~0.01842~~	~~0.04~~	~~0.01836~~	~~0.00297~~
~~0.00111~~	~~0.00705~~	~~0.01966~~	~~0.01854~~	~~0.00389~~	~~0.00062~~
~~0.00087~~	~~0.01088~~	~~0.02986~~	~~0.01953~~	~~0.00148~~	~~0.00012~~
~~0.00087~~	~~0.00315~~	~~0.01175~~	~~0.01409~~	~~0.00278~~	~~0.0008~~
~~0.00049~~	~~0.00105~~	~~0.00328~~	~~0.00532~~	~~0.00241~~	~~0.00099~~
~~0.00025~~	~~0.00087~~	~~0.0047~~	~~0.00717~~	~~0.0034~~	~~0.00142~~
~~0.00025~~	~~0.00161~~	~~0.00822~~	~~0.0264~~	~~0.01379~~	~~0.00797~~
~~0.00019~~	~~0.00253~~	~~0.00927~~	~~0.01205~~	~~0.00464~~	~~0.00105~~
		~~Stability Class E~~			
~~0.00130~~	~~0.00445~~	~~0.00099~~	~~0.00006~~	~~0.00000~~	~~0.00000~~
~~0.00148~~	~~0.00427~~	~~0.00278~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00148~~	~~0.00507~~	~~0.00291~~	~~0.00012~~	~~0.00000~~	~~0.00000~~
~~0.00068~~	~~0.00192~~	~~0.00111~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00025~~	~~0.00111~~	~~0.00031~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00043~~	~~0.00099~~	~~0.00068~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00074~~	~~0.00278~~	~~0.00130~~	~~0.00019~~	~~0.00000~~	~~0.00000~~
~~0.00260~~	~~0.01162~~	~~0.00161~~	~~0.00012~~	~~0.00000~~	~~0.00000~~
~~0.00340~~	~~0.01688~~	~~0.00661~~	~~0.00025~~	~~0.00000~~	~~0.00000~~
~~0.00321~~	~~0.01607~~	~~0.00427~~	~~0.00006~~	~~0.00000~~	~~0.00000~~
~~0.00272~~	~~0.01249~~	~~0.00865~~	~~0.00019~~	~~0.00006~~	~~0.00000~~
~~0.00161~~	~~0.00439~~	~~0.00377~~	~~0.00006~~	~~0.00000~~	~~0.00000~~
~~0.00099~~	~~0.00148~~	~~0.00056~~	~~0.00006~~	~~0.00000~~	~~0.00000~~
~~0.00056~~	~~0.00148~~	~~0.00124~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00068~~	~~0.00179~~	~~0.00130~~	~~0.00031~~	~~0.00000~~	~~0.00000~~
~~0.00093~~	~~0.00204~~	~~0.00074~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
		~~Stability Class F~~			
~~0.00321~~	~~0.00161~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~

~~**Table 2.5-14 Joint Frequency Distribution**~~

~~0.00161~~	~~0.00130~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00093~~	~~0.00136~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00136~~	~~0.00074~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00124~~	~~0.00043~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00173~~	~~0.00099~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00167~~	~~0.00173~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00365~~	~~0.00464~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00729~~	~~0.01175~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00705~~	~~0.01280~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00631~~	~~0.00779~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00266~~	~~0.00253~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00173~~	~~0.00142~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00080~~	~~0.00093~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00130~~	~~0.00117~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~
~~0.00130~~	~~0.00049~~	~~0.00000~~	~~0.00000~~	~~0.00000~~	~~0.00000~~

TABLE 2.5-14 CBR ONSITE MET STATION JOINT FREQUENCY DISTRIBUTION

Stability Class A					
0.00056	0.00488	0.00148	0.00006	0.00000	0.00000
0.00142	0.00495	0.00167	0.00006	0.00000	0.00000
0.00093	0.00482	0.00074	0.00000	0.00000	0.00000
0.00037	0.00247	0.00031	0.00000	0.00000	0.00000
0.00068	0.00111	0.00043	0.00000	0.00000	0.00000
0.00019	0.00049	0.00012	0.00000	0.00000	0.00000
0.00056	0.00099	0.00093	0.00000	0.00000	0.00000
0.00025	0.00142	0.00093	0.00006	0.00000	0.00000
0.00056	0.00210	0.00087	0.00000	0.00000	0.00000
0.00031	0.00111	0.00117	0.00012	0.00000	0.00000
0.00043	0.00210	0.00087	0.00000	0.00000	0.00000
0.00037	0.00117	0.00087	0.00000	0.00000	0.00000
0.00037	0.00099	0.00099	0.00006	0.00000	0.00000
0.00043	0.00080	0.00056	0.00025	0.00000	0.00000
0.00037	0.00130	0.00087	0.00006	0.00000	0.00000
0.00087	0.00223	0.00105	0.00025	0.00000	0.00000
Stability Class B					
0.00074	0.00198	0.00408	0.00049	0.00000	0.00000

TABLE 2.5-14 CBR ONSITE MET STATION JOINT FREQUENCY DISTRIBUTION

0.00099	0.00260	0.00278	0.00025	0.00000	0.00000
0.00068	0.00389	0.00402	0.00037	0.00000	0.00000
0.00062	0.00130	0.00210	0.00019	0.00000	0.00000
0.00012	0.00062	0.00056	0.00006	0.00000	0.00000
0.00043	0.00043	0.00080	0.00000	0.00000	0.00000
0.00006	0.00093	0.00167	0.00019	0.00000	0.00000
0.00049	0.00087	0.00179	0.00037	0.00000	0.00000
0.00080	0.00074	0.00297	0.00068	0.00000	0.00000
0.00074	0.00148	0.00167	0.00056	0.00000	0.00000
0.00068	0.00235	0.00185	0.00043	0.00000	0.00000
0.00043	0.00148	0.00192	0.00062	0.00006	0.00000
0.00031	0.00099	0.00173	0.00031	0.00006	0.00000
0.00049	0.00080	0.00155	0.00025	0.00000	0.00000
0.00019	0.00080	0.00297	0.00080	0.00006	0.00000
0.00031	0.00111	0.00365	0.00124	0.00006	0.00000

TABLE 2.5-14 CBR ONSITE MET STATION JOINT FREQUENCY DISTRIBUTION

Stability Class C					
0.00080	0.00167	0.00291	0.00080	0.00080	0.00000
0.00068	0.00284	0.00315	0.00093	0.00093	0.00000
0.00099	0.00247	0.00618	0.00130	0.00130	0.00000
0.00049	0.00111	0.00321	0.00105	0.00105	0.00000
0.00000	0.00062	0.00080	0.00031	0.00031	0.00000
0.00025	0.00037	0.00099	0.00025	0.00025	0.00000
0.00019	0.00074	0.00198	0.00080	0.00080	0.00000
0.00049	0.00080	0.00241	0.00161	0.00161	0.00000
0.00105	0.00179	0.00575	0.00080	0.00000	0.00000
0.00124	0.00328	0.00427	0.00093	0.00000	0.00000
0.00111	0.00365	0.00507	0.00130	0.00012	0.00000
0.00105	0.00328	0.00389	0.00105	0.00006	0.00006
0.00012	0.00099	0.00216	0.00031	0.00012	0.00000
0.00019	0.00056	0.00111	0.00025	0.00006	0.00000
0.00043	0.00080	0.00402	0.00080	0.00006	0.00000
0.00043	0.00155	0.00371	0.00161	0.00000	0.00000
Stability Class D					
0.00087	0.00266	0.00587	0.00427	0.00105	0.00012
0.0008	0.00575	0.01205	0.0149	0.00457	0.00099
0.00068	0.00785	0.01311	0.01397	0.00235	0.00043
0.00019	0.00241	0.00408	0.0026	0.00031	0.00000
0.00012	0.00031	0.00142	0.00111	0.00019	0.00000
0.00006	0.0013	0.00179	0.00068	0.00000	0.00000
0.00031	0.00216	0.00365	0.00266	0.00093	0.00006
0.00068	0.00915	0.00773	0.01335	0.00624	0.00173
0.00173	0.00859	0.01842	0.04	0.01836	0.00297
0.00111	0.00705	0.01966	0.01854	0.00389	0.00062
0.00087	0.01088	0.02986	0.01953	0.00148	0.00012
0.00087	0.00315	0.01175	0.01409	0.00278	0.0008
0.00049	0.00105	0.00328	0.00532	0.00241	0.00099
0.00025	0.00087	0.0047	0.00717	0.0034	0.00142
0.00025	0.00161	0.00822	0.0264	0.01379	0.00797
0.00019	0.00253	0.00927	0.01205	0.00464	0.00105

TABLE 2.5-14 CBR ONSITE MET STATION JOINT FREQUENCY DISTRIBUTION

Stability Class E					
0.00130	0.00445	0.00099	0.00006	0.00000	0.00000
0.00148	0.00427	0.00278	0.00000	0.00000	0.00000
0.00148	0.00507	0.00291	0.00012	0.00000	0.00000
0.00068	0.00192	0.00111	0.00000	0.00000	0.00000
0.00025	0.00111	0.00031	0.00000	0.00000	0.00000
0.00043	0.00099	0.00068	0.00000	0.00000	0.00000
0.00074	0.00278	0.00130	0.00019	0.00000	0.00000
0.00260	0.01162	0.00161	0.00012	0.00000	0.00000
0.00340	0.01688	0.00661	0.00025	0.00000	0.00000
0.00321	0.01607	0.00427	0.00006	0.00000	0.00000
0.00272	0.01249	0.00865	0.00019	0.00006	0.00000
0.00161	0.00439	0.00377	0.00006	0.00000	0.00000
0.00099	0.00148	0.00056	0.00006	0.00000	0.00000
0.00056	0.00148	0.00124	0.00000	0.00000	0.00000
0.00068	0.00179	0.00130	0.00031	0.00000	0.00000
0.00093	0.00204	0.00074	0.00000	0.00000	0.00000
Stability Class F					
0.00321	0.00161	0.00000	0.00000	0.00000	0.00000
0.00161	0.00130	0.00000	0.00000	0.00000	0.00000
0.00093	0.00136	0.00000	0.00000	0.00000	0.00000
0.00136	0.00074	0.00000	0.00000	0.00000	0.00000
0.00124	0.00043	0.00000	0.00000	0.00000	0.00000
0.00173	0.00099	0.00000	0.00000	0.00000	0.00000
0.00167	0.00173	0.00000	0.00000	0.00000	0.00000
0.00365	0.00464	0.00000	0.00000	0.00000	0.00000
0.00729	0.01175	0.00000	0.00000	0.00000	0.00000
0.00705	0.01280	0.00000	0.00000	0.00000	0.00000
0.00631	0.00779	0.00000	0.00000	0.00000	0.00000
0.00266	0.00253	0.00000	0.00000	0.00000	0.00000
0.00173	0.00142	0.00000	0.00000	0.00000	0.00000
0.00080	0.00093	0.00000	0.00000	0.00000	0.00000
0.00130	0.00117	0.00000	0.00000	0.00000	0.00000
0.00130	0.00049	0.00000	0.00000	0.00000	0.00000

Note: Joint frequency distribution in this table is a set of data that represents a summary of meteorological conditions at the meteorological station location for a two-year period (May 1982 – April1984). Joint frequency distribution is computed by compiling meteorological data, determined and recorded for each hour, over a designated time interval and computing the frequency of occurrence of each joint frequency category. Each joint frequency category represents a band of wind speeds, directions and stability conditions.

sites discussed above, Rapid City, and Scottsbluff, the two-year Crow Butte site wind record is considered the most representative.

CBR recognizes the importance of capturing local wind patterns since this data is used to determine the predominant air pollutant dispersion direction. The 1982 to 1984 meteorological data from the Crow Butte Project station was used to show the trends in wind patterns for the project site. This older data is the only data available from the onsite monitoring station. For evaluation of wind patterns, older data from the actual site is more representative than recent data from available off-site weather stations. The wind patterns are largely impacted by local terrain, and these 1982 to 1984 data should be considered to still be climatologically valid, and hence, appropriate for regulatory purposes.

At the outset of operations, CBR will install, and for one year will operate a meteorological tower at the NTEA to verify the representativeness of the historic CPF data used in the NTEA license amendment application. ~~For one year prior to operations, CBR will install and operate a meteorological tower at the North Trend site to verify the representativeness of the historic Crow Butte CPF data used in this application.~~ In addition CBR will compare the data collected at the North Trend site to concurrent data collected that National Weather Service station at Chadron Nebraska to determine if the data collection period is representative of long term conditions. The meteorological tower will be operated to collect data to meet the NRC Regulatory Guide 3.63 requirements for data recovery.

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~~If data requirements, characteristics of the surrounding area, or approved air quality/radiological model requirements change the meteorological data may need to be reprocessed for use. However, at the current time, with the limited air/radiological modeling required for a satellite facility that is basically a wet process, the current meteorological database appears adequate for North Trend. In addition, as discussed above, wind patterns (e.g., wind roses) have not changed significantly over a 40-year period for Scottsbluff and Rapid City, which would suggest there would be no significant changes with wind patterns at the CRB meteorological monitoring site.~~

2.5.6 Air Quality

Radon gas is expected to be the major radiological emission at the North Trend operations. The air dispersion of radiological particulates during routine operations is not expected to be major issue at the NTEA since there will be no yellowcake drying and packaging operations. These later operations are the major source of radioactive particulates for uranium in situ operations. However, surface spills of pregnant lixiviant could be a source of radiological emissions that could eventually become entrained and airborne. Preoperational ambient atmospheric radon and air particulate monitoring (Uranium, Ra-226 and Pb-210) were collected at designated air monitoring stations (1996-1997 and 2004-2005) Preoperational baseline direct radiation (gamma) measures

were also made at the abovementioned air monitoring stations and the proposed North Trend Satellite Facility. In addition preoperational vegetation, soils, surface water and groundwater sampling for the North Trend area were also completed. Additional vegetation, soils and gamma surveys will be completed to better document baseline conditions for site conditions within the NTEA. A description of the completed monitoring programs including the results of monitoring, and planned monitoring activities are presented in Section 2.9.

The primary new emission source of non-radiological pollutants will be tailpipe emissions of nitrogen oxides (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2), non-methane-ethane volatile organic compounds (VOC), and particulate matter with a diameter less than ten micrometers (PM_{10}) resulting from vehicle traffic within the North Trend Expansion Area. Approximately 6-8 vehicle trips per day (VTPD) are anticipated as part of regular operations. These vehicles are expected to be light duty pick-up style trucks. Heavy equipment in the form of drill rigs, equipment haulers, or water trucks will be used as necessary and are anticipated to average less than one VTPD. These emissions are expected to be minor and should not affect the local ambient air quality.

Although there are no ambient air quality monitoring data for these non-radiological pollutants in the license area, PM_{10} concentrations have been measured in Rapid City, South Dakota and Badlands National Park in South Dakota. Both locations are geographically similar to the license area.

The Rapid City data were collected at the National Guard Camp Armory site about 2 miles west of the city. This area is classified as suburban. The Badlands data were collected in an area classified as rural. Because of the degree of urbanization, the air quality at the license area would probably fall somewhere between the air quality at these two locations. These data were obtained from the United States Environmental Protection Agency (USEPA) air quality monitoring database (USEPA 2007), and are presented in Table 2.5-15.

The National Ambient Air Quality Standards (NAAQS) for PM_{10} are 150 micrograms per cubic meter (24-hour average), and 50 micrograms per cubic meter (annual average). All counties within the 80-km radius or the project are in attainment of NAAQS.

2.5.7 References

HPRC Center 2004, Historical Data Summaries. [Web page] located at http://hprcc.unl.edu/cgi-bin/cli_perl_lib/cliMAIN.pl?ne1575. Accessed May 24, 2004.

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United State Department of Agriculture, Natural Resources Conservation Service. (NRCS). 2009. [Webpage]. Located at: http://www.wcc.nrcs.usda.gov/climate/windrose.html. Accessed on February 05, 2009.

United States Environmental Protection Agency (USEPA). 2007. AirData: Access to Air Pollution Data. [Web page] located at http://www.epa.gov/air/data/index.html Accessed on March 2, 2007.

United States Nuclear Regulatory Commission (USNRC), 1979. *Draft Generic Environmental Impact Statement on Uranium Milling* NUREG – 0511. Washington, D.C.

Weather Underground. (WUG). 2009. [Website]. Located at: http://www.wunderground.com/. Accessed on February 05, 2009.

TABLE 2.5-15
PM_{10} MONITORING SUMMARY
(MICROGRAMS PER CUBIC METER)

Year	Maximum 24-hr Average		Annual Average	
	Black Hills, SD	Rapid City, SD	Black Hills, SD	Rapid City, SD
1998	-	87.4	-	30.7
1999	-	116.9	-	28.2
2000	38.5	97.4	12.0	31.3
2001	47.9	81.5	12.6	34.6
2002	26.0	104.7	9.9	34.9
2003	74.4	91.8	16.3	36.2
2004	24.0	72.0	10.0	30.0
2005	40.0	94.00	9.0	27.0
2006	30.0	124.0	10.0	29.0

Figure 2.5-1 Comparison of Chadron and Crawford Temperature for Spring and Summer 1999

Figure 2.5-2 Rainfall Comparison for Chadron and Crawford Area for Spring and Summer 1999

Table 2.5-3 Comparison of Relative Humidity for Chadron, Scottsbluff and Rapid City in 2006

Figure 2.5-4 Wind Rose for Scottsbluff, Nebraska

Figure 2.5-5 Wind Rose for Rapid City, South Dakota

Figure 2.5-6 Wind Rose for Crow Butte Site

Figure 2.5-7 Location of CBR and Chadron Meteorological Stations

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~~**2.5.7 References**~~

~~HPRC Center 2004, Historical Data Summaries. [Web page] located at http://hprcc.unl.edu/cgi-bin/cli_perl_lib/cliMAIN.pl?ne1575. Accessed May 24, 2004.~~

~~National Climatic Data Center. (NCDC). 2009. [Webpage]. Located at: http://www.ncdc.noaa.gov/oa/ncdc.html. Accessed on February 05, 2009.~~

~~NOAA. 1993. Solar and Meteorological Surface Observation Network 1961 – 1990, Version 1.0. September.~~

~~United States Department of Agriculture (USDA). 1981. *Draft Environmental Impact Statement. Nebraska National Forest, Land, and Resource Management Plan.* USDA 02-07-81-07. USDA Forest Service, Chadron, NE.~~

~~United State Department of Agriculture, Natural Resources Conservation Service. (NRCS). 2009. [Webpage]. Located at: http://www.wcc.nrcs.usda.gov/climate/windrose.html. Accessed on February 05, 2009.~~

~~United States Environmental Protection Agency (USEPA). 2007. AirData: Access to Air Pollution Data. [Web page] located at http://www.epa.gov/air/data/index.html Accessed: March 2, 2007.~~

~~United States Nuclear Regulatory Commission (USNRC), 1979. *Draft Generic Environmental Impact Statement on Uranium Milling* NUREG – 0511. Washington, D.C.~~

~~Weather Underground. (WUG). 2009. [Website]. Located at: http://www.wunderground.com/. Accessed on February 05, 2009.~~

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Replacement Pages for Section 2.7
Hydrology

Replace All of Section 2.7, pp. 2.7-1 through 2.7-54

Note: Red-line version located behind blue cover page after replacement pages

2.7 HYDROLOGY

NUREG 1569 Section 2.7 states: "Characterization of the hydrology at *in situ* leach uranium extraction facilities must be sufficient to establish the potential effects of *in situ* operations on the adjacent surface-water and groundwater resources and the potential effects of surface-water flooding on the *in situ* leach facility." To meet these requirements, this section addresses surface water features (Section 2.7.1), groundwater characteristics (Section 2.7.2), surface water and groundwater quality (Section 0), water use information (Section 2.7.4) and the overall hydrologic conceptual model for the North Trend area (Section 0) based on site geology and hydrology.

Because of the extensive historical operations at the current licensed mining area (referred to herein as the Commercial Study Area [CSA]), Crow Butte has conducted more limited investigation/sampling for North Trend than would have been conducted if North Trend were a remote property. References to data from the CSA are used throughout this section, and distinctions between the two areas noted where warranted.

2.7.1 Surface Water

The North Trend Expansion Area lies within the watershed of Spring Creek and an unnamed creek which are small tributaries to the major regional water course, the White River.

Based on available maps and site investigations conducted by CBR, no surface water impoundments, lakes or ponds have been identified within the North Trend Expansion Area. Permanent impoundments occur southeast of the North Trend Expansion Area, but these are south of the White River and hydraulically isolated from North Trend.

2.7.1.1 Location

The North Trend Expansion Area lies in Sections 21, 22, 27, 28, 33, and 34 of Township 32 North, Range 52 West within the drainage basin of the White River. The White River originates in Sioux County and flows northeasterly across Dawes County into South Dakota. Tributaries of the White River northeast of the Crawford area cross upland portions of the Pierre Shale, an impermeable formation. These streams are dry except for runoff flow, and include the ephemeral Spring Creek and an unnamed creek that occur within the boundaries of North Trend. The southern tributaries, across the White River and to the south – southeast of North Trend, originate in the Pine Ridge escarpment, and flow primarily over forest, range, and agricultural land. These streams are generally ephemeral except for source water from occasional springs.

Spring Creek and the unnamed creek within the North Trend Expansion Area are northern tributaries of the White River. The unnamed creek originates in Red Cloud

Buttes southwest of the North Trend Expansion Area. Spring Creek originates in the hills of the Fort Robinson Wildlife Area, west of North Trend. From the headwaters, these ephemeral creeks flow eastward over range and agricultural land to the White River. Contributions to flow appear to be snowmelt and runoff, as well as springs. Figure 2.7-1 shows the location of all surface water features in the North Trend Expansion Area.

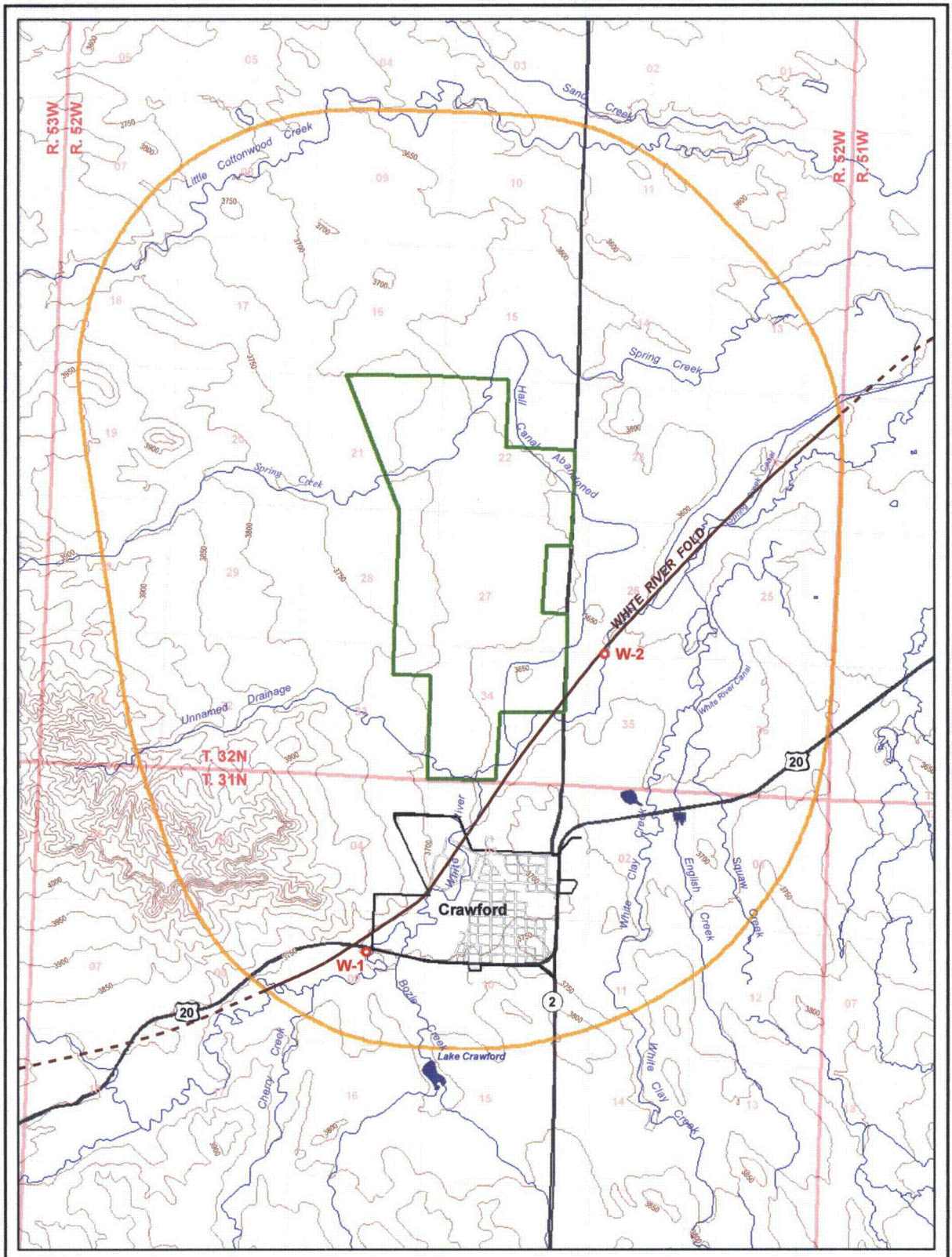
Spring Creek enters the proposed North Trend license boundary from the west in Section 21. The creek flow direction then changes to nearly due north. At the northern edge of the North Trend license boundary, a historic diversion canal (the Hall Canal) was constructed to direct flow from Spring Creek to the White River. Vestiges of this diversion canal can still be found in some locations. The unnamed creek crosses only the far southwestern edge of the North Trend Expansion Area (Section 34) before discharging to the White River. The White River crosses into the North Trend license boundary in the southern portion of Section 34.

2.7.1.2 Stream Flow

Table 2.7-1 shows the mean monthly discharge of the White River as compared to the mean monthly precipitation over several years (NOAA, 2006). These extended data show that a general correlation can be made between the direct precipitation and discharge. Higher flows are recorded in spring and early summer with lowest flow rates in late summer to early fall, reflecting seasonal changes related to precipitation. For the period of 1931 to 2004 the average normal annual mean discharge at the White River Station at Crawford was 20.3 cubic feet per second (cfs) with a standard deviation of 2.8 cfs. The maximum was 27 cfs and the minimum was 13 cfs.

Peak rainfall at Harrison and Scottsbluff, Nebraska occurs in May and June (NOAA, 1976 and 1980), and this precipitation pattern appears to be representative of the Crawford area. Table 2.7-2 provides mean monthly discharge information for the White River for 1992 through 1995, as well as data for 2004 and 2005. The recent data for the White River is comparable to the stream flow data shown in Table 2.7-1.

No flow measurements were attempted on Spring Creek or the unnamed creek due to the seasonal nature of flow in these features.



LEGEND

- Surface Water Monitor
- Streams
- White River Fold
- Elevation Contours (in Feet)
- Lake/Spring
- Proposed North Trend Expansion Area
- 2-Mile Radius Offset

N
W — E

0 3,000 6,000
Scale in Feet

CROW BUTTE RESOURCES, INC.

FIGURE 2.7-1
NORTH TREND
SURFACE WATER FEATURES

PROJECT: CO001322 MAPPED: JC CHECKED: MS

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Table 2.7-1: Comparison of Mean Monthly Precipitation With Normal Mean Monthly Discharge of the White River at Crawford, Nebraska

Month	Mean Precipitation [1]		Mean Discharge [2]	
	inches	centimeters	Ft^3/sec	$Meters^3$/sec
January	0.61	1.55	21	0.59
February	0.76	1.93	23	0.65
March	1.74	4.42	27	0.76
April	2.65	6.73	25	0.71
May	3.11	7.9	27	0.76
June	2.42	6.15	22	0.62
July	2.77	7.04	16	0.45
August	1.21	3.07	13	0.37
September	1.38	3.51	14	0.4
October	1.66	4.22	17	0.48
November	0.82	2.08	19	0.54
December	0.79	2.01	20	0.57

1 - Climatology of the US No. 81, 1971-2000, NOAA, 25-Nebraska.

2 - U.S. Department of the Interior, 1981, Period of Record 1931-2004 (see http://waterdata.usgs.gov/nwis/sw)

Table 2.7-2 Normal Mean Monthly Discharge of the White River at Crawford (06444000), (cubic feet per second)

Monthly	1992[a]	1993[a]	1994[a]	1995[a]	1996[a]	1997[a]	1998[a]	1999[a]
January	21.4	20.7	21.4	20.3	22.3	23.3	23.1	22.6
February	22.5	23.5	23	21.5	24.4	20.4	22.7	22.4
March	22.3	31.2	23.3	19.7	24.0	19.4	24.8	23.1
April	20.0	26.1	21.3	22.1	23.4	22.8	24.2	26.1
May	18.8	19.7	19.6	27	26.3	27.6	22.1	23.7
June	18.1	30.6	14	29.8	20.4	27.0	10.9	27.1
July	15.6	25.3	12.3	18.5	17.5	17.3	17.4	21.4
August	12.4	16.4	9.87	12.9	14.1	16.4	15.6	15.0
September	12.4	17.8	11.1	13.6	14.5	14.4	13.4	17.0
October	16.0	20.9	16.3	18.8	16.6	17.2	20.9	19.4
November	18.8	21.2	17.9	19.8	20.1	20.4	22.5	20.8
December	22.9	26.4	18.8	19.7	20.8	21.7	21.3	21.4
Average	**18.4**	**23.3**	**17.4**	**20.3**	**20.4**	**20.7**	**19.9**	**21.7**

Monthly	2000[b]	2001[b]	2002[b]	2003[b]	2004[b]	2005[b]	2006[b]	2007[b]
January	21.7	21.0	22.9	22.6	23.0	23.9	24.1	18.9
February	24.1	24.3	23.6	24.0	24.8	23.3	24.5	20.2
March	25.5	27.0	26.8	26.4	25.9	24.5	26.4	22.6
April	29.1	26.4	25.3	26.5	22.7	25.3	25.9	23.4
May	10.0	24.7	23.9	25.9	21.1	26.5	23.2	20.2
June	20.5	18.6	16.6	23.2	17.1	26.5	17.8	15.9
July	15.4	14.4	10.3	13.2	17.4	17.6	11.0	10.0
August	11.5	12.5	10.1	11.7	11.3	18.1	10.0	4.1
September	12.1	12.9	13.7	23.3	17.8	14.8	14.8	8.7
October	17.4	17.2	18.1	17.5	20.8	18.5	18.6	[c]
November	20.1	22.0	22.3	22.6	21.3	21.0	21.1	[c]
December	20.7	22.2	22.2	23.1	22.1	23.1	21.3	[c]
Average	**16.7**	**20.3**	**19.7**	**21.6**	**20.4**	**21.9**	**19.9**	**16.0**

[a] USGS 2009 (USGS National Water Information System for USGS gauging station 06444000)
[b] Nebraska Department of Natural Resources (NDNR) 2009.
[c] Data not available for fourth quarter of 2007 The USGS ceased flow data measurements at this gaging station on June 14, 2007 (D.L. Curtis 2009).

2.7.1.3 Surface Water Impoundments

No private surface water impoundments have been identified at or within the North Trend Expansion Area. Similarly, no naturally occurring lakes or ponds have been identified within the boundary.

2.7.1.4 Assessment of Surface Water Features

As shown in Tables 2.7-1 and 2.7-2, the average monthly stream flow of the White River at the Crawford gauge station is about 20 cfs. The highest discharge and gauge height on record between 1920 and 2004 occurred on May 10, 1991. On that date, severe thunderstorms resulted in significant rainfall, the gauge height was 16.32 feet and the stream flow exceeded 13,300 cfs (State of Nebraska Department of Natural Resources, 2004). Several city facilities were damaged by floodwaters and hail, including the local golf course and fish hatchery, and the event was considered a "100 year" flood. The Rocky Mountain News (May 12, 1991) reported that mobile homes were swept away and the town's water system was knocked out of service. However, it is noted that, while there are certainly historical extremes, the average gauge height on the White River at Crawford is less than 5 feet, with an average annual stream flow of 20.2 cfs.

An assessment of the potential for flooding or erosion that could impact the in-situ mining processing facilities and surface impoundments has been performed based on data from the Federal Emergency Management Agency (FEMA; http://msc.fema.gov). FEMA has not mapped unincorporated Dawes County north of Crawford, Nebraska; however, FEMA maps are available for the City of Crawford, and an analogy can be drawn between the flooding potential in Crawford and that immediately north of Crawford adjacent to the proposed North Trend Expansion Area. As shown in Figure 2.7-1a, FEMA has classified the portion of Crawford between the D M & E Railroad (immediately west of First Street) as Zone A (i.e., an area that could be impacted by a 100-year flood) (*Managing Floodplain Development in Approximate Zone A Areas; FEMA, April 1995*). The elevation of the White River in the Zone A classification ranges from 3,669 to 3,659 feet AMSL. The surface elevation of the railroad tracks ranges from 3,678 to 3,671 feet AMSL. These data suggest that significant flooding potential exists with a rise in the White River elevation of 9 to 12 feet above base flow conditions. This is consistent with the data from the 1991 100-year flood event, where the river elevation was approximately 11.3 feet above base gauge height (approximately 5 feet).

The proposed North Trend surface facilities are to be located in the north-central portion of Section 27, approximately one mile northwest of White River, and approximately 70 feet topographically above the common river elevation. Proposed wellfields are planned for portions of Sections 21, 22, 27, 28, 33 and 34, T32N, R52W (Figure 2.7-1). With the exception of Section 34, the wellfields are projected to be at least 50 feet above the White River elevation.

The portion of the proposed North Trend Expansion Area where the greatest flooding potential related to the White River exists is the southeast part of Section 34 (Figure 2.7-1). The White River elevation in that area varies from 3,645 feet AMSL on the western portion of the southern permit boundary, to 3,622 feet AMSL to the northeast. Because of lower elevation and proximity to the White River, final wellfield layout in Section 34 may necessitate consideration of potential flood impacts (e.g., below a surface elevation of 3,657 feet on the west, and 3,634 feet to the northeast).

Based on these data, the North Trend surface facilities occur outside of the 100 year flood plain, and are not considered to be in a "flood prone" area. Therefore, consistent with NUREG-1623, erosion modeling was not considered necessary or performed.

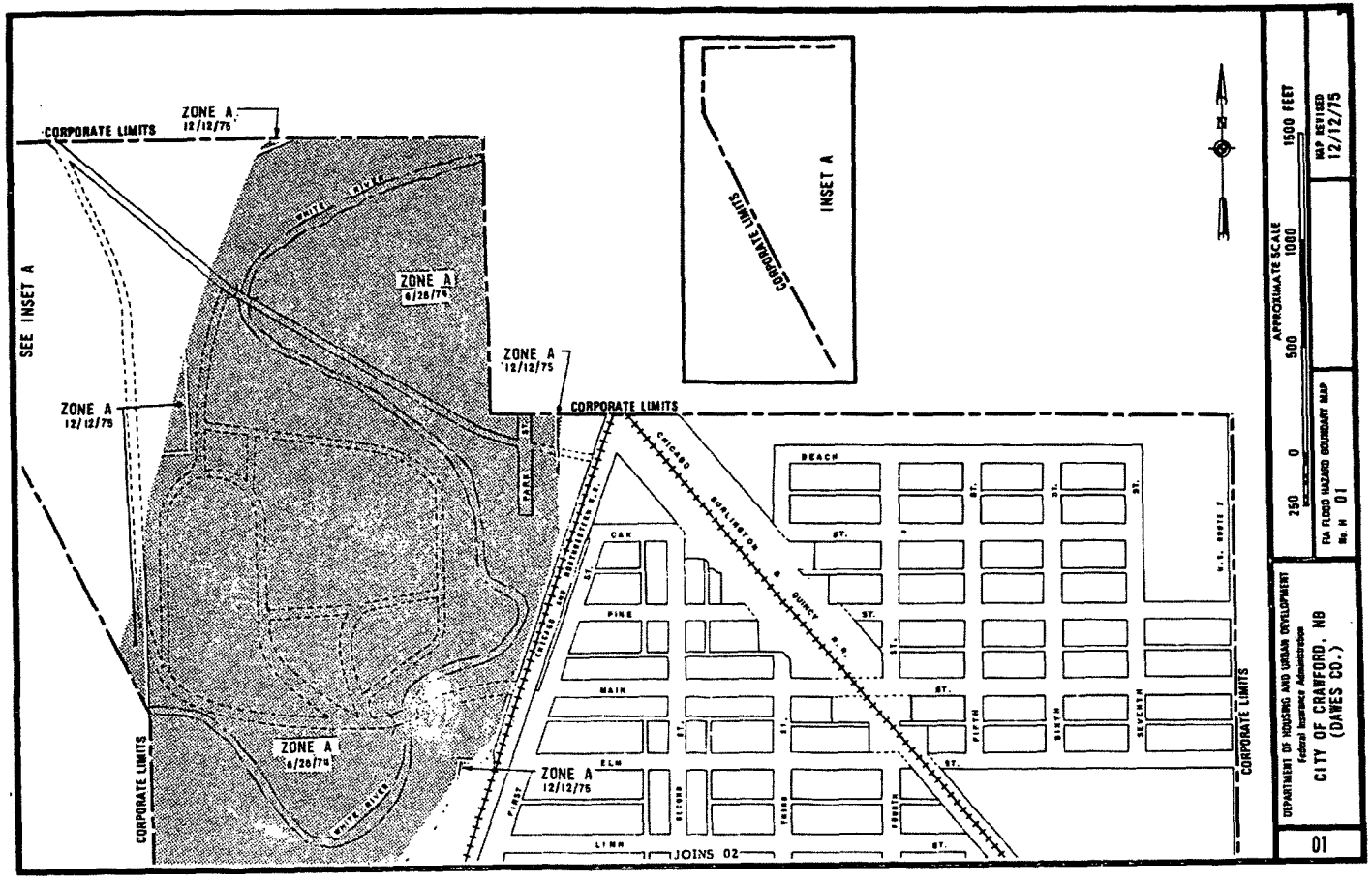
The operational areas in Section 34 nearest the White River having the highest potential of a major release reaching the White River will be Mine Units NT-7 and NT-9. Therefore, risks are primarily associated with wellfield operations. As described in Section 2.2 above, the North Trend operations will be operated in a manner to prevent any large releases of mining fluids such as pregnant lixiviant. In addition to the operational controls, the wellfield areas would be installed with dikes or berms to prevent spilled process solutions from entering the White River. Wellfield workers at North Trend conduct daily inspections and would be in a position to observe any such major releases. Risks associated with a wellfield spill risk are discussed in Section 7.5.4 of the application, and spill contingency plan measures are discussed in Section 5.7.1.3 of the application.

The North Trend Area does not include any major surface water features other than the White River. This feature is used to support agricultural production, wildlife habitat, and both warm- and cold-water fish. Upstream from the North Trend Expansion Area, the White River supplies drinking water for the City of Crawford (see Section 2.2 for additional discussion).

2.7.1.5 Water Quality

Water samples were collected from the single perennial surface water feature identified within the North Trend Expansion Area, the White River. White River water quality data were assembled by EPA for various years from 1969-1994. These data, as well as groundwater quality sampling results, are presented in Section 2.7.3

Figure 2.7-1a: FEMA Zone A Flood Map



2.7.2 Groundwater

This section describes the regional and local groundwater hydrology including local and regional hydraulic gradient and hydrostratigraphy, hydraulic parameters, baseline water quality conditions, and local groundwater use including well locations related to the North Trend Expansion Area. The discussion is based on information from investigations performed within the North Trend Expansion Area, data presented in previous applications/reports for the Commercial Study Area (CSA) where In Situ Leach (ISL) mining is being conducted, and the geologic information presented in Section 2.6. In this regard, the hydrogeology of the North Trend Area is expected to be similar in many respects to that encountered in the CSA, recognizing that North Trend is on the north side of the White River while the CSA is on the south side of this river.

The hydrostratigraphic section of interest for North Trend includes the following (presented in descending order):

- Alluvium
- Brule Formation (including the first "aquifer" in the Brule sand/clay)
- Chadron Formation (Upper Confining Unit including the Upper Chadron confining layer, Middle/Upper Chadron sand [aquifer, where present], and Middle Chadron confining layer)
- Basal Chadron Sandstone (Mining Unit)
- Pierre Shale (Lower Confining Unit)

With regard to the Crow Butte Uranium Project and the North Trend Area in particular, two groundwater sources are of interest in the Crawford and Crow Butte area. These are the Brule Formation sand and the Basal Chadron Sandstone. The Basal Chadron Sandstone contains the uranium mineralization in the CSA, and at North Trend.

2.7.2.1 Regional Groundwater Hydrology

A map prepared by Souders (2004) indicates that the water table configuration in the region trends north-northeast. No published regional water level maps are available for the Basal Chadron Sandstone or the local Brule Formation sands. Souders (2004) states that aquifers within the White River Basin, which encompasses the northern half of Dawes County, are "nearly nonexistent". He indicates that a groundwater divide occurs to the south of the CSA along the Pine Ridge; groundwater north of this divide in the CSA and North Trend Expansion Area flows to the north, northwest and northeast, depending upon location with respect to the White River. The Brule Formation, Chadron Formation and Pierre Shale outcrop progressively northward from the Pine Ridge divide through the White River Basin, and Souder states that none of these formations "are considered major sources of groundwater".

Souder indicates that the Brule Formation is a tight formation with a minimal hydraulic conductivity of less than 25 feet/day, although in a few areas there may be a significant saturated thickness, presumably where sandier intervals are present. The Chadron Formation is described as consisting of claystones with extensive volcanic ash that is tight with low hydraulic conductivity comparable to the Brule Formation, except where fractured, although the coarse Basal Chadron Sandstone is present at the bottom of the formation. The Pierre Shale is described by Souders (2004) as a dark grey, bentonitic shale that is "very tight and is not considered to hold any extractable groundwater" except where fractured. Fractures may increase Brule Formation and Chadron Formation permeability in localized areas (Souders, 2004). It is noted that CBR operations in the CSA to date do not support evidence of fracturing in the Pierre Shale to a degree such that it would impact the designation of the Pierre Shale as a lower confining unit below the Basal Chadron Sandstone.

Prior to mining in the CSA, water levels were measured in existing wells throughout the Crawford-Crow Butte area for the local Brule Formation sand and the Basal Chadron Sandstone. Historical water level data for a one-year period from wells located in the CSA are included on Tables 2.7-3a (Brule Formation wells) and 2.7-3b (Basal Chadron Sandstone wells). Maps showing the regional water levels for these two aquifers are included as Figures 2.7-2 and 2.7-3.

South of the White River, historical water levels measured in the Brule Formation in the 1982 to 1983 timeframe indicate groundwater flow in the Brule Formation is to the

Table 2.7-3a: Brule Water Levels
(in feet above mean sea level)

Well	1982 Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec	1993 April	1993 July
11**	3831.7	3831.5	3831.8	3833	3833	3833.6	3833	3832.6	3831.5	3830.6	3830.3	3830.3	3843.5*	3837
12**	3928	3924	3923	3922.7	3923.7	3921.1	3922.1	3921.5	3922.2	3921.3	3903.3*	3918.7	3922.9	3920
13	3968.5	3968.7	3968.8	3969.4	3969.6	3969.2	3969.5	3968.9	3968.1	3967.5	3968.1	3968.4	3969	3970
17	3865	3863.5	3863.3	3862.6	3863.6	3864.8	3863.3	3862.8	3863.5	3863.8	3865.3	3864.6	3864.8	3862.8
24**	3902	3910.5	3909	3903	3910.9	3910.5	3910.5	3910	3904.7	3901.5	3895.7*	3910.1	3910.4	3911
25	3870	3870.8	3870	3871	3871	3871.3	3869.5	3870.9	3870.6	3870.5	3870.8	3870.9	3870.1	3871.6
31**	3883.1	3883.1	3883.2	3883.1	3883.3	3883	3882.6	3882.3	3882.6	3880	3882.3	3882.5	388.2	3872.3*
64	3882	3882.9	3882.6	3883.5	3883.6	3883.8	3881.4	3880.8	3881.5	3880	3880.4	3882	3884.3	3883.5

	1982 Sept	Oct	Nov	Dec	1983 Jan	Feb	March	April	May	June	July	August	Sept
RA-2	3737.1	3737	3738.5	3737.9	3739.2	3739.1	3739.7	3740.2	3740.9	3741	3739.9	3739.2	3738.1
RB-3	3962.6	3961.2	3963.5	3963.6	3963.8	3963.8	3963.3	3969.7*	3963.7	3963.7	3964.2	3964.1	3964.2
PM-6	------	3844.9	3844.9	------	3843.5*	3844.5	3844.9	3845.3	3845.5	3846	3845.9	3945.9	3845.7
PM-7	------	3845.7	3845.5	------	3845.9	3845.8	3845.7	3846.1	3846.3	3846.9	3846.7	3846.7	3846.6

Notes: *Suspect Data
**Well may have been pumped prior to water level reading.

Table 2.7-3b: Basal Chadron Water Levels (in feet above mean sea level)

Well	1982 Sept	Oct	Nov	Dec	1983 Jan	Feb	March	April	May	June	July	August	Sept
62	3748.4	3748	3747.2	3746.6	------	------	3746.1	3746.2	------	------	3746.1	3745.8	3745.4
RC-4	------	------	------	3746.7	------	------	------	3746.2	------	------	3746.2	3746.2	3746.3
RC-5	3753.6	3753.4	3753.4	3753.2	3753	3752.6	3752.7	3752.9	3752.8	3752.9	3752.7	3752.5	3752.4
RC-6	3755.2	3755.2	3755.7	3756.8	3757.5	3754.7	3754.9	3755.7	3755.6	3755.6	3755.4	3755.2	3754.7
RC-7	3755.2	3756.8	3756.3	3756.2	3756.4	3755.8	3756	3756.4	3756.5	3756.7	3756.2	3756.1	3755.9
PM-1	------	3754.5	3754.4	3754.1	3754.3	3754	3753.8	3754	3754.2	3754.1	3753.8	3753.5	3753.5
PM-4	------	3755.2	3755.2	3754.4	3754.4	3754.1	3754.2	3754.4	3754.8	3754.6	3754.3	3753.9	3754.6
PT-2	------	3747.1*	3747.1*	3754	3754.6	3754.3	3754.1	3754.3	3754.5	3754.7	3754.3	3753.9	3753.7
PT-7	------	3755.1	3755	3754.2	3754.2	3754	3754	3754.1	3754.8	3754.6	3754.3	3754.1	3753.9
PT-8	------	3755.5	3755.6	3754.6	3754.4	3754.4	3755.7	3754.4	3754.5	3754.6	3754.2	3753.8	3753.7
PT-9	------	3753.5	3753.5	3754.9	3754.6	3754.6	3754.6	3754.8	3854.8	3754.9	3754.5	3754.3	3754.1

Notes: *Suspect Data

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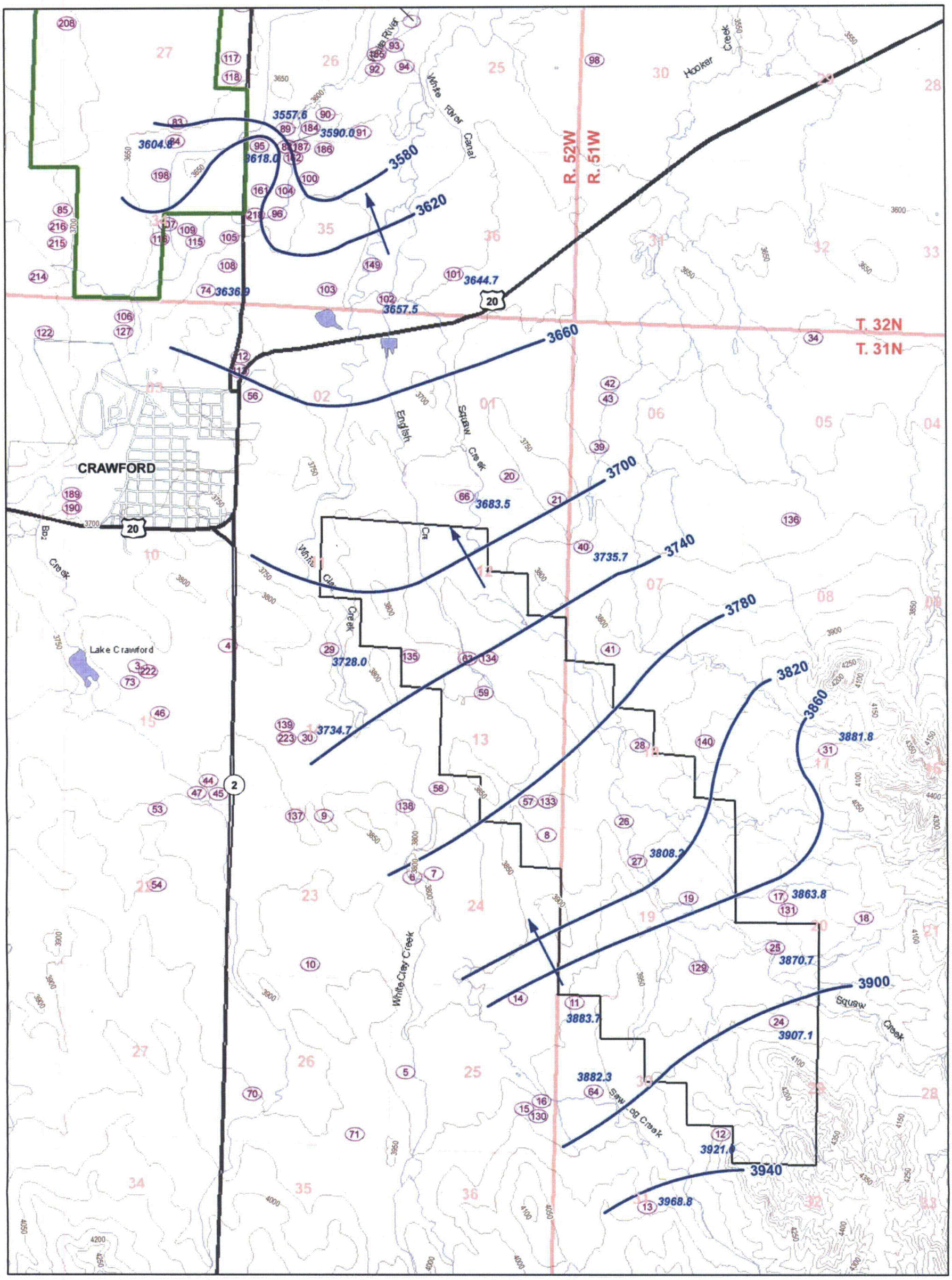

LEGEND

- Groundwater Elevation (Brule Formation, FT-AMSL)
- Elevation Contours (FT-AMSL, 40-Ft Interval)
- (129) 3968.8 Brule Formation Water Well and Water Level Elevation (FT-AMSL)
- Proposed North Trend Expansion Area
- Class III Permit Boundary
- Groundwater Flow Direction

0 3,000 6,000
Scale in Feet

N
W — E

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FIGURE 2.7–2
REGIONAL WATER LEVEL MAP
BRULE SANDSTONE 1982–1983

PROJECT: 223–37	DATE: MARCH 2007	
NTAAFig2.7–2&3.dwg	BY: KRS	CHECKED: HPD

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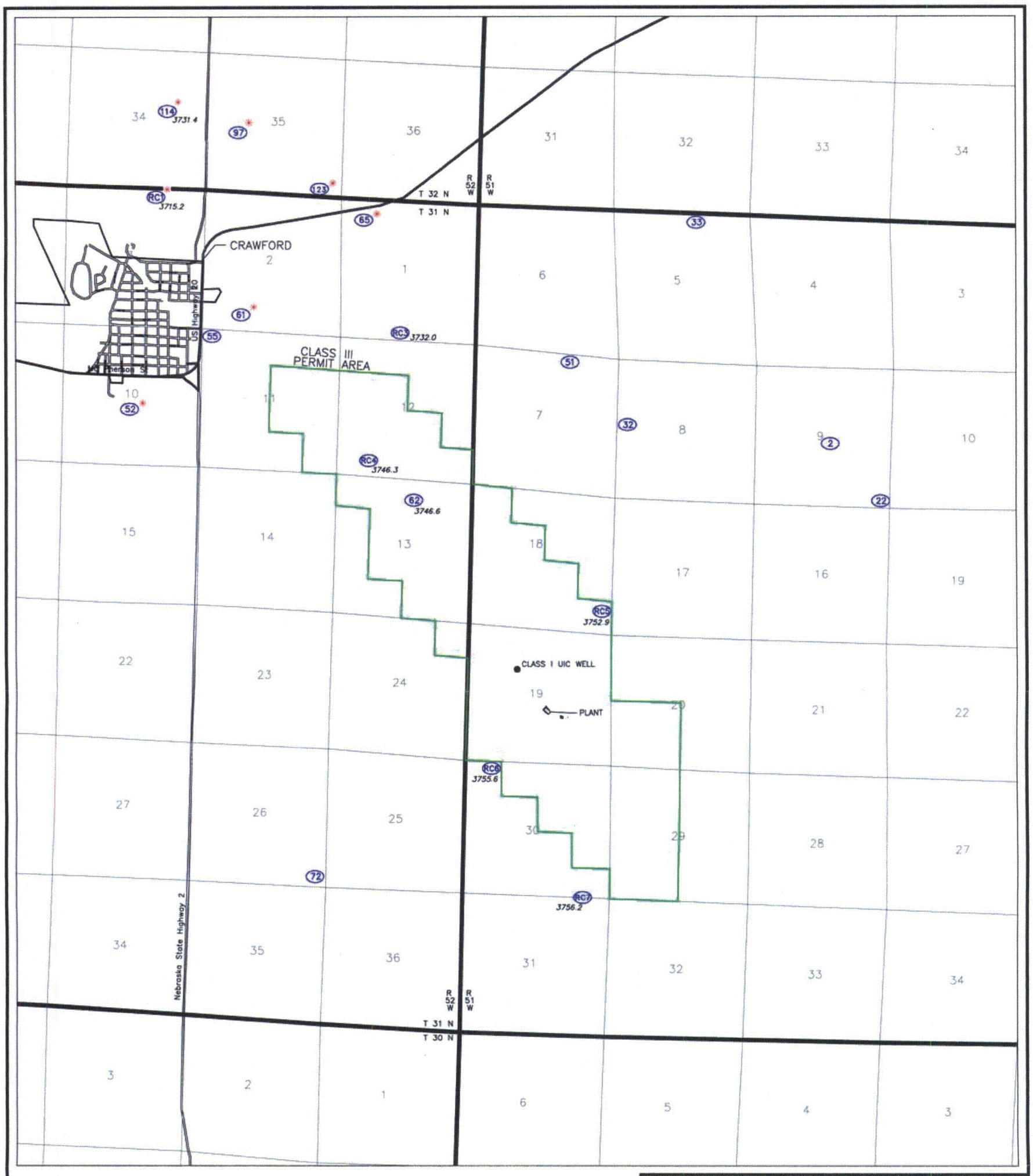

LEGEND

3968.8 Chadron Formation Water Level Elevation (amsl)

* Chadron Formation Artesian Well

Notes: Wells 52, 65, 114 and RC-3 have been abandoned.

0 0.5 1.0 2.0

SCALE IN FEET 1" = 1 MILE

N

W — E

CROW BUTTE RESOURCES, INC.

FIGURE 2.7-3

REGIONAL WATER LEVEL MAP
BASAL CHADRON SANDSTONE 1982-1983

PROJECT: 223-37	DATE: MARCH 2007	
NTAAFig2.7-2&3.dwg	BY: KRS	CHECKED: HPD

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northwest toward the White River with an average hydraulic gradient of approximately 0.011 ft/ft (Figure 2.7-2). North of the White River, recently collected water levels in the Brule Formation in the North Trend Area indicate groundwater flow is similarly convergent with the White River (see discussion in Section 2.7.2.2).

The Basal Chadron Sandstone is an artesian (confined) aquifer, and wells completed in it may flow to the surface near the White River. Figure 2.7-3 shows the location of artesian wells in the region. Artesian wells screened in the Basal Chadron Sandstone occur throughout the North Trend Area and in the vicinity of the White River. South of the White River, historic water levels indicate the direction of groundwater flow in the Basal Chadron Sandstone is to the north. Farther to the south, the potentiometric surface is almost flat. In the vicinity of the North Trend Area, groundwater flow in the Basal Chadron Sandstone is toward the east-southeast (see discussion in Section 2.7.2.2).

Regionally, the principal water bearing rocks below the Pierre Shale are the G Sand, J Sand, and the Dakota, Morrison and Sundance Formations. The Total Dissolved Solids (TDS) concentrations of the water below the Pierre Shale have been interpreted from deep oil and gas exploration logs. The Dakota Sandstone is at a depth of 2,972 to 3,020 feet in the Bunch No. 1 hole (Section 5, T31N, R52W). The minimum TDS of the water in the Dakota Sandstone, calculated from the spontaneous potential and sonic logs, is estimated to range from 14,000 to 26,000 mg/l (as NaCl). Based on samples collected during the installation and testing of the Crow Butte deep disposal well (DW #1, Section 19, T31N, R51W) located approximately six miles southeast of the North Trend area, TDS levels in the Morrison Formation (3,580 feet midpoint depth) and Sundance Formation (3,784 feet) are approximately 24,000 and 40,000 mg/l, respectively.

The Pierre Shale is essentially impermeable which precludes its use as a water supply. A number of shallow wells are reported as having the Pierre Shale as the bedrock unit (Spalding, 1982) in Township 32 North, Range 51-52 West. These wells range in depth from 18 to 100 feet with an average depth of 44 feet, and were drilled in areas that have considerable alluvium atop the Pierre Shale, including locations along Spring Creek and the White River between Crawford and Whitney Lake. These wells produce water from a few tens of feet of Quaternary Alluvium overlying the Pierre Shale, with the bottom few tens of feet in those wells providing storage. Spalding (1982) states that, *"In very shallow wells (a few tens of feet) significant amounts of water utilized may be contained in the thin Quaternary sediments overlying the designated hydrogeologic unit. This situation is particularly true for those wells noted as completed in the Pierre Shale"*. In the geologic summary of the Spalding report, the groundwater potential of the Pierre Shale is discussed by Marvin Carlson (page 14), *"The oldest bedrock unit in the area, the Pierre Shale of Cretaceous Age, is not considered as a potential aquifer. It is, however, included in the discussion of completion horizons and hydrogeologic units. A few of the shallow wells produce from the Quaternary sediments immediately overlying the Pierre Shale"*.

2.7.2.2 North Trend Area Groundwater Hydrology

The hydrogeologic system within and surrounding the Crow Butte CSA is similar to that found regionally, including North Trend.

Alluvial deposits occur intermittently in ephemeral drainages, but are not considered to be a reliable water source. Over most of the North Trend Expansion Area, the Brule Formation outcrops, and is underlain by the Chadron Formation (including the Basal Chadron Sandstone) and the Pierre Shale. The occurrence and thickness of these geologic units within North Trend have been confirmed during exploratory drilling and logging activities. Based on these data, the relationship of the hydrostratigraphic units within North Trend is shown on a cross-section location map (Figure 2.7-4) and six cross-sections (Figures 2.7-5 through Figure 2.7-10). Appendix B presents data for the boreholes used in cross-section construction, and Table 2.7-4 summarizes information pertaining to these boreholes, including data from boreholes completed as wells.

The Basal Chadron Sandstone, the aquifer which is host to the uranium mineralization, is bounded above and below by strata, which form aquicludes. The term "aquiclude" is used to describe strata capable of transmitting only minor amounts of fluid either vertically or horizontally. Typical values for vertical and horizontal permeability of "aquicludes" are in the range of 10^{-4} to 10^{-5} darcys (Todd, 1980), which is equivalent to a hydraulic conductivity of 10^{-7} to 10^{-8} cm/sec. The vertical hydraulic conductivities of the aquicludes calculated from pumping tests conducted in the CSA (discussed further in Section 2.7.2.3) are on the order of 10^{-11} cm/sec (Ferret Exploration of Nebraska, 1987). Laboratory analysis of cores from wells in the CSA indicates vertical hydraulic conductivities on the order of 10^{-10} to 10^{-11} cm/sec (Ferret Exploration of Nebraska, 1987).

The Upper/Middle Chadron sand occurs intermittently, and is underlain and overlain by hundreds of feet of low-permeability Chadron clays. The unit was monitored during the North Trend Pump Test because, where present, it is possible that it could contain recoverable water. However, no domestic or livestock wells in the North Trend Expansion Area are completed in this interval, and it is unlikely that this zone would be considered an "overlying aquifer". To be conservative, CBR chose to monitor a water level response in this interval. However, because of such limited production capacity in the Upper/Middle Chadron sand, the collection of representative groundwater samples could not be achieved. The wells did not produce sufficient water such that they could be adequately developed. Samples that were collected appeared to be impacted by drilling mud and cement.

In the upper part of the Brule Formation, sandstones and sandy siltstones are present which locally may be water bearing. However, these sandstones, siltstones, and clay stringers are difficult to correlate over any large distance, and are discontinuous lenses rather than laterally continuous strata. In the North Trend Area, private water wells are completed in this interval (see Section 2.2), and it is therefore the uppermost aquifer above the mined interval.

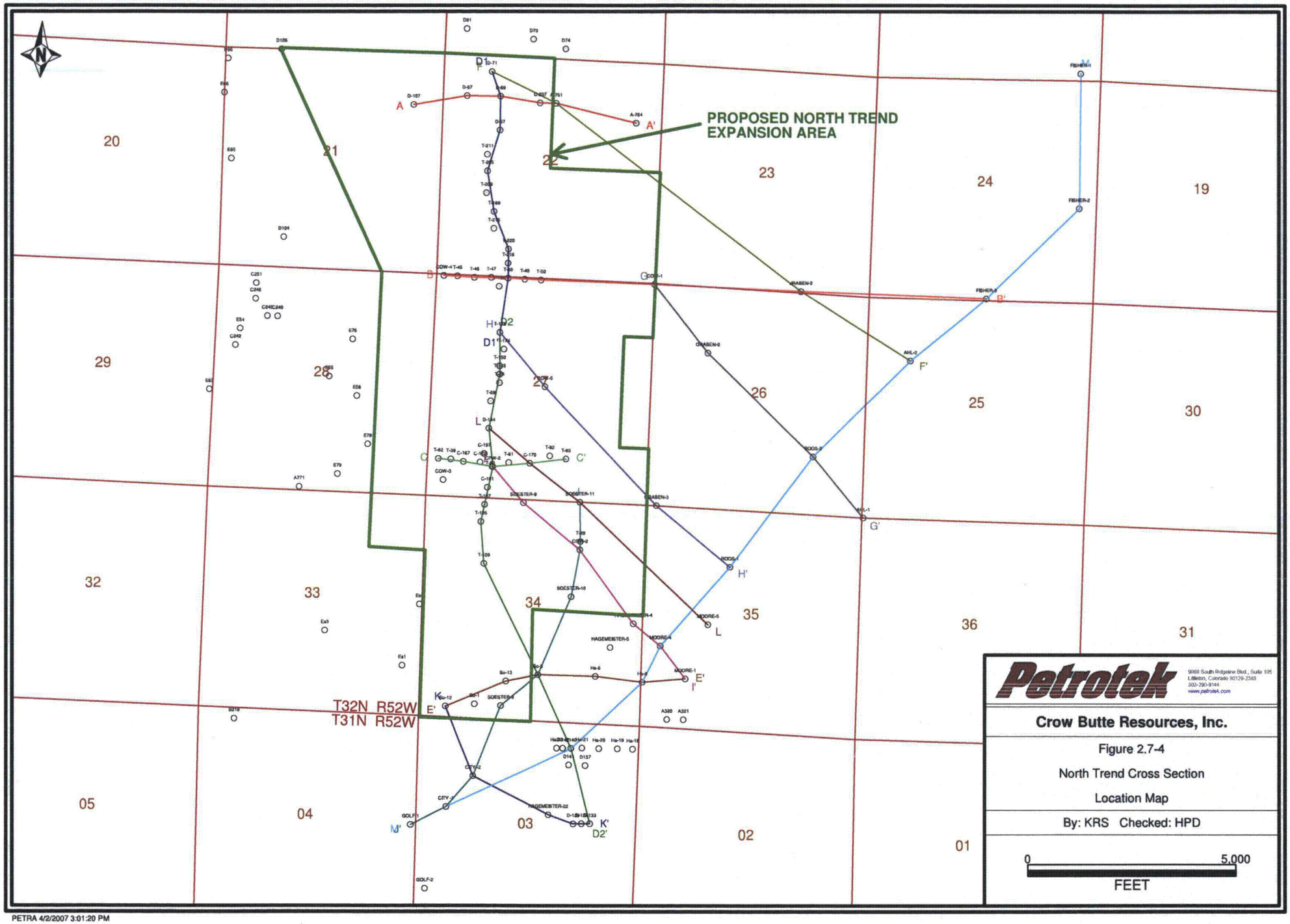

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Figure 2.7-4

North Trend Cross Section

Location Map

By: KRS Checked: HPD

0 5,000
FEET

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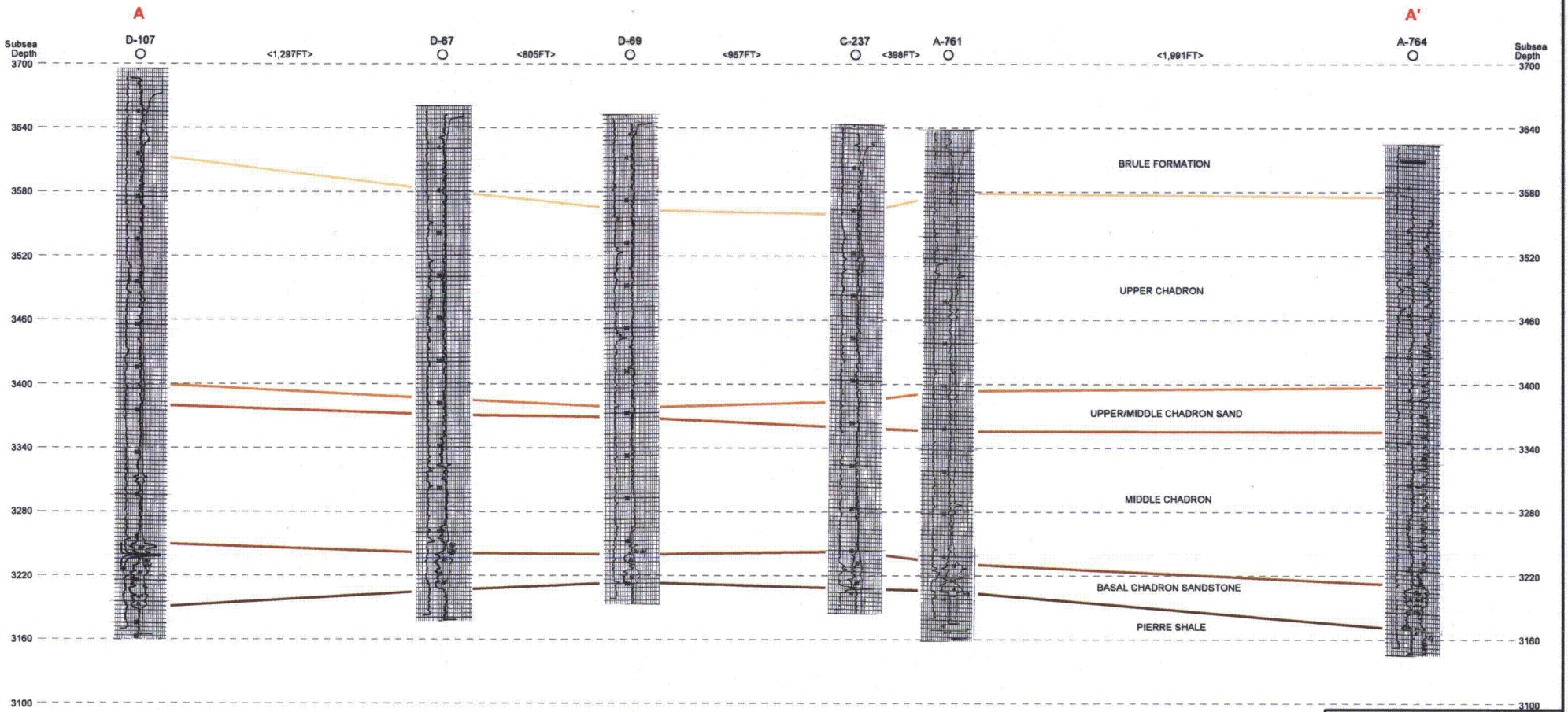

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North Trend Structural

Cross Section: A - A'

TOPS AND MARKERS

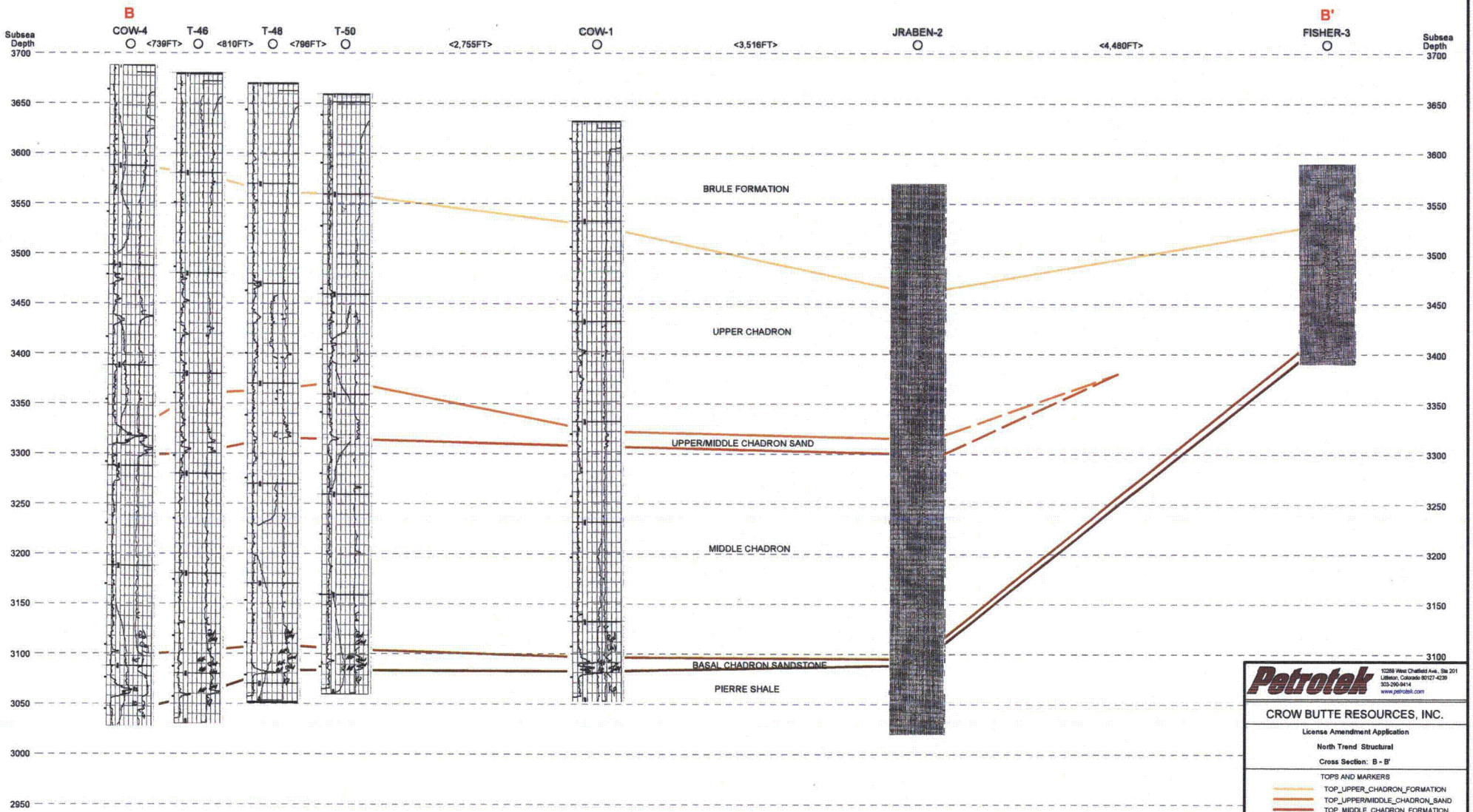
- TOP_UPPER_CHADRON_FORMATION
- TOP_UPPER/MIDDLE_CHADRON_SAND
- TOP_MIDDLE_CHADRON_FORMATION
- TOP_BASAL_CHADRON
- TOP_PIERRE

Figure 2.7-5

By: KRS Checked: HPD/WB

March 12,2007 11:45 AM

PETRA 3/12/2007 11:46:59 AM (Fig267.CSP)



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North Trend Structural

Cross Section: B - B'

TOPS AND MARKERS

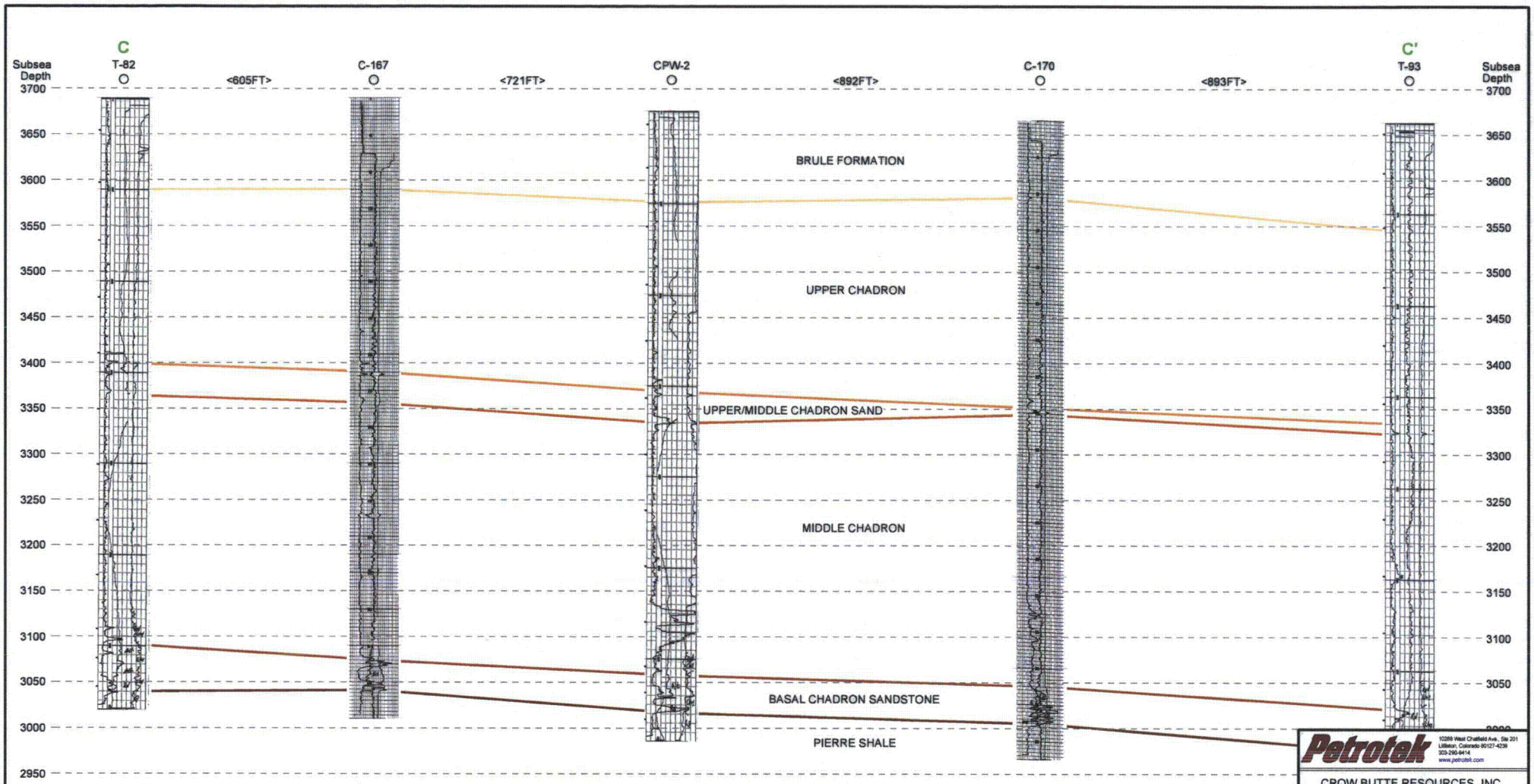
- TOP_UPPER_CHADRON_FORMATION
- TOP_UPPER/MIDDLE_CHADRON_SAND
- TOP_MIDDLE_CHADRON_FORMATION
- TOP_BASAL_CHADRON
- TOP_PIERRE

Figure 2.7-6

By: KRS Checked: HPD/WB

March 12,2007 11:46 AM

PETRA 3/12/2007 11:46:45 AM (Fig268.CSP)



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North Trend Structural

Cross Section: C - C'

TOPS AND MARKERS

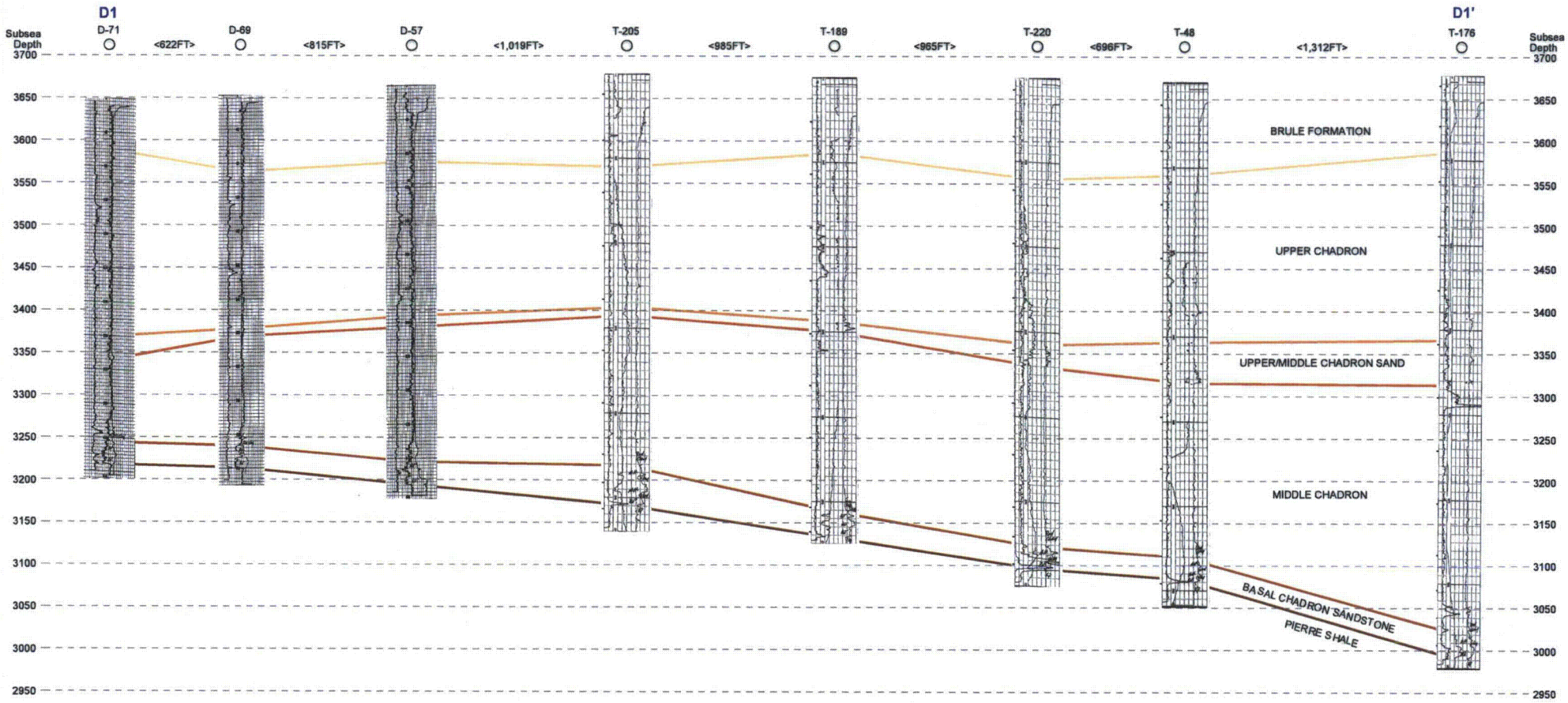
- TOP_UPPER_CHADRON_FORMATION
- TOP_UPPER/MIDDLE_CHADRON_SAND
- TOP_MIDDLE_CHADRON_FORMATION
- TOP_BASAL_CHADRON
- TOP_PIERRE

Figure 2.7-7

By: KRS Checked: HPD/WB

March 12,2007 11:47 AM

PETRA 3/12/2007 11:47:29 AM (Fig269.CSP)



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North Trend Structural

Cross Section: D1 - D1'

TOPS AND MARKERS

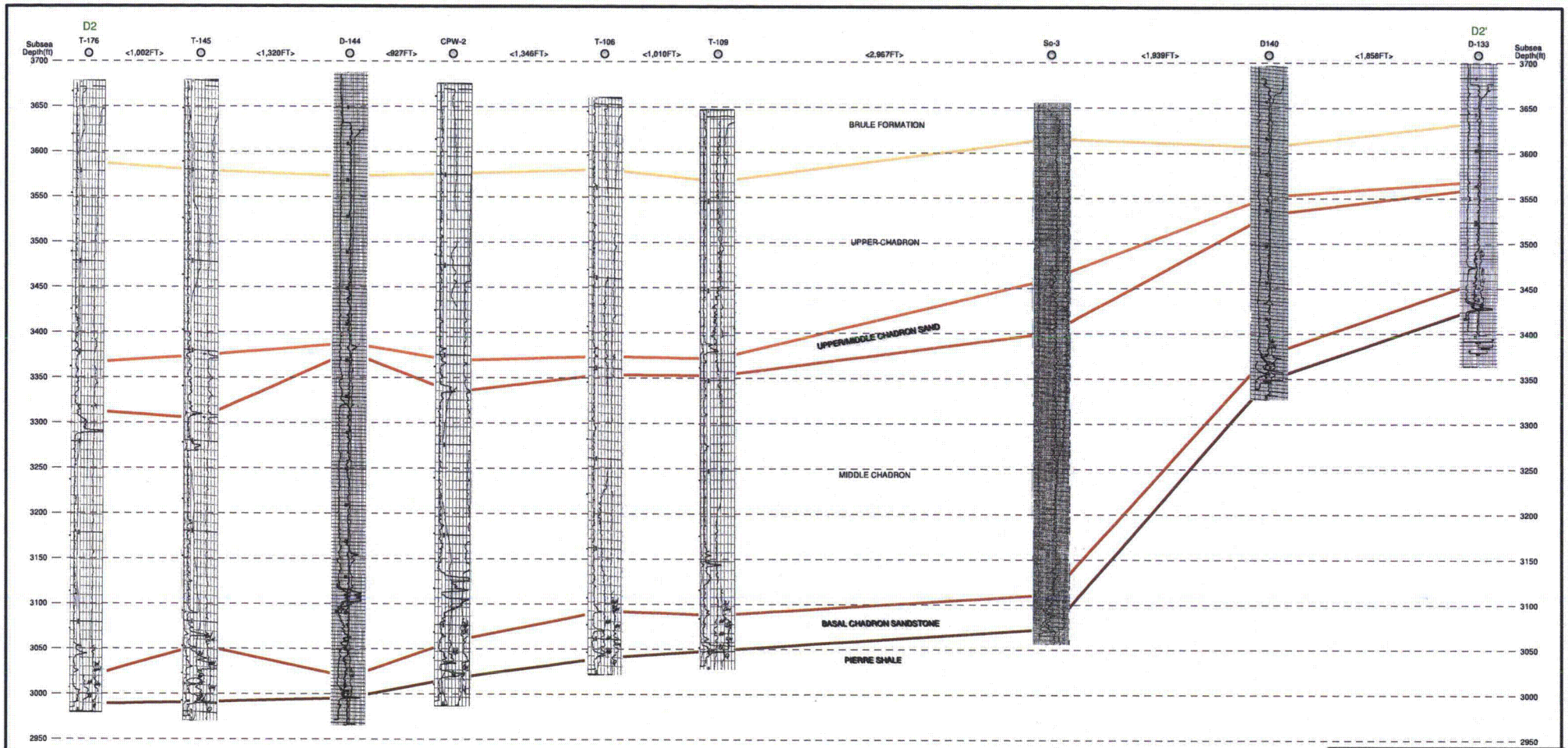
- TOP_UPPER_CHADRON_FORMATION
- TOP_UPPER/MIDDLE_CHADRON_SAND
- TOP_MIDDLE_CHADRON_FORMATION
- TOP_BASAL_CHADRON
- TOP_PIERRE

Figure 2.7-8

By: KRS Checked: HPD/WB

March 13,2007 4:38 PM

PETRA 3/13/2007 4:38:42 PM (Fig2610.CSP)



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North Trend Structural

Cross Section: D2 - D2'

TOPS AND MARKERS

- TOP_UPPER_CHADRON_FORMATION
- TOP_UPPER/MIDDLE_CHADRON_SAND
- TOP_MIDDLE_CHADRON_FORMATION
- TOP_BASAL_CHADRON
- TOP_PIERRE

Figure 2.7-9

By: KRS Checked: HPD/WB

April 2,2007 3:47 PM

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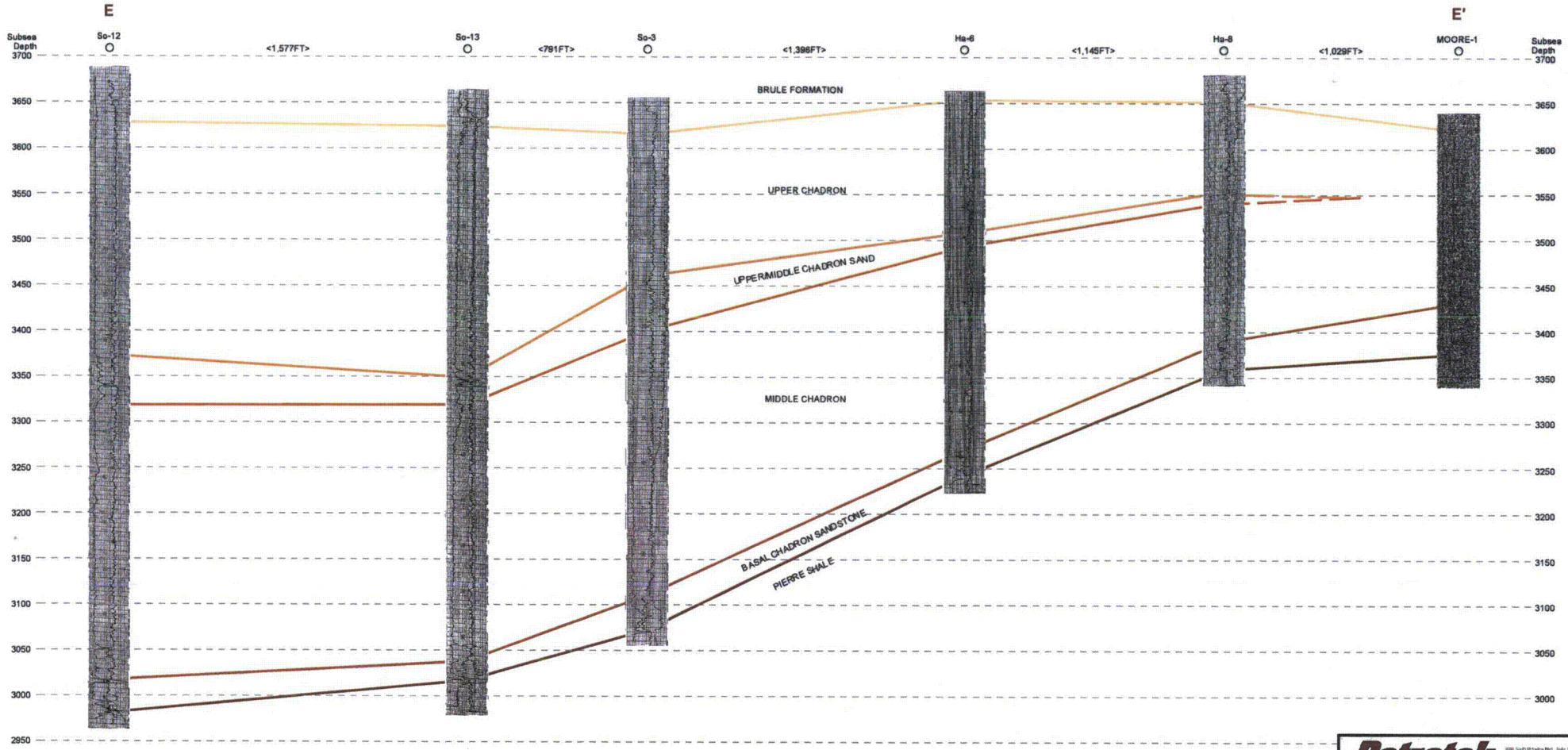

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North Trend Structural

Cross Section: E - E'

TOPS AND MARKERS

- TOP_UPPER_CHADRON_FORMATION
- TOP_UPPER/MIDDLE_CHADRON_SAND
- TOP_MIDDLE_CHADRON_FORMATION
- TOP_BASAL_CHADRON
- TOP_PIERRE

Figure 2.7-10

By: KRS Checked: HPD/WB

March 13,2007 4:44 PM

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Table 2.7-4: North Trend Pump Test Well Data and Cross Section Data

		Easting	Northing	TOC Elev	GL Elev	Casing Ht.	Bottom Brule	Top Mid Chadron	Bottom Mid Chadron	Top Basal Chadron	Top Pierre Shale
North	D-71	1,081,671.1	531,086.0		3,648.9		36	280	308	405	431
	D-69	1,081,875.6	530,498.7		3,652.8		36	275	284	413	439
	D-57	1,081,859.7	529,684.1		3,665.3		44	272	285	444	471
	T-211	1081556.19	529107.44		3666.47		47	270	295	442	490
	T-205	1081559.493	528710.35		3679.237		50	275	285	462	509
North - South Cross Section from the middle of Section 22 through Section 27 down to the middle of Section 34 T32N R 52W	T-209	1081533.912	528183.78		3679.773		60	270	284	493	527
	T-189	1081717.376	527738.07		3675.38		75	288	300	512	543
	T-216	1081713.165	527332.21		3677.565		75	302	326	543	558
	T-220	1082063.03	526836.69		3674.948		73	315	340	553	579
	T-218	1082053.79	526501.19		3668.89		56	330	345	567	583
	T-48	1082056.673	526140.59		3670.362		65	307	355	561	587
	T-130	1081840.767	525946.41		3672.661		42	315	350	537	610
	T-176	1081857.635	524844.05		3678.254		52	312	365	632	656
	T-174	1081955.57	524443.17		3674.022		47	318	362	664	688
	T-150	1081854.864	524041.97		3678.895		65	302	372	670	708
	T-145	1081854.596	523841.69		3679.205		65	305	375	626	689
	T-24	1081847.864	523637.10		3679.816		65	305	377	644	689
	T-69	1081636.60	523200.97		3683.6		55	295	380	628	698
	D-144	1,081,592.3	522,548.2		3,687.9		70	305	370	670	693
	CPW-2*	1081689	521626.3		3675.82		100	307	342	618	659
	C-197	1,081,482.3	521,942.6		3,688.2		72	310	354	609	671
	T-80	1081670.302	521633.07		3678.377		70	305	345	597	660
	C-181	1,081,557.1	521,134.6		3,657.6		67	285	310	598	630
	T-107	1081488.24	520720.51		3657.5		60	285	310	590	629

	T-106	1081399.095	520311.58		3660.693		70	287	307	569	621
	T-109	1081470.41	519304.14		3647.2		62	276	295	560	599
	So-3	1082777	516640.8		3655.7		40	195	255	545	583
	D140*	1083583	514877.6		3697		40	145	165	320	348
South	D133*	1084039	513075.9		3723.7		90	No data	No data	266	295
West	COW 2004-4	1080512.23	526200.97	3686.8	3686.0	0.8	70	367	390	589	645
	T-45	1080840.266	526195.72		3685.539		85	347	386	586	635
West to East Cross Section along the North side of Section 27 T32N R52W	T-46	1081246.405	526159.15		3680.201		85	320	380	578	622
	T-47	1081651.543	526159.50		3674.768		67	310	355	563	600
	T-48	1082056.673	526140.59		3670.362		65	307	355	561	587
	T-49	1082454.729	526113.09		3664.861		48	290	348	545	580
	T-50	1082851.45	526094.75		3659.473		55	287	345	555	576
	COW 2004-1	1085606.42	525988.48	3633.0	3631.9	1.1	50	310	325	536	550
	Jraben2	1089116	525824		3570		110	255	270	475	481
East	Fisher3*	1093593	525653		3590		60	No data	No data	165	175
West	T-82	1080377.726	521824.06		3689.506		67	290	325	598	650
	T-39	1080676.211	521810.14		3689.569		45	290	328	579	646
West to East Cross Section Along the South side of Section 27 T32N R52W	C-167	1,080,978.5	521,749.8		3,690.3		77	300	334	616	649
	C-162	1,081,381.2	521,736.6		3,678.8		60	295	335	626	645
	CPW-2*	1081689	521626.3		3675.82		100	307	342	618	659
	T-80	1081670.302	521633.07		3678.377		70	305	345	597	660
	T-81	1082070	521724.86		3676.078		54	315	345	625	661
	C-170	1,082,577.2	521,706.8		3,666.0		37	315	322	620	661
	T-92	1083065.239	521885.55		3666.041		58	325	345	639	675
East	T-93	1083464.293	521808.92		3663.462		77	330	342	644	691

West	D-107	1,079,790.2	530,303.8		3,695.5		70	295	315	445	506
Cross Section West	D-67	1,081,070.9	530,511.1		3,661.0		40	275	290	420	455
to East	D-69	1,081,875.6	530,498.7		3,652.8		36	275	284	413	439
Section 22 T 32N	C-237	1,082,829.0	530,335.1		3,643.8		42	260	285	401	436
R 52W	A-761	1,083,226.9	530,324.6		3,638.5		42	245	283	407	433
East	A-764	1,085,160.0	529,850.0		3,625.0		45	228	270	414	456
West	So-12	1080544	515886.3		3688.3		60	315	370	671	707
Cross Section West	So-13	1082001	516487.9		3664.1		40	315	345	626	647
to East along South	So-3	1082777	516640.8		3655.7		40	195	255	545	583
Side Section 34	Ha-6	1084172	516599.5		3663.3		10	155	170	393	421
T32N R52W	Ha-8*	1085309	516460.9		3681.6		30	128	140	292	323
East	Mo-1*	1086335	516539		3640		20	No data	No data	208	264
Northwest	CPW2*	1081689	521626.3		3675.82		100	307	342	618	659
NW-SE Cross	So-9	1082421	520762.7		3648		103	285	312	600	645
Section through	COW2*	1083807.09	519628.76	3654.0	3652.1	1.9	50	250	275	578	598
Sections 27, 34, 25	Ha-4	1085092	517860.5		3620		85	170	200	350	385
T32N R52 W	Mo-4*	1085741	517327		3680		90	No data	No data	320	360
Southeast	Mo-1*	1086335	516539		3640		20	No data	No data	208	264
West	So-12*	1080544	515886.3		3688.3		60	315	370	671	707
West to East Cross	City-2	1081209	514220.4		3671.1		70	No data	No data	520	595
Section, Section 3	Ha-22	1083028	513291.4		3694.6		20	No data	No data	230	288
T31N R52W	D-138	1083636	513072.8		3711.8		80	No data	No data	232	291
	D-133*	1084039	513075.9		3723.7		90	No data	No data	266	295
East											

Northeast	Fi1	1095856	531039		3570		80	No data	No data	242	250
Northeast-Southwest	Fi2	1095815	527813		3560		15	No data	No data	100	100
Cross Section	Fi3*	1093593	525653		3590		60	No data	No data	165	175
through Sections	Ah2	1091762	524166		3600		40	No data	No data	195	215
24,25,36,3	Rs2	1089402	521865		3590		30	No data	No data	154	178
T31 and 32N R52W	Rs1	1087407	519217		3615		40	No data	No data	152	172
	Mo4*	1085741	517327		3680		90	No data	No data	320	360
	Ha8*	1085309	516460.9		3681.6		30	128	140	292	323
	D140*	1083583	514877.6		3697		40	145	165	320	348
	City 1	1080560	513483.6		3679.8		175	245	255	592	632
Southwest	Golf 1	1079712	513055.5		3709.4		140	No data	No data	705	743
North Trend	COW 2004-1	1085606.42	525988.48	3633.0	3631.9	1.1	50	310	325	536	550
Pump Test Wells	COW 2004-2	1083807.09	519628.76	3654.0	3652.1	1.9	50	250	275	578	598
	COW 2004-3	1080497.45	521312.27	3684.5	3682.8	1.7	60	282	310	580	647
	COW 2004-4	1080512.23	526200.97	3686.8	3686.0	0.8	70	367	390	589	645
	COW 2004-5	1082950.491	523539.30	3671.04	3669.242	1.8	32	338	390	670	723
	CPW 2004-1	1081687.73	521629.85	3677.1	3675.3	1.8	37	307	342	618	658
	CPW 2004-2	1081697.12	521622.58	3680.1	3678.6	1.5	37	307	342	618	659
	BOW-2004	1081652.70	521638.30	3678.0	3676.4	1.6					

Figures 2.7-11 through 2.7-14 present the location of all groundwater wells in the North Trend Expansion Area, as well as potentiometric surfaces for the Brule Formation, Basal Chadron Sandstone, and Middle Chadron sand, measured in February 2007. As shown on these maps, local groundwater flow within the Basal Chadron Sandstone is to the east-southeast, with a gradient of 0.0016 ft/ft (8.5 ft/mile). Groundwater flow in the Brule Formation is convergent with the White River. Based on water levels collected in June 2008, groundwater flow in the Brule Formation is directed to the southeast in the northern portion of the North Trend Area and to the northeast (parallel with flow in the White River) in the southern portion of the North Trend Area (Figure 2.7-12) with an average hydraulic gradient of 0.0081 ft/ft. As discussed in Section 2.7.2.1, historic groundwater flow in the Brule Formation south of the White River is to the northwest, toward the White River (Figure 2.7-2).

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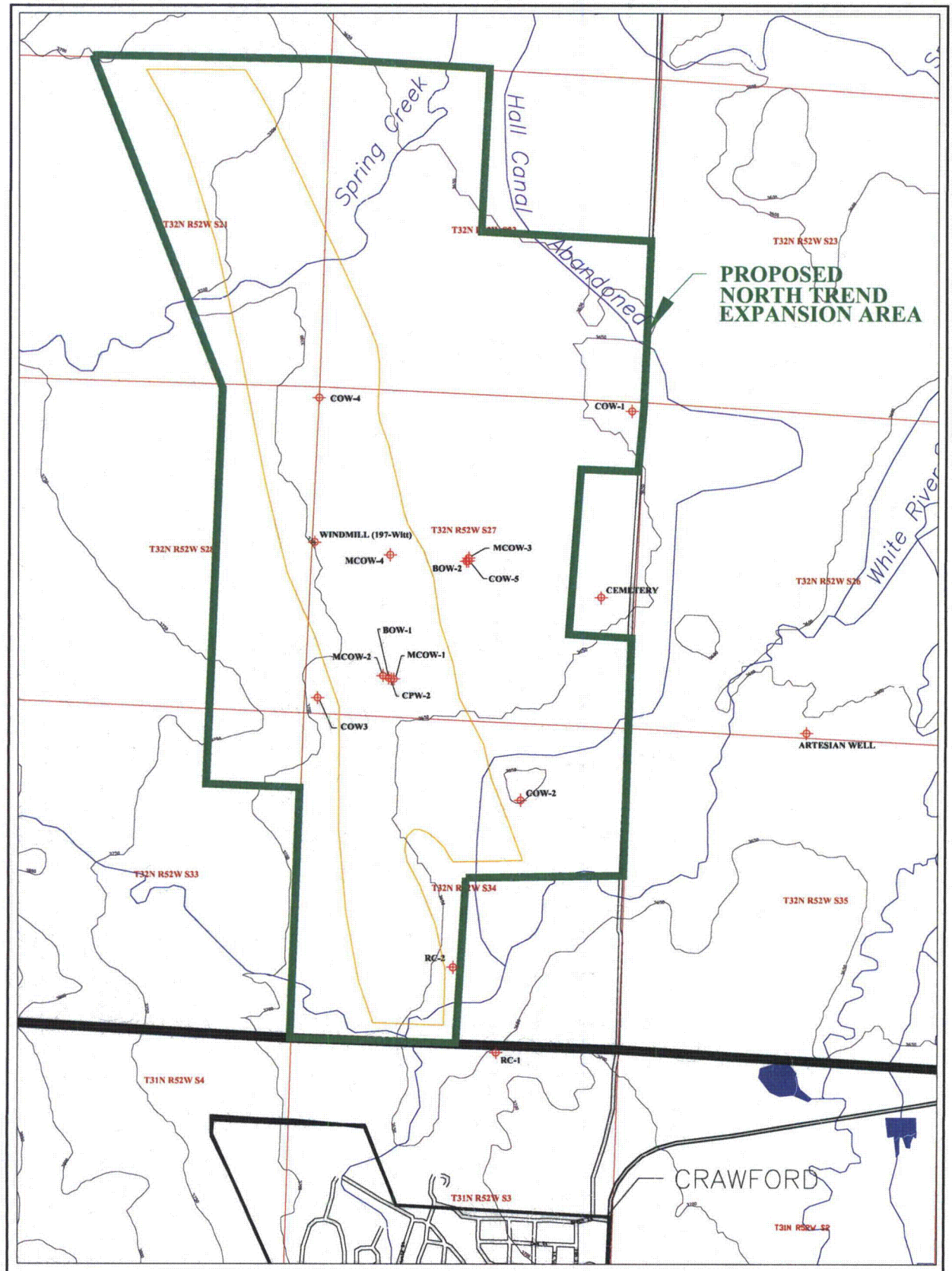

LEGEND

North Trend Monitoring Well

Ore Trend Outline

N
W — E

0 750 1500 3000
SCALE IN FEET 1" = 1500'

CROW BUTTE RESOURCES, INC.

FIGURE 2.7-11
NORTH TREND WELL LOCATION MAP

PROJECT: 223-37	DATE: MARCH 2007
DWG: CBRNT3CBase.dwg	BY: KRS CHECKED: HPD

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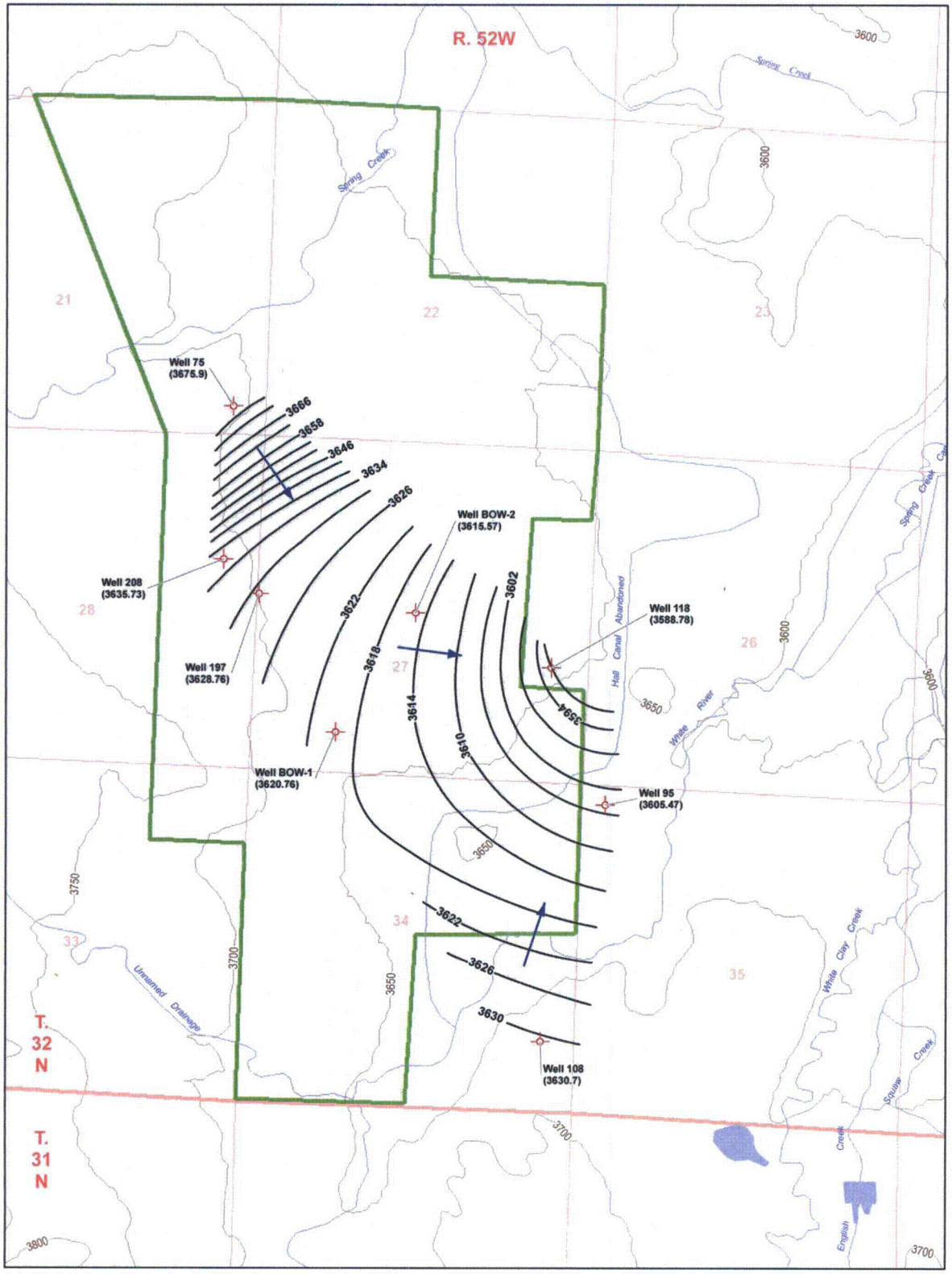

LEGEND

- North Trend Monitoring Well
- Elevation Contours (FT-AMSL)
- Groundwater Elevation Contour (FT-AMSL, 4-FT Interval)
- (3560.17) Groundwater Elevation (FT-AMSL)
- Stream or Canal
- Direction of Groundwater Flow
- Lake

0 1,500 3,000
Scale in Feet

N
W E

CROW BUTTE RESOURCES, INC.

FIGURE 2.7-12
NORTH TREND EXPANSION AREA
WATERLEVEL MAP
BRULE FORMATION (06/09/08)

PROJECT: 223-37	DATE: FEB. 09
NTAAFig2.7-2&3.dwg	BY: KRS CHECKED: HPD

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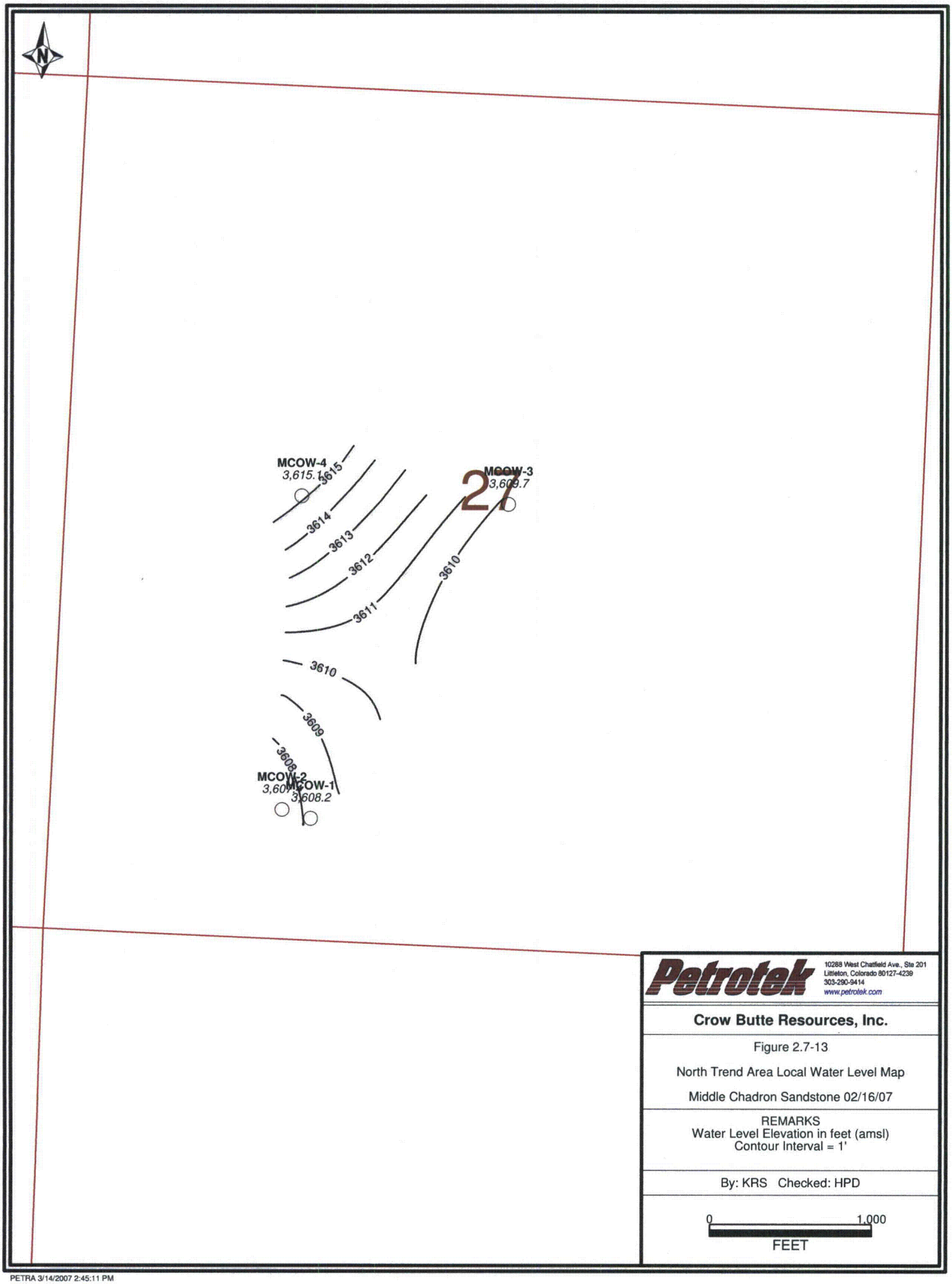

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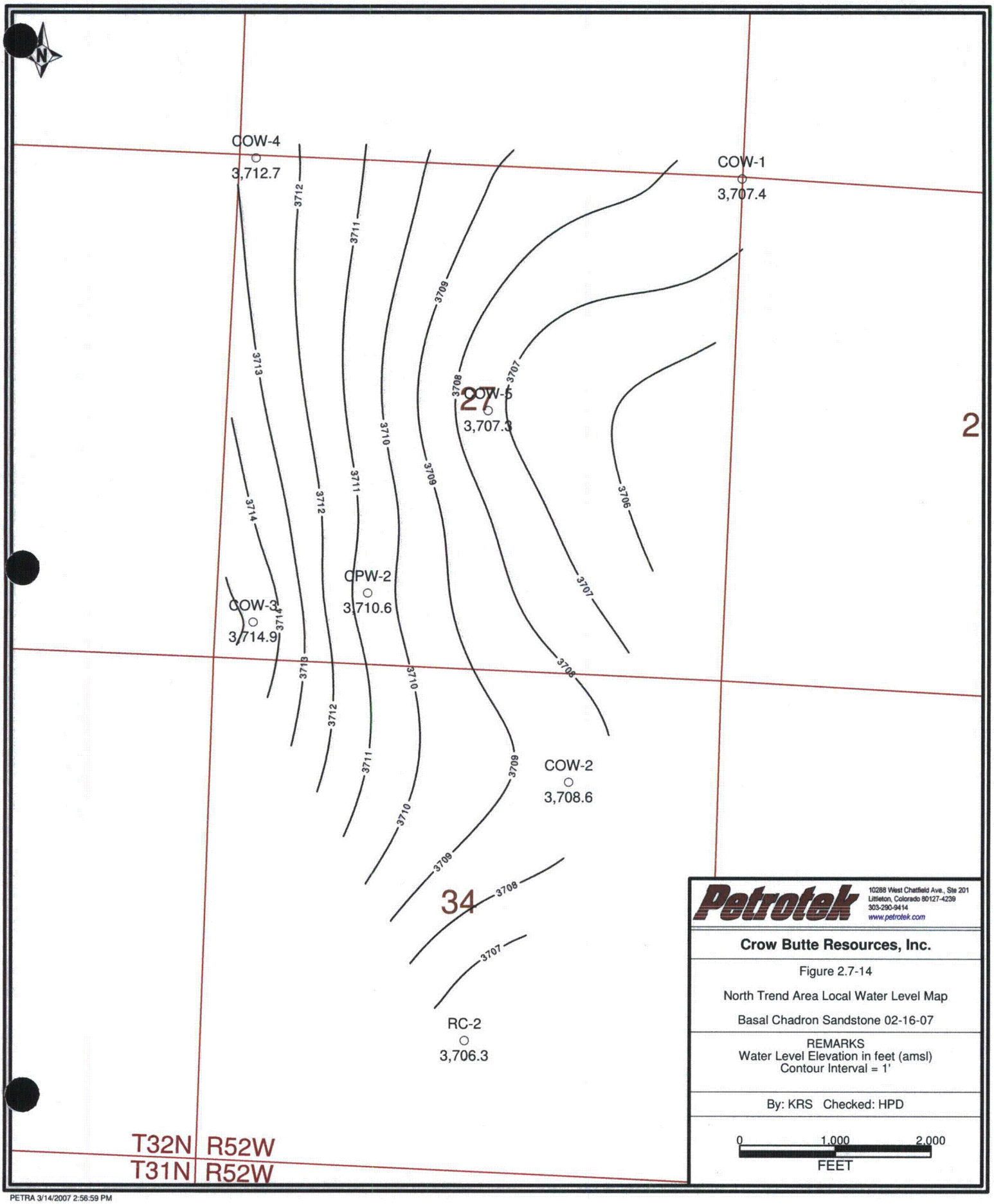

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Potentiometric levels in the overlying Upper/Middle Chadron sand and Brule Formation are approximately 90 feet and 80 feet below that of the Basal Chadron (mined interval), respectively, indicating hydraulic isolation between the overlying units that were monitored and the Basal Chadron Sandstone.

Table 2.7-4 presents data for wells measured to construct the potentiometric maps; this data includes well locations as surveyed, well depths, and screened intervals. Water levels in each well were measured and recorded with In-Situ LevelTROLL transducer/dataloggers (Table 2.7-5).

Table 2.7-5: North Trend Pump Test Monitoring Information

Location ID	Monitoring Equipment	Serial Number	PSI
COW-5 (PW)	LevelTROLL	107167	100
COW-1	LevelTROLL	107145	30
COW-2	LevelTROLL	107156	30
COW-3	LevelTROLL	107139	30
COW-4	LevelTROLL	107140	30
CPW-2	LevelTROLL	107134	30
RC-2	LevelTROLL	107135	30
BOW-1	LevelTROLL	107058	30
BOW-2	LevelTROLL	107155	30
MCOW-1	LevelTROLL	107138	30
MCOW-2	LevelTROLL	107143	30
MCOW-3	LevelTROLL	107144	30
MCOW-4	LevelTROLL	107103	30

2.7.2.3 Aquifer Testing and Hydraulic Parameter Identification

Basal Chadron Aquifer tests were conducted in the North Trend Expansion Area in 2004/2005 and 2006. Initial testing activities at North Trend commenced in 2004; however, the results from the 2004 tests were not definitive. For this reason, CBR conducted a longer test with additional monitoring wells in June and July 2006. A summary of testing and field operations for the 2004/2005 events are presented in Table 2.7-6, and a comparison of North Trend data obtained through testing versus data from the CSA is presented in Table 2.7-7.

Table 2.7-6: Summary of North Trend Pump Test Activities, 2004 and 2005

Start Date	Test/Field Operations	Purpose/Description	Result
8/9/2004	Test 1 (old #5)	Initial NT test to assess hydraulics and provide permitting data	Infiltration to Brule; possible hydraulic communication between Basal Chadron and Upper/Mid Chadron in MCOW1
8/23/2004	Test 2 (old #5a)	Duplicate Test 1	Confirmed responses observed in Test 1
9/28/2004	MITs and sampling	CPW-2, COW-3, MCOW-1, BOW-1	All wells pass MIT; samples could not be obtained from MCOW-1
12/8/04 to 12/22/04	Re-plugging	CPW-1	CWP-1 drilled out and re-plugged
	Install new monitoring wells	MCOW-2, COW-5	MCOW-2, COW-5 successfully installed
	Modify discharge line	Extend line 2500' to the east	Line extended along drain and across field
3/9/2005	Test 3	Assess confinement (MCOW-2); assess aquifer (COW-5)	Infiltration to Brule eliminated; drawdown in MCOW-1 during pumping
4/13/2005	Re-abandon exploration holes	Holes T80 & T85 re-abandoned	Holes located, re-drilled and re-plugged
5/2/2005	Test 4a	Evaluate whether meaningful data could be obtained by flowing CPW2	No meaningful data obtained; significant background trend in MCOW-1
5/10/2005	Test 4b	Pump CPW2; evaluate response in MCOW wells	Possible rain directly into wells; significant background trend in MCOW-1; generator ran out of fuel
5/24/2005	Test 4c	As above	No useful data; equipment problems
6/6/2005	Test 5a	As above; 2 cycles pumping and recovery	MCOW1 drawdown during both pumping periods; heavy rain - possible flow directly into wells
6/24/2005	Test 5b	Slug tests to test hypothesis that rain caused increase in water levels during Test 5a	Slug tests confirmed that water levels in BOW and MCOWs had been affected by rain.

Table 2.7-7: Comparison of 2004-2005 Testing Results to the Existing License Area

	Existing License Area Tests #1-#4 (mean)	Test #5 North Trend 2004-2005 (mean)
Transmissivity (ft^2/day)	363	103
Formation Thickness (feet)	39.0	19.8
Hyd. Cond. (ft/day)	9.3	5.2
Storativity	9.7E-05	7.1E-05

The June/July 2006 North Trend Pump Test was conducted in accordance with a Test Plan submitted by Crow Butte Resources, Inc. (CBR) to the Nebraska Department of Environmental Quality (NDEQ) in June 2006. In accordance with the Plan, CBR installed the necessary wells and performed a pump test to evaluate hydrogeologic conditions in the vicinity of the proposed North Trend expansion area. The pump test was designed to assess:

- The degree of hydrologic communication between the Basal Chadron production zone pumping well and the surrounding production zone monitor wells;
- The presence or absence of hydrologic boundaries within the Production Zone aquifer over the test area;
- The hydrologic characteristics of the production zone aquifer within the test area; and,
- The degree of hydrologic isolation between the Production Zone and the overlying aquifers.

The production zone in North Trend is the Basal Chadron Sandstone. The majority of the wells monitored during this test were completed in the Basal Chadron. The exact definition of the "overlying aquifer" at North Trend is somewhat difficult to determine. As such, to assess hydrogeologic isolation between the Production Zone and the overlying sands, overlying monitor wells were installed in both a Middle/Upper Chadron sand and a sandy clay within the base of the shallow Brule Formation. Because the production zone (Basal Chadron sand) is underlain by the Pierre Shale, no underlying monitoring wells were installed.

For the 2006 test, 13 wells (Table 2.7-8) were monitored using automated equipment. The test was conducted by pumping well COW-5 at 16.4 gpm for 357 hours (14.9 days). More than 110 feet of drawdown was achieved in the pumping well during testing. All of the Basal Chadron wells showed adequate drawdown (e.g., greater than 1.3 feet), which confirms hydrologic communication within the production zone sand. Summary test results are presented in Tables 2.7-9 and 2.7-10.

The nearest overlying sand monitor well (MCOW-3; Upper/Middle Chadron sand completion) was approximately 43 feet away from the pumping well used in the 2006 Test (see Figures 2.7-4 and 2.7-11); the nearest shallow aquifer monitor well (BOW-2; Brule completion) was located 32 feet from the pumping well. No significant water level changes due to the pump test were observed in the overlying or shallow monitor wells. Test results are summarized in Tables 2.7-9 and 2.7-10. The test results demonstrate:

- The Basal Chadron monitor wells are in communication with the Basal Chadron production zone throughout the North Trend test area;
- The Basal Chadron Sandstone has been adequately characterized with respect to hydrogeologic conditions within the majority of the proposed North Trend Expansion Area;
- Adequate confinement exists between the Basal Chadron sand production zone and the overlying Middle/Upper Chadron sand, and the overlying Brule Formation throughout the central portion of Section 27 of the proposed North Trend Expansion Area; and,
- While additional future testing will be necessary prior to mining in part of the proposed license area, the 2006 testing is sufficient to proceed with Class III permitting and NRC licensing for North Trend.

The North Trend Hydrologic Testing Report that provides a detailed description of the testing activities and results is attached to this application as Appendix C. Well completion reports are included with that document.

Regional aquifer analysis data are also available. During the initial permitting and development activities within the CSA, two pumping tests were conducted in the central portion of the CSA to (1) assess the hydraulic characteristics of the Chadron Sandstone, and (2) demonstrate the confinement provided by the overlying and underlying aquicludes (the Brule-Chadron Formation and Pierre Shale, respectively). Those tests, referred to as Test #1 and Test #2, were performed in 1982 and 1987, respectively (Wyoming Fuel, 1983; Ferret Exploration of Nebraska, 1987). Test #3 was conducted in September 1996 (Harlan & Associates, Inc., 1996).

The results from those tests indicate that the Chadron Sandstone is relatively homogeneous and isotropic (i.e., the hydraulic conductivity [permeability] is consistent with respect to direction and location) within the CSA. This is consistent with regional geologic information that suggests that the nature and characteristics of the Brule and Chadron Formations, and the Pierre Shale are consistent within the Crawford Basin. The depositional environment of these sections has been confirmed by exploratory drilling in the North Trend Expansion Area.

The CSA 1995 Application for Renewal of USNRC License SUA-1534 states that a porosity of 29% was assumed for the Basal Chadron Sandstone for a first aquifer test.

Table 2.7-8: Summary of 2006 North Trend Pump Test Well Information

Well ID	Distance to PW	North	East	Town-ship & Range	Sect	TOC Elev. (ft; AMSL)	Surface Elev. (ft; AMSL)	Casing Height (ft)	Hole Depth (ft; bgs)	Casing Depth (ft; bgs)	Top Screen (ft; bgs)	Bottom Screen (ft; bgs)	Screen Length (ft)	Screen Interval (feet)	Cas-ing O.D. (in.)	28 Jun 2006 Static Water Elev. (ft; AMSL)
Basal Chadron Pumping Well																
COW-5 (PW)	0.00	523,541.90	1,082,946.00	T32N R52W	27	3,669.05	3,667.65	1.40	740	708	653	708	55	22	4.5	3,704.85
Basal Chadron Observation Wells																
COW-1	3,614.28	525,991.00	1,085,604.00	T32N R52W	27	3,633.77	3,632.57	1.20	580	557	537	557	20	10	4.5	3,699.81
COW-2	4,001.38	519,632.50	1,083,799.00	T32N R52W	34	3,654.52	3,653.22	1.30	620	594	569	594	25	15	4.5	3,704.41
COW-3	3,315.00	521,315.40	1,080,490.00	T32N R52W	27	3,685.33	3,684.63	0.70	670	646	596	646	50	33	4.5	3,710.59
COW-4	3,609.34	526,204.30	1,080,509.00	T32N R52W	27	3,689.04	3,687.94	1.10	670	645	585	645	60	41	4.5	3,705.30
CPW-2	2,291.19	521,626.30	1,081,689.00	T32N R52W	27	3,676.92	3,675.82	1.10	710	685	615	685	70	35	4.5	3,705.99
RC-2	6,634.66	516,911.30	1,082,714.00	T32N R52W	34	3,651.22	3,648.42	2.80	630	630	572	630	58	25	4.5	3,703.93
Brule Observation Wells																
BOW-1	2,301.76	521,642.20	1,081,644.00	T32N R52W	27	3,677.39	3,675.49	1.90	65	65	45	65	20	5	4.5	3,620.68
BOW-2	31.78	523,534.20	1,082,915.00	T32N R52W	27	3,668.73	3,667.93	0.80	59	59	22	59	37	10	4.5	3,608.57
Middle Chadron Observation Wells																
MCOW -1	2,268.07	521,627.10	1,081,729.00	T32N R52W	27	3,676.80	3,675.50	1.30	380	350	305	350	45	5	4.5	3,607.29
MCOW -2	2,323.47	521,681.10	1,081,552.00	T32N R52W	27	3,678.82	3,677.52	1.30	370	360	315	360	45	7	4.5	3,606.83
MCOW -3	43.45	523,582.40	1,082,951.00	T32N R52W	27	3,668.85	3,667.65	1.20	390	391	325	391	66	17	4.5	3,606.14
MCOW -4	1,280.16	523,634.60	1,081,671.00	T32N R52W	27	3,681.66	3,679.86	1.80	371	371	290	371	81	19	4.5	3,608.27

Table 2.7-9: Summary of 2006 North Trend Pump Test Results

Well	Distance from Pumping Well (feet)	Analytical Results	Test #6 Analytical Method	
			Theis	Theis Recovery
COW-5 (PW)	0.00	Transmissivity (ft^2/day)	NA	*
		Hyd. Cond. (ft/day)	NA	*
		Storativity	NA	*
COW-1	3,614.28	Transmissivity (ft^2/day)	42.0	NA
		Hyd. Cond. (ft/day)	1.6	NA
		Storativity	2.30E-05	NA
COW-2	4,001.38	Transmissivity (ft^2/day)	74.8	NA
		Hyd. Cond. (ft/day)	2.9	NA
		Storativity	7.05E-05	NA
COW-3	3,315.00	Transmissivity (ft^2/day)	71.5	NA
		Hyd. Cond. (ft/day)	2.8	NA
		Storativity	8.40E-05	NA
COW-4	3,609.34	Transmissivity (ft^2/day)	51.7	NA
		Hyd. Cond. (ft/day)	2.0	NA
		Storativity	3.43E-05	NA
CPW-2	2,291.19	Transmissivity (ft^2/day)	60.7	NA
		Hyd. Cond. (ft/day)	2.3	NA
		Storativity	4.55E-05	NA
RC-2	6,634.66	Transmissivity (ft^2/day)	58.2	NA
		Hyd. Cond. (ft/day)	2.2	NA
		Storativity	6.18E-05	NA

NA - Data not analyzed; pumping data were sufficient for analysis.
* Unable to analyze recovery data due to lack of check valve on top of pump.

Table 2.7-10: Summary of 2006 North Trend Pump Test Results vs. Existing License Area

	Existing License Area Tests #1-#4 (mean)	Test #5 North Trend 2004 & 2005 (mean)	Test #6 North Trend 2006 (mean)
Transmissivity (ft^2/day)	363	103	60
Formation Thickness (feet)	39.0	19.8	26
Hyd. Cond. (ft/day)	9.3	5.2	2.3
Storativity	9.7E-05	7.1E-05	5.3E-05

2.7.3 Surface Water and Groundwater Quality

Historical surface water quality data for the White River, assembled by EPA, are presented in Table 2.7-11a. Historical groundwater quality data from the CSA for the Brule Alluvium, Brule Formation, and Basal Chadron Formation are presented in Table 2.7-11b.

A monitoring program was conducted to establish baseline groundwater quality conditions in the North Trend Area. The program was conducted in 1996 and 1997, and includes samples from a Basal Chadron well (Well 81) and Brule well (Well 78) in the North Trend Expansion Area (Figure 2.7-11). The radiological results of baseline sampling for these wells are also discussed in section 2.9. Note that well 81 has since been abandoned.

Tables 2.7-12 and 2.7-13 summarize data obtained from these wells for four monitoring periods, obtained from October 1996 through June 1997 to assess seasonable variability in water quality. These data establish the groundwater conditions associated with the mineralized Basal Chadron Sandstone and Brule in the North Trend area, at a location immediately outside and northeast of the proposed License area. The data indicate that the TDS for the Chadron ranges from 1790 to 1820 mg/l, while the TDS for the Brule ranges from 423 to 479 mg/l. Major ion content in groundwater is slightly higher in the Basal Chadron than the Brule, as would be expected by the TDS values. Alkalinity and conductivity are higher in the Chadron than Brule, but neither formation shows there to be measurable concentrations of most trace metals. Measurable uranium ranging in concentration from <0.0003 to 0.006 mg/l was detected in Chadron groundwater. These Chadron samples also showed radium-226 concentrations ranging from 10.3 to 14.7 pCi/l, which is above the NDEQ MCL of 5 pCi/l. Measurable uranium was also present in all four Brule samples with a maximum concentration of 0.016 mg/l. Radium-226 was present in the Brule samples with a maximum concentration of 0.5 pCi/l. The concentrations of uranium and radium in the Brule aquifer at North Trend are directly in line with average concentrations at the CSA.

It is noted that gross alpha and beta analyses were not performed because uranium and radium were the anticipated compounds and were thus specifically included on the analyte list. Also, that the average values for all parameters presented on Tables 2.7-12 and 2.7-13 are almost identical to the individual sample values, and the sample value range for each parameter is relatively limited. Based on these data, there is little seasonable variability in water quality.

Table 2.7-11a: Historic White River Water Quality Data, 1968-1994*

PARAMETER	RESULTS										
	8/20/1968	5/6/1969	7/15/1969	5/24/1970	8/28/1970	8/5/1971	6/5/1972	10/2/1972	6/4/1973	9/23/1981	7/13/1994
NUMBER USED IN SAMPLE ACCOUNTING PROCEDURE	66	66	65	95	77	109	no data	no data	no data	1	1
TEMPERATURE, WATER (DEGREES CENTIGRADE)	21	18	28	18.5	21	19.5	22	12.5	17	no data	20
TEMPERATURE, AIR (DEGREES CENTIGRADE)	32	21	36	23	27	30	21	11.1	23	no data	no data
FLOW, STREAM, MEAN DAILY CFS	10	22	10	22	21	12	19	12	24	no data	no data
TURBIDITY, (JACKSON CANDLE UNITS)	41	62	10	45	337	5	36	4	4	no data	no data
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	400	390	355	353	305	340	340	340	400	330	700
OXYGEN, DISSOLVED MG/L	7.4	8.5	6.9	7.8	7	8	8.1	9.6	7.9	no data	6.9
OXYGEN, DISSOLVED, PERCENT OF SATURATION	82.2321	89.4889	87.3453	82.106	77.7793	85.1096	92.0463	88.8907	81.4491	no data	75
PH (STANDARD UNITS)	7.7	8.2	8.2	7.9	7	8.5	8.4	8.5	7.6	no data	8.3
ALKALINITY, TOTAL (MG/L AS CACO3)	208	108	180	184	168	176	192	200	189	188	no data
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	258	270	250	250	220	250	240	260	no data	288	no data
NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	0.1	1	0.1	0.6	0.1	0.2	0.1	no data	no data	no data
PHOSPHATE, TOTAL (MG/L AS PO4)	0.8	0.1	0.5	0.2	0.3	0.1	0.2	0.1	no data	no data	no data
HARDNESS, TOTAL (MG/L AS CACO3)	176	148	168	160	156	172	160	172	172	no data	159
CALCIUM, DISSOLVED (MG/L AS CA)	39	35	51	50	52	46	51	56	no data	no data	no data
MAGNESIUM, DISSOLVED (MG/L AS MG)	10	1	10	9	6	14	8	8	no data	no data	no data
SODIUM, DISSOLVED (MG/L AS NA)	36	24	43	24	22	16	15	15	no data	no data	no data
SODIUM ADSORPTION RATIO	0.4	0.9	1.5	0.8	0.8	0.5	0.5	0.5	no data	no data	no data
POTASSIUM, DISSOLVED (MG/L AS K)	6	8	13	8	9	9	10	9	no data	no data	no data
CHLORIDE,TOTAL IN WATER MG/L	12	18	4	1	2	4	1	2	7	5	no data
HARDNESS, CA MG CALCULATED (MG/L AS CACO3)	138.563	91.513	168.527	161.912	154.552	172.514	160.291	172.776	no data	174.528	159.437

* Summaries of data collected are presented. See http://www.epa.gov/storet/updates.html, EPA' STORET database, for full data sets

Table 2.7-11b: Water Quality Summary; Brule Formation and Basal Chadron Sandstone

CONSTITUENT[1)]	BRULE FORMATION		CHADRON FORMATION		BRULE ALLUVIUM	
	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN
Calcium	7.1 - 98	48	11 - 41	20	67 - 74	70.6
Magnesium	0.3 - 16	6.6	0.8 - 7.2	3.2	6.4 - 10	8.7
Sodium	12 - 340	104	340 - 540	411	34 - 41	36.5
Potassium	4.1 - 15.9	9.9	7.0 - 19.8	12.4	10.3 - 13	11.1
Bicarbonate	137 - 627	364	308 - 411	368	299 - 364	321
Sulfate	1 - 23	10	254 - 620	407	11 - 20	16.3
Chloride	1.6 - 192	48	134 - 250	176	5 - 10	6.7
Specific Conductance (µmhos)	246 - 1481	714	1500 - 2500	1932	507 - 614	548
pH (pH units)	6.80 - 8.50	7.80	7.60 - 8.70	8.20	7.10 - 8.40	7.70
Uranium (mg/l)	0.001 - 0.021	0.0064	<0.001 - 2.40	0.092	0.006 - 0.022	0.015
Radium-226 (pCi/l)	0.1 - 3.0	0.7	0.1 - 619	53	0.4 - 18.3	2.5

[1)] Concentrations in mg/l, unless otherwise noted.

Table 2.7-12: Laboratory Analysis Report - Chadron Well W-81

			RESULTS				
Major Ions	Units	Detection Limit	9/5/1996	12/13/1996	3/20/1997	6/26/1997	Average Value
Calcium (Ca)	mg/L	1.0	29.4	28.9	29.1	30.9	29.6
Magnesium (Mg)	mg/L	1.0	5.4	5.33	5.2	5.2	5.3
Sodium (Na)	mg/L	1.0	555	568	561	582	567
Potassium (K)	mg/L	1.0	15.0	14.7	15.1	15.1	15.0
Carbonate (CO3)	mg/L	0.10	0	0	0	0	0
Bicarbonate (HCO3)	mg/L	0.10	399	404	398	401	401
Sulfate (SO4)	mg/L	1.0	740	744	743	720	737
Chloride (Cl)	mg/L	0.10	196	204	208	201	202
Ammonium (NH4) as N	mg/L	0.05	0.73	0.68	0.75	1	0.74
Nitrite (NO2) as N	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Nitrate (N03) as N	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Fluoride (F)	mg/L	0.10	1.24	1.21	1.22	1.24	1.23
Silica (S102)	mg/L	1.0	11.5	11.3	10.9	11.5	11.3
Non-Metals							
Total Dissolved Solids (TDS) @ 180°C	mg/L	1.0	1820	1810	1795	1790	1804
Conductivity	µmho/cm	1.0	2640	2750	2790	2710	2723
Alkalinity (CaCO3)	mg/L	1.0	327	331	326	329	328
pH	std. units	0.10	8.02	8.21	8	8.15	8.10
Trace Metals							
Aluminum (Al)	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Arsenic (As)	mg/L	0.001	< 0.001	< 0.001	0.002	< 0.001	<0.002
Barium (Ba)	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Boron (B)	mg/L	0.10	1.66	1.60	1.60	1.59	1.61
Cadmium (Cd)	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.01
Chromium (Cr)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
Copper (Cu)	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.01
Iron (Fe)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
Lead (Pb)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
Manganese (Mn)	mg/L	0.01	0.02	< 0.01	0.01	0.01	0.01
Mercury (Hg)	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.001
Molybdenum (Mo)	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Nickel (Ni)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05

Table 2.7-12: Laboratory Analysis Report - Chadron Well W-81

			RESULTS				
Major Ions	Units	Detection Limit	9/5/1996	12/13/1996	3/20/1997	6/26/1997	Average Value
Selenium (Se)	mg/L	0.001	< 0.001	0.175	< 0.001	< 0:001	<0.175
Vanadium (V)	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Zinc (Zn)	mg/L	0.01	0.02	0.01	0.02	< 0.01	<0.02
Radiometric							
Uranium (U nat)	mg/L	0.0003	< 0.0003	0.0060	<0.0003	0.0003	<0.0032
Radium 226 (Ra-226)	pCi/L	0.2	10.5	11.9	10.3	14.7	11.9
Radium Precision ±			0.4	0.6	0.6	1.3	
Quality Assurance Data		target range					
Anion	meq		27.55	27.94	27.93	27.31	27.68
Cation	meq		26.45	27.02	26.74	27.74	26.99
WYDEQ A/C Balance	%	-5 - +5	-2.04	-1.66	-2.18	0.77	-1.28
Calc TDS	mg/L		1754	1780	1773	1768	1769
TDS A/C Balance	dec. %	0.80 - 1.20	1.04	1.02	1.01	1.01	1.02

Table 2.7-13: Laboratory Analysis Report - Brule Well W-78

			RESULTS				
Major Ions	Units	Detection Limit	10/11/1996	12/13/1996	3/20/1997	7/17/1997	Average Value
Calcium (Ca)	mg/L	1.0	67.6	67.6	67.4	77.0	69.9
Magnesium (Mg)	mg/L	1.0	9.2	9.2	9.0	9.8	9.3
Sodium (Na)	mg/L	1.0	41.8	43.9	41.0	46.3	43.3
Potassium (K)	mg/L	1.0	16.6	16.7	16.1	16.9	16.6
Carbonate (CO3)	mg/L	0.10	0	0	0	0	0
Bicarbonate (HCO3)	mg/L	0.10	244	248	245	248	246
Sulfate (SO4)	mg/L	1.0	52.2	51.0	51.3	66.5	55.3
Chloride (Cl)	mg/L	0.10	26.9	27.0	27.2	31.9	28.3
Ammonium (NH4) as N	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
Nitrite (NO2) as N	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Nitrate (N03) as N	mg/L	0.10	6.12	5.66	5.76	5.47	5.75
Fluoride (F)	mg/L	0.10	0.38	0.35	0.38	0.35	0.37
Silica (S102)	mg/L	1.0	68.0	68.0	64.9	68.0	67.2
Non-Metals							
Total Dissolved Solids (TDS) @ 180°C	mg/L	1.0	423	432	479	443	436
Conductivity	µmho/cm	1.0	622	618	650	624	606
Alkalinity (CaCO3)	mg/L	1.0	203	201	203	202	200
pH	std. units	0.1	8.22	7.91	7.90	7.98	7.89
Trace Metals							
Aluminum (Al)	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Arsenic (As)	mg/L	0.001	0.005	0.003	0.006	0.007	0.005
Barium (Ba)	mg/L	0.10	0.20	0.20	0.19	0.20	0.20
Boron (B)	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Cadmium (Cd)	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.01
Chromium (Cr)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
Copper (Cu)	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.01
Iron (Fe)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
Lead (Pb)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
Manganese (Mn)	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.01
Mercury (Hg)	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.001
Molybdenum (Mo)	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Nickel (Ni)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05

Table 2.7-13: Laboratory Analysis Report - Brule Well W-78

			RESULTS				
Major Ions	Units	Detection Limit	10/11/1996	12/13/1996	3/20/1997	7/17/1997	Average Value
Selenium (Se)	mg/L	0.001	0.018	0.018	0.015	0.017	0.017
Vanadium (V)	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Zinc (Zn)	mg/L	0.01	0.04	0.02	0.02	0.03	0.02
Radiometric							
Uranium (U nat)	mg/L	0.0003	0.0123	0.0069	0.014	0.016	0.0123
Radium 226 (Ra-226)	pCi/L	0.2	<0.2	0.5	0.3	<0.2	0.4
Radium Precision ±				0.1	0.2		
Quality Assurance Data		target range					
Anion	meq		6.30	6.31	6.29	6.75	6.41
Cation	meq		6.41	6.50	6.33	7.13	6.59
WYDEQ A/C Balance	%	-5 - +5	0.81	1.53	0.38	2.73	1.36
Calc TDS	mg/L		432	433	425	465	439
TDS A/C Balance	dec. %	0.80 - 1.20	1.01	0.98	1.02	1.03	1.01

Based on similar regional deposition, the North Trend Expansion Area ore body is expected to be similar mineralogically and geochemically to that of the CSA. The ore bodies in the two areas are within the same geologic unit (i.e. Basal Chadron Sandstone) and have the same mineralization source (see Section 2.6). The sites are separated by only a few miles, and the cause of mineral deposition in the two areas appears to be similar (see Section 2.6). Neither site is anticipated to be affected by any recharge or other processes that would uniquely affect each area, so the groundwater characteristics of the CSA mineralized zone are presumed representative of that in the North Trend Expansion Area. Tables 2.7-14a through 2.7-14c are the Baseline and Restoration Values for Mine Units 1-3 in the CSA area (additional data for MU 1-9 are presented in Attachment 6.1[A]). The values in these tables are expected to be representative of the geochemical characteristics of the North Trend Expansion Area ore body. The North Trend Expansion Area ore body, the outline of which is presented on Figure 2.7-11, is considered a zone of distinct water quality characteristics primarily due to the presence of relatively concentrated uranium and radium in the zone when compared to the concentration of these parameters outside of the zone (e.g. Tables 2.7-12 vs. Tables 2.7-14a-c).

Available groundwater data for both the Brule and Chadron do not indicate that there are any documented flow rate variations or recharge issues that would impact groundwater quality. There are no surface water ponds within the area, and only limited stream flow (see Section 2.7.1). The Brule, while considered an overlying aquifer, is not an extensive or exceptionally productive system. The available monitoring data (Table 2.7-3) do not indicate any seasonality or pumping effects by domestic wells within this zone. With respect to the Basal Chadron Sandstone, there are no domestic wells completed within this interval in the immediate North Trend area, and there is no information to indicate that there are recharge or flow rate issues associated with the Basal Chadron Sandstone that would affect groundwater quality.

During the course of mining the water quality is expected to change as outlined in Table 2.7-15. The chemicals used in the mining and recovery process will include sodium bicarbonate, an oxidizer such as oxygen, carbon dioxide, and chloride for elution. As a result, the greatest changes in water quality are expected to be in alkalinity, bicarbonate, chloride, sodium, conductivity, and TDS. Significant increases are also likely to occur in calcium concentrations as a result of ion exchange with clays. The oxidant will cause significant increases in uranium, vanadium, and radium and minor increases in trace metals such as copper, arsenic, molybdenum and selenium. The genesis of the ore body and the facies of the host rock at North Trend are similar to that of the CSA so it is probable the change in water quality at North Trend will be similar to that experienced at the CSA. Historic restoration activities at the CSA have demonstrated the ability to successfully restore groundwater to established restoration standards. As indicated in Section 2.7.1, Spring Creek and an unnamed creek are within the North Trend Expansion

Table 2.7-14a: Baseline and Restoration Values for CSA Mine Unit 1

Baseline and Restoration Values for CSA Mine Unit 1	Groundwater Standard	MU-1 Baseline (Primary Standard)	MU-1 Standard Deviation	MU-1 NDEQ Restoration Value
Ammonium (mg/l)	10	<0.372		10
Arsenic (mg/l)	0.05	<0.00214		0.05
Barium (mg/l)	1	<0.1		1
Cadmium (mg/l)	0.01	<0.00644		0.005
Chloride (mg/l)	250	203.9	38	250
Copper (mg/l)	1	<0.017		1
Fluoride (mg/l)	4	0.686	0.04	4
Iron (mg/l)	0.3	<0.0441		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.011		0.05
Molybdenum (mg/l)	1	<0.0689		1
Nickel (mg/l)	0.15	<0.0340		0.15
Nitrate (mg/l)	10	<0.050		10
Lead (mg/l)	0.05	0.0315		0.05
Radium (pCi/L)	5	229.7	177.1	584
Selenium (mg/l)	0.01	<0.00323		0.05
Sodium (mg/l)	N/A	412	19.2	4120
Sulfate (mg/l)	250	356.2	9.4	375
Uranium (mg/l)	5	0.0922	0.089	5
Vanadium (mg/l)	0.2	<0.0663		0.2
Zinc (mg/l)	5	<0.036		5
pH (Std. Units)	6.5 - 8.5	8.46	0.2	6.5 – 8.5
Calcium (mg/l)	N/A	12.5	3.2	125
Total Carbonate (mg/l)	N/A	351	31.1	585
Potassium (mg/l)	N/A	12.5	1.5	125
Magnesium (mg/l)	N/A	3.2	0.8	32
TDS (mg/l)	N/A	1170.2	47.6	1170.2

Table 2.7-14b: Baseline and Restoration Values for CSA Mine Unit 2

Baseline and Restoration Values for CSA Mine Unit 2	Groundwater Standard	MU-2 Baseline (Primary Standard)	MU-2 Standard Deviation	MU-2 NDEQ Restoration Value
Ammonium (mg/l)	10	0.37	0.07	10
Arsenic (mg/l)	0.05	<0.001		0.05
Barium (mg/l)	1	<0.1		1
Cadmium (mg/l)	0.005	<0.007		0.005
Chloride (mg/l)	250	208.6	30.8	250
Copper (mg/l)	1	<0.013		1
Fluoride (mg/l)	4	0.67	0.04	4
Iron (mg/l)	0.3	<0.045		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.01		0.05
Molybdenum (mg/l)	1	<0.073		1
Nickel (mg/l)	0.15	<0.037		0.15
Nitrate (mg/l)	10	<0.039		10
Lead (mg/l)	0.05	<0.035		0.05
Radium (pCi/L)	5	234.5	411.8	1058
Selenium (mg/l)	0.05	<0.001		0.05
Sodium (mg/l)	N/A	410.8	18.2	4108
Sulfate (mg/l)	250	348.2	10.3	369
Uranium (mg/l)	5	0.046	0.037	5
Vanadium (mg/l)	0.2	<0.07		0.2
Zinc (mg/l)	5	<0.026		5
pH (Std. Units)	6.5 - 8.5	8.32	0.2	6.5 – 8.5
Calcium (mg/l)	N/A	13.4	2.4	134
Total Carbonate (mg/l)	N/A	366.9	13.3	585
Potassium (mg/l)	N/A	12.6	2.5	126
Magnesium (mg/l)	N/A	3.5	0.4	35
TDS (mg/l)	N/A	1170.4	41	1170.4

Table 2.7-14c: Baseline and Restoration Values for CSA Mine Unit 3

Baseline and Restoration Values for CSA Mine Unit 3	Groundwater Standard	MU-3 Baseline (Primary Standard)	MU-3 Standard Deviation	MU-3 NDEQ Restoration Value
Ammonium (mg/l)	10	<0.329		10
Arsenic (mg/l)	0.05	<0.001		0.05
Barium (mg/l)	1	<0.1		1
Cadmium (mg/l)	0.005	<0.01		0.005
Chloride (mg/l)	250	197.6	16.7	250
Copper (mg/l)	1	<0.0108		1
Fluoride (mg/l)	4	0.719	0.05	4
Iron (mg/l)	0.3	<0.05		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.01		0.05
Molybdenum (mg/l)	1	<0.1		1
Nickel (mg/l)	0.15	<0.05		0.15
Nitrate (mg/l)	10	<0.0728		10
Lead (mg/l)	0.05	<0.05		0.05
Radium (pCi/L)	5	165	222.5	611
Selenium (mg/l)	0.05	<0.00115		0.05
Sodium (mg/l)	N/A	428	27.6	4280
Sulfate (mg/l)	250	377	13.4	404
Uranium (mg/l)	5	0.115	0.158	5
Vanadium (mg/l)	0.2	<0.1		0.2
Zinc (mg/l)	5	<0.0131		5
pH (Std. Units)	6.5 - 8.5	8.37	0.3	6.5 – 8.5
Calcium (mg/l)	N/A	13.3	3.1	133
Total Carbonate (mg/l)	N/A	358.7	24.8	592
Potassium (mg/l)	N/A	13.9	4	139
Magnesium (mg/l)	N/A	3.5	0.9	35
TDS (mg/l)	N/A	1183	47.4	1183

Table 2.7-15: Anticipated Changes in Water Quality During Mining

Average Ore Zone Water Quality			
Analyte	**Units**	**Pre-Mining (Well W-007)**	**Typical Water Quality During Mining at CSA**
Alkalinity, Total as CaCO3	mg/L	328	1,600
	mg/L	0	<1.0
Bicarbonate as HCO3	mg/L	401	2,050
Calcium	mg/L	29.6	77
Chloride	mg/L	202	600
Fluoride	mg/L	1.23	0.6
Magnesium	mg/L	5.3	23
Ammonia as N	mg/L	0.74	<0.05
Nitrate+Nitrite as N	mg/L		0.46
Potassium	mg/L	15.0	35
Silica	mg/L	11.3	21
Sodium	mg/L	567	1,310
Sulfate	mg/L	737	900
Conductivity	umhos/cm	2,723	6,000
pH	s.u.	8.1	7.8
TDS	mg/L	1,804	4,080
Aluminum	mg/L	<0.10	<0.1
Arsenic	mg/L	<0.002	0.06
Barium	mg/L	<0.10	<0.1
Boron	mg/L	1.61	1.1
Cadmium	mg/L	<0.01	<0.005
Chromium	mg/L	<0.05	<0.05
Copper	mg/L	<0.01	0.04
Iron	mg/L	<0.05	<0.030
Lead	mg/L	<0.05	<0.05
Manganese	mg/L	0.01	0.05
Mercury	mg/L	<0.001	<0.001
Molybdenum	mg/L	<0.10	0.5
Nickel	mg/L	<0.05	<0.05
Selenium	mg/L	<0.175	0.07
Uranium	mg/L	<0.0032	44
Vanadium	mg/L	<0.10	2.5
Zinc	mg/L	<0.02	0.02
Radium 226	pCi/L	11.9	1,090

Area, and are northern tributaries of the White River. Both of the creeks are ephemeral and therefore could not be sampled on a seasonal basis for a period of one or more years. The White River is present to the south of the North Trend Expansion Area, and is perennial.

2.7.4 WATER USE INFORMATION

As discussed previously in Section 2.2, local water use is very limited. Isolated household wells are completed in the Brule Formation, and the city of Crawford uses two wells completed in the Brule outside the North Trend Expansion Area (see Figure 2.2-4). One well completed in the Basal Chadron is used for household purposes (Well No. 61; approximately 1.5 miles southeast of the expansion area boundary).

2.7.5 CONCEPTUAL MODELING OF SITE HYDROLOGY

Tables 2.6.1 and 2.6.2 present the regional and local stratigraphic columns within the North Trend area. As shown in these figures, the principal aquifers within the North Trend area are the Basal Chadron Sandstone, intermittent Upper/Middle Chadron sand, a sandy interval in the Brule Formation, and rarely, alluvial deposits. The Basal Chadron Sandstone is isolated from underlying sandstone intervals by more than 1,500 feet of thick Pierre Shale. Overlying confinement between the Basal Chadron and the Upper/Middle Chadron sand is provided by more than 200 feet of clay and shale in the Middle Chadron interval. Additional Overlying confinement above the Basal Chadron Sandstone is provided by more than 300 feet of clay and shale in the Brule Formation and the Upper Chadron.

Water level data presented in Figures 2.7-12, 2.7-13, and 2.7-14 show each saturated zone to have distinct elevations, with the Basal Chadron Sandstone water elevations approximately 80 to 90 feet higher than overlying units (Brule and Upper/Middle Chadron sand) indicating confined conditions within the Basal Chadron. Water level data indicate that the Brule is unconfined. Water level data support hydrologic isolation of the Basal Chadron Sandstone with respect to the other water-bearing intervals of interest in the North Trend Expansion Area. Ground water production rates within the Brule and Upper/Middle Chadron sands are low to exceptionally low.

The geochemical groundwater characteristics of the Brule and Chadron further indicate that the two zones are not naturally interconnected. For example, Table 2.7-11b shows that sulfate, sodium, and chloride concentrations as well as specific conductance significantly differ between the Brule and Basal Chadron Sandstone.

Groundwater information (Figure 2.7-12) indicates that groundwater within the Brule flows in a general east/northeastern direction in the North Trend Expansion Area with a gradient of about 0.005 ft/ft, toward the White River. This interval, in all likelihood, is

dissected by the White River, which is either gaining from the Brule or losing to the Brule, depending upon the season. Alluvial deposits along the margins of the White River may offer limited groundwater storage depending on river levels. Recharge to the Brule likely occurs directly at or immediately north of North Trend, as geologic maps indicate this interval subcrops in the North Trend Expansion Area.

The Basal Chadron Sandstone outcrops approximately 10 miles north of the North Trend Expansion Area, where recharge occurs. Potentiometric maps (Figure 2.7-14) indicate groundwater flow within the Basal Chadron is predominantly to the east in the North Trend Expansion Area with a gradient of approximately 0.0016 ft/ft (8.5 ft/mile). This flow is roughly concurrent with the local dip on the top of the Basal Chadron sand. The Basal Chadron sand is over 500 feet below the base of the White River.

There is no identified hydraulic communication between the Basal Chadron and the White River. However, a distinct structural feature occurs in the general area of the White River (see Section 2.6.2), a monocline or fold within the Pierre, Chadron and Brule Formations, possibly caused by movement along a fault that is present at depth, but which terminates before transecting these near surface formations. Along this feature, the orientation and dip of the Chadron changes from dipping to the southeast to the northwest.

Regional data regarding flow in the Basal Chadron are limited. Based on those data, the structural feature does not appear to dramatically impact flow in the Basal Chadron Sandstone. Additional investigations to be conducted during development of North Trend are expected to provide detailed information regarding the impact of this feature on regional and local flow in the Basal Chadron.

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2.7 HYDROLOGY

NUREG 1569 Section 2.7 states: "Characterization of the hydrology at *in situ* leach uranium extraction facilities must be sufficient to establish the potential effects of *in situ* operations on the adjacent surface-water and groundwater resources and the potential effects of surface-water flooding on the *in situ* leach facility." To meet these requirements, this section addresses surface water features (Section 2.7.1), groundwater characteristics (Section 2.7.2), surface water and groundwater quality (Section 0), water use information (Section 2.7.4) and the overall hydrologic conceptual model for the North Trend area (Section 0) based on site geology and hydrology.

Because of the extensive historical operations at the current licensed mining area (referred to herein as the Commercial Study Area [CSA]), Crow Butte has conducted more limited investigation/sampling for North Trend than would have been conducted if North Trend were a remote property. References to data from the CSA are used throughout this section, and distinctions between the two areas noted where warranted.

2.7.1 Surface Water

The North Trend Expansion Area lies within the watershed of Spring Creek and an unnamed creek which are small tributaries to the major regional water course, the White River.

Based on available maps and site investigations conducted by CBR, no surface water impoundments, lakes or ponds have been identified within the North Trend Expansion Area. Permanent impoundments occur southeast of the North Trend Expansion Area, but these are south of the White River and hydraulically isolated from North Trend.

2.7.1.1 Location

The North Trend Expansion Area lies in Sections 21, 22, 27, 28, 33, and 34 of Township 32 North, Range 52 West within the drainage basin of the White River. The White River originates in Sioux County and flows northeasterly across Dawes County into South Dakota. Tributaries of the White River northeast of the Crawford area cross upland portions of the Pierre Shale, an impermeable formation. These streams are dry except for runoff flow, and include the ephemeral Spring Creek and an unnamed creek that occur within the boundaries of North Trend. The southern tributaries, across the White River and to the south – southeast of North Trend, originate in the Pine Ridge escarpment, and flow primarily over forest, range, and agricultural land. These streams are generally ephemeral except for source water from occasional springs.

Spring Creek and the unnamed creek within the North Trend Expansion Area are northern tributaries of the White River. The unnamed creek originates in Red Cloud Buttes southwest of the North Trend Expansion Area. Spring Creek originates in the hills

of the Fort Robinson Wildlife Area, west of North Trend. From the headwaters, these ephemeral creeks flow eastward over range and agricultural land to the White River. Contributions to flow appear to be snowmelt and runoff, as well as springs. Figure 2.7-1 shows the location of all surface water features in the North Trend Expansion Area.

Spring Creek enters the proposed North Trend license boundary from the west in Section 21. The creek flow direction then changes to nearly due north. At the northern edge of the North Trend license boundary, a historic diversion canal (the Hall Canal) was constructed to direct flow from Spring Creek to the White River. Vestiges of this diversion canal can still be found in some locations. The unnamed creek crosses only the far southwestern edge of the North Trend Expansion Area (Section 34) before discharging to the White River. The White River crosses into the North Trend license boundary in the southern portion of Section 34.

2.7.1.2 Stream Flow

Table 2.7-1 shows the mean monthly discharge of the White River as compared to the mean monthly precipitation over several years (NOAA, 2006). These extended data show that a general correlation can be made between the direct precipitation and discharge. Higher flows are recorded in spring and early summer with lowest flow rates in late summer to early fall, reflecting seasonal changes related to precipitation. For the period of 1931 to 2004 the average normal annual mean discharge at the White River Station at Crawford was 20.3 cubic feet per second (cfs) with a standard deviation of 2.8 cfs. The maximum was 27 cfs and the minimum was 13 cfs.

Peak rainfall at Harrison and Scottsbluff, Nebraska occurs in May and June (NOAA, 1976 and 1980), and this precipitation pattern appears to be representative of the Crawford area. Table 2.7-2 provides mean monthly discharge information for the White River for 1992 through 1995, as well as data for 2004 and 2005. The recent data for the White River is comparable to the stream flow data shown in Table 2.7-1.

No flow measurements were attempted on Spring Creek or the unnamed creek due to the seasonal nature of flow in these features.

Figure 2.7-1: Map of North Trend Surface Water Features

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~~2.7.1.2 Stream Flow~~

~~Table 2.7-1 shows the mean monthly discharge of the White River as compared to the mean monthly precipitation over several years (NOAA, 2006). These extended data show that a general correlation can be made between the direct precipitation and discharge. Higher flows are recorded in spring and early summer with lowest flow rates in late summer to early fall, reflecting seasonal changes related to precipitation. For the period of 1931 to 2004 the average normal annual mean discharge at the White River Station at Crawford was 20.3 cubic feet per second (cfs) with a standard deviation of 2.8 cfs. The maximum was 27 cfs and the minimum was 13 cfs.~~

~~Peak rainfall at Harrison and Scottsbluff, Nebraska occurs in May and June (NOAA, 1976 and 1980), and this precipitation pattern appears to be representative of the Crawford area. Table 2.7-2 provides mean monthly discharge information for the White River for 1992 through 1995, as well as data for 2004 and 2005. The recent data for the White River is comparable to the stream flow data shown in Table 2.7-1.~~

~~No flow measurements were attempted on Spring Creek or the unnamed creek due to the seasonal nature of flow in these features.~~

Table 2.7-1: Comparison of Mean Monthly Precipitation With Normal Mean Monthly Discharge of the White River at Crawford, Nebraska

Month	Mean Precipitation [1]		Mean Discharge [2]	
	inches	centimeters	Ft^3/sec	$Meters^3$/sec
January	0.61	1.55	21	0.59
February	0.76	1.93	23	0.65
March	1.74	4.42	27	0.76
April	2.65	6.73	25	0.71
May	3.11	7.9	27	0.76
June	2.42	6.15	22	0.62
July	2.77	7.04	16	0.45
August	1.21	3.07	13	0.37
September	1.38	3.51	14	0.4
October	1.66	4.22	17	0.48
November	0.82	2.08	19	0.54
December	0.79	2.01	20	0.57

1 - Climatology of the US No. 81, 1971-2000, NOAA, 25-Nebraska.
2 - U.S. Department of the Interior, 1981, Period of Record 1931-2004 (see http://waterdata.usgs.gov/nwis/sw)

Table 2.7-2 Normal Mean Monthly Discharge of the White River at Crawford (06444000), (cubic feet per second)

Monthly	1992[a]	1993[a]	1994[a]	1995[a]	1996[a]	1997[a]	1998[a]	1999[a]
January	21.4	20.7	21.4	20.3	22.3	23.3	23.1	22.6
February	22.5	23.5	23	21.5	24.4	20.4	22.7	22.4
March	22.3	31.2	23.3	19.7	24.0	19.4	24.8	23.1
April	20.0	26.1	21.3	22.1	23.4	22.8	24.2	26.1
May	18.8	19.7	19.6	27	26.3	27.6	22.1	23.7
June	18.1	30.6	14	29.8	20.4	27.0	10.9	27.1
July	15.6	25.3	12.3	18.5	17.5	17.3	17.4	21.4
August	12.4	16.4	9.87	12.9	14.1	16.4	15.6	15.0
September	12.4	17.8	11.1	13.6	14.5	14.4	13.4	17.0
October	16.0	20.9	16.3	18.8	16.6	17.2	20.9	19.4
November	18.8	21.2	17.9	19.8	20.1	20.4	22.5	20.8
December	22.9	26.4	18.8	19.7	20.8	21.7	21.3	21.4
Average	**18.4**	**23.3**	**17.4**	**20.3**	**20.4**	**20.7**	**19.9**	**21.7**

Monthly	2000[b]	2001[b]	2002[b]	2003[b]	2004[b]	2005[b]	2006[b]	2007[b]
January	21.7	21.0	22.9	22.6	23.0	23.9	24.1	18.9
February	24.1	24.3	23.6	24.0	24.8	23.3	24.5	20.2
March	25.5	27.0	26.8	26.4	25.9	24.5	26.4	22.6
April	29.1	26.4	25.3	26.5	22.7	25.3	25.9	23.4
May	10.0	24.7	23.9	25.9	21.1	26.5	23.2	20.2
June	20.5	18.6	16.6	23.2	17.1	26.5	17.8	15.9
July	15.4	14.4	10.3	13.2	17.4	17.6	11.0	10.0
August	11.5	12.5	10.1	11.7	11.3	18.1	10.0	4.1
September	12.1	12.9	13.7	23.3	17.8	14.8	14.8	8.7
October	17.4	17.2	18.1	17.5	20.8	18.5	18.6	[c]
November	20.1	22.0	22.3	22.6	21.3	21.0	21.1	[c]
December	20.7	22.2	22.2	23.1	22.1	23.1	21.3	[c]
Average	**16.7**	**20.3**	**19.7**	**21.6**	**20.4**	**21.9**	**19.9**	**16.0**

[a] USGS 2009 (USGS National Water Information System for USGS gauging station 06444000)
[b] Nebraska Department of Natural Resources (NDNR) 2009.
[c] Data not available for fourth quarter of 2007 The USGS ceased flow data measurements at this gaging station on June 14, 2007 (D.L. Curtis 2009).

2.7.1.3 Surface Water Impoundments

No private surface water impoundments have been identified at or within the North Trend Expansion Area. Similarly, no naturally occurring lakes or ponds have been identified within the boundary.

2.7.1.4 Assessment of Surface Water Features

As shown in Tables 2.7-1 and 2.7-2, the average monthly stream flow of the White River at the Crawford gauge station is about 20 cfs. The highest discharge and gauge height on record between 1920 and 2004 occurred on May 10, 1991. On that date, severe thunderstorms resulted in significant rainfall, the gauge height was 16.32 feet and the stream flow exceeded 13,300 cfs (State of Nebraska Department of Natural Resources, 2004). Several city facilities were damaged by floodwaters and hail, including the local golf course and fish hatchery, and the event was considered a "100 year" flood. The Rocky Mountain News (May 12, 1991) reported that mobile homes were swept away and the town's water system was knocked out of service. However, it is noted that, while there are certainly historical extremes, the average gauge height on the White River at Crawford is less than 5 feet, with an average annual stream flow of 20.2 cfs.

An assessment of the potential for flooding or erosion that could impact the in-situ mining processing facilities and surface impoundments has been performed based on data from the Federal Emergency Management Agency (FEMA; http://msc.fema.gov). FEMA has not mapped unincorporated Dawes County north of Crawford, Nebraska; however, FEMA maps are available for the City of Crawford, and an analogy can be drawn between the flooding potential in Crawford and that immediately north of Crawford adjacent to the proposed North Trend Expansion Area. As shown in Figure 2.7-1a, FEMA has classified the portion of Crawford between the D M & E Railroad (immediately west of First Street) as Zone A (i.e., an area that could be impacted by a 100-year flood) (*Managing Floodplain Development in Approximate Zone A Areas; FEMA, April 1995*). The elevation of the White River in the Zone A classification ranges from 3,669 to 3,659 feet AMSL. The surface elevation of the railroad tracks ranges from 3,678 to 3,671 feet AMSL. These data suggest that significant flooding potential exists with a rise in the White River elevation of 9 to 12 feet above base flow conditions. This is consistent with the data from the 1991 100-year flood event, where the river elevation was approximately 11.3 feet above base gauge height (approximately 5 feet).

The proposed North Trend surface facilities are to be located in the north-central portion of Section 27, approximately one mile northwest of White River, and approximately 70 feet topographically above the common river elevation. Proposed wellfields are planned for portions of Sections 21, 22, 27, 28, 33 and 34, T32N, R52W (Figure 2.7-1). With the exception of Section 34, the wellfields are projected to be at least 50 feet above the White River elevation.

The portion of the proposed North Trend Expansion Area where the greatest flooding potential related to the White River exists is the southeast part of Section 34 (Figure 2.7-1). The White River elevation in that area varies from 3,645 feet AMSL on the western portion of the southern permit boundary, to 3,622 feet AMSL to the northeast. Because of lower elevation and proximity to the White River, final wellfield layout in Section 34 may necessitate consideration of potential flood impacts (e.g., below a surface elevation of 3,657 feet on the west, and 3,634 feet to the northeast).

Based on these data, the North Trend surface facilities occur outside of the 100 year flood plain, and are not considered to be in a "flood prone" area. Therefore, consistent with NUREG-1623, erosion modeling was not considered necessary or performed.

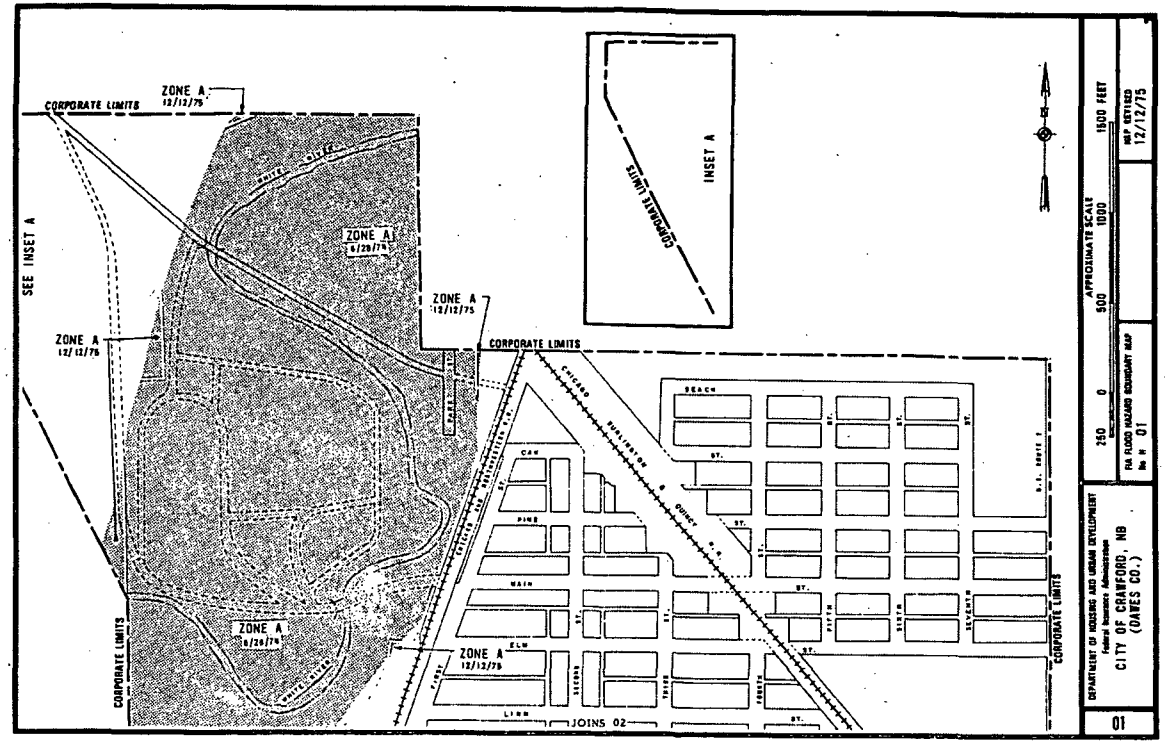
The operational areas in Section 34 nearest the White River having the highest potential of a major release reaching the White River will be Mine Units NT-7 and NT-9. Therefore, risks are primarily associated with wellfield operations. As described in Section 2.2 above, the North Trend operations will be operated in a manner to prevent any large releases of mining fluids such as pregnant lixiviant. In addition to the operational controls, the wellfield areas would be installed with dikes or berms to prevent spilled process solutions from entering the White River. Wellfield workers at North Trend conduct daily inspections and would be in a position to observe any such major releases. Risks associated with a wellfield spill risk are discussed in Section 7.5.4 of the application, and spill contingency plan measures are discussed in Section 5.7.1.3 of the application.

The North Trend Area does not include any major surface water features other than the White River. This feature is used to support agricultural production, wildlife habitat, and both warm- and cold-water fish. Upstream from the North Trend Expansion Area, the White River supplies drinking water for the City of Crawford (see Section 2.2 for additional discussion).

2.7.1.5 Water Quality

Water samples were collected from the single perennial surface water feature identified within the North Trend Expansion Area, the White River. White River water quality data were assembled by EPA for various years from 1969-1994. These data, as well as groundwater quality sampling results, are presented in Section 2.7.3

Figure 2.7-1a: FEMA Zone A Flood Map



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2.7.2 Groundwater

This section describes the regional and local groundwater hydrology including local and regional hydraulic gradient and hydrostratigraphy, hydraulic parameters, baseline water quality conditions, and local groundwater use including well locations related to the North Trend Expansion Area. The discussion is based on information from investigations performed within the North Trend Expansion Area, data presented in previous applications/reports for the Commercial Study Area (CSA) where In Situ Leach (ISL) mining is being conducted, and the geologic information presented in Section 2.6. In this regard, the hydrogeology of the North Trend Area is expected to be similar in many respects to that encountered in the CSA, recognizing that North Trend is on the north side of the White River while the CSA is on the south side of this river.

The hydrostratigraphic section of interest for North Trend includes the following (presented in descending order):

- Alluvium
- Brule Formation (including the first "aquifer" in the Brule sand/clay)
- Chadron Formation (Upper Confining Unit including the Upper Chadron confining layer, Middle/Upper Chadron sand [aquifer, where present], and Middle Chadron confining layer)
- Basal Chadron Sandstone (Mining Unit)
- Pierre Shale (Lower Confining Unit)

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With regard to the Crow Butte Uranium Project and the North Trend Area in particular, two groundwater sources are of interest in the Crawford and Crow Butte area. These are the Brule Formation sand and the Basal Chadron Sandstone. The Basal Chadron Sandstone contains the uranium mineralization in the CSA, and at North Trend.

2.7.2.1 Regional Groundwater Hydrology

A map prepared by Souders (2004) indicates that the water table configuration in the region trends north-northeast. No published regional water level maps are available for the Basal Chadron Sandstone or the local Brule Formation sands. Souders (2004) states that aquifers within the White River Basin, which encompasses the northern half of Dawes County, are "nearly nonexistent". He indicates that a groundwater divide occurs to the south of the CSA along the Pine Ridge; groundwater north of this divide in the CSA and North Trend Expansion Area flows to the north, northwest and northeast, depending upon location with respect to the White River. The Brule Formation, Chadron Formation and Pierre Shale outcrop progressively northward from the Pine Ridge divide through the White River Basin, and Souder states that none of these formations "are considered major sources of groundwater".

Souder indicates that the Brule Formation is a tight formation with a minimal hydraulic conductivity of less than 25 feet/day, although in a few areas there may be a significant saturated thickness, presumably where sandier intervals are present. The Chadron Formation is described as consisting of claystones with extensive volcanic ash that is tight with low hydraulic conductivity comparable to the Brule Formation, except where fractured, although the coarse Basal Chadron Sandstone is present at the bottom of the formation. The Pierre Shale is described by Souders (2004) as a dark grey, bentonitic shale that is "very tight and is not considered to hold any extractable groundwater" except where fractured. Fractures may increase Brule Formation and Chadron Formation permeability in localized areas (Souders, 2004). It is noted that CBR operations in the CSA to date do not support evidence of fracturing in the Pierre Shale to a degree such that it would impact the designation of the Pierre Shale as a lower confining unit below the Basal Chadron Sandstone.

Prior to mining in the CSA, water levels were measured in existing wells throughout the Crawford-Crow Butte area for the local Brule Formation sand and the Basal Chadron Sandstone. Historical water level data for a one-year period from wells located in the CSA are included on Tables 2.7-3a (Brule Formation wells) and 2.7-3b (Basal Chadron Sandstone wells). Maps showing the regional water levels for these two aquifers are included as Figures 2.7-2 and 2.7-3.

South of the White River, historical water levels measured in the Brule Formation in the 1982 to 1983 timeframe indicate groundwater flow in the Brule Formation is to the

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Table 2.7-3a: Brule Water Levels (in feet above mean sea level)

Well	1982 Jan	Feb	Mar	April	May	June	July	August	Sept	Oct	Nov	Dec	1993 April	1993 July
11**	3831.7	3831.5	3831.8	3833	3833	3833.6	3833	3832.6	3831.5	3830.6	3830.3.	3830.3	3843.5*	3837
12**	3928	3924	3923	3922.7	3923.7	3921.1	3922.1	3921.5	3922.2	3921.3	3903.3*	3918.7	3922.9	3920
13	3968.5	3968.7	3968.8	3969.4	3969.6	3969.2	3969.5	3968.9	3968.1	3967.5	3968.1	3968.4	3969	3970
17	3865	3863.5	3863.3	3862.6	3863.6	3864.8	3863.3	3862.8	3863.5	3863.8	3865.3	3864.6	3864.8	3862.8
24**	3902	3910.5	3909	3903	3910.9	3910.5	3910.5	3910	3904.7	3901.5	3895.7*	3910.1	3910.4	3911
25	3870	3870.8	3870	3871	3871	3871.3	3869.5	3870.9	3870.6	3870.5	3870.8	3870.9	3870.1	3871.6
31**	3883.1	3883.1	3883.2	3883.1	3883.3	3883	3882.6	3882.3	3882.6	3880	3882.3	3882.5	388.2	3872.3*
64	3882	3882.9	3882.6	3883.5	3883.6	3883.8	3881.4	3880.8	3881.5	3880	3880.4	3882	3884.3	3883.5

	1982 Sept	Oct	Nov	Dec	1983 Jan	Feb	March	April	May	June	July	August	Sept
RA-2	3737.1	3737	3738.5	3737.9	3739.2	3739.1	3739.7	3740.2	3740.9	3741	3739.9	3739.2	3738.1
RB-3	3962.6	3961.2	3963.5	3963.6	3963.8	3963.8	3963.3	3969.7*	3963.7	3963.7	3964.2	3964.1	3964.2
PM-6	------	3844.9	3844.9	------	3843.5*	3844.5	3844.9	3845.3	3845.5	3846	3845.9	3945.9	3845.7
PM-7	------	3845.7	3845.5	------	3845.9	3845.8	3845.7	3846.1	3846.3	3846.9	3846.7	3846.7	3846.6

Notes: *Suspect Data
**Well may have been pumped prior to water level reading.

Table 2.7-3b: Basal Chadron Water Levels
(in feet above mean sea level)

Well	1982 Sept	Oct	Nov	Dec	1983 Jan	Feb	March	April	May	June	July	August	Sept
62	3748.4	3748	3747.2	3746.6	------	------	3746.1	3746.2	------	------	3746.1	3745.8	3745.4
RC-4	------	------	------	3746.7	------	------	------	3746.2	------	------	3746.2	3746.2	3746.3
RC-5	3753.6	3753.4	3753.4	3753.2	3753	3752.6	3752.7	3752.9	3752.8	3752.9	3752.7	3752.5	3752.4
RC-6	3755.2	3755.2	3755.7	3756.8	3757.5	3754.7	3754.9	3755.7	3755.6	3755.6	3755.4	3755.2	3754.7
RC-7	3755.2	3756.8	3756.3	3756.2	3756.4	3755.8	3756	3756.4	3756.5	3756.7	3756.2	3756.1	3755.9
PM-1	------	3754.5	3754.4	3754.1	3754.3	3754	3753.8	3754	3754.2	3754.1	3753.8	3753.5	3753.5
PM-4	------	3755.2	3755.2	3754.4	3754.4	3754.1	3754.2	3754.4	3754.8	3754.6	3754.3	3753.9	3754.6
PT-2	------	3747.1*	3747.1*	3754	3754.6	3754.3	3754.1	3754.3	3754.5	3754.7	3754.3	3753.9	3753.7
PT-7	------	3755.1	3755	3754.2	3754.2	3754	3754	3754.1	3754.8	3754.6	3754.3	3754.1	3753.9
PT-8	------	3755.5	3755.6	3754.6	3754.4	3754.4	3755.7	3754.4	3754.5	3754.6	3754.2	3753.8	3753.7
PT-9	------	3753.5	3753.5	3754.9	3754.6	3754.6	3754.6	3754.8	3854.8	3754.9	3754.5	3754.3	3754.1

Notes: *Suspect Data

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Figure 2.7-2 Regional Water level map Brule Sandstone (1982-1983)

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Figure 2.7-3 Regional water level Map Basal Chadron Sandstone 1982 – 1983

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northwest toward the White River with an average hydraulic gradient of approximately 0.011 ft/ft (Figure 2.7-2). North of the White River, recently collected water levels in the Brule Formation in the North Trend Area indicate groundwater flow is similarly convergent with the White River (see discussion in Section 2.7.2.2).

The Basal Chadron Sandstone is an artesian (confined) aquifer, and wells completed in it may flow to the surface near the White River. Figure 2.7-3 shows the location of artesian wells in the region. Artesian wells screened in the Basal Chadron Sandstone occur throughout the North Trend Area and in the vicinity of the White River. South of the White River, historic water levels indicate the direction of groundwater flow in the Basal Chadron Sandstone is to the north. Farther to the south, the potentiometric surface is almost flat. In the vicinity of the North Trend Area, groundwater flow in the Basal Chadron Sandstone is toward the east-southeast (see discussion in Section 2.7.2.2).

Regionally, the principal water bearing rocks below the Pierre Shale are the G Sand, J Sand, and the Dakota, Morrison and Sundance Formations. The Total Dissolved Solids (TDS) concentrations of the water below the Pierre Shale have been interpreted from deep oil and gas exploration logs. The Dakota Sandstone is at a depth of 2,972 to 3,020 feet in the Bunch No. 1 hole (Section 5, T31N, R52W). The minimum TDS of the water in the Dakota Sandstone, calculated from the spontaneous potential and sonic logs, is estimated to range from 14,000 to 26,000 mg/l (as NaCl). Based on samples collected during the installation and testing of the Crow Butte deep disposal well (DW #1, Section 19, T31N, R51W) located approximately six miles southeast of the North Trend area, TDS levels in the Morrison Formation (3,580 feet midpoint depth) and Sundance Formation (3,784 feet) are approximately 24,000 and 40,000 mg/l, respectively.

The Pierre Shale is essentially impermeable which precludes its use as a water supply. A number of shallow wells are reported as having the Pierre Shale as the bedrock unit (Spalding, 1982) in Township 32 North, Range 51-52 West. These wells range in depth from 18 to 100 feet with an average depth of 44 feet, and were drilled in areas that have considerable alluvium atop the Pierre Shale, including locations along Spring Creek and the White River between Crawford and Whitney Lake. These wells produce water from a few tens of feet of Quaternary Alluvium overlying the Pierre Shale, with the bottom few tens of feet in those wells providing storage. Spalding (1982) states that; *"In very shallow wells (a few tens of feet) significant amounts of water utilized may be contained in the thin Quaternary sediments overlying the designated hydrogeologic unit. This situation is particularly true for those wells noted as completed in the Pierre Shale"*. In the geologic summary of the Spalding report, the groundwater potential of the Pierre Shale is discussed by Marvin Carlson (page 14), *"The oldest bedrock unit in the area, the Pierre Shale of Cretaceous Age, is not considered as a potential aquifer. It is, however, included in the discussion of completion horizons and hydrogeologic units. A few of the shallow wells produce from the Quaternary sediments immediately overlying the Pierre Shale"*.

2.7.2.2 North Trend Area Groundwater Hydrology

The hydrogeologic system within and surrounding the Crow Butte CSA is similar to that found regionally, including North Trend.

Alluvial deposits occur intermittently in ephemeral drainages, but are not considered to be a reliable water source. Over most of the North Trend Expansion Area, the Brule Formation outcrops, and is underlain by the Chadron Formation (including the Basal Chadron Sandstone) and the Pierre Shale. The occurrence and thickness of these geologic units within North Trend have been confirmed during exploratory drilling and logging activities. Based on these data, the relationship of the hydrostratigraphic units within North Trend is shown on a cross-section location map (Figure 2.7-4) and six cross-sections (Figures 2.7-5 through Figure 2.7-10). Appendix B presents data for the boreholes used in cross-section construction, and Table 2.7-4 summarizes information pertaining to these boreholes, including data from boreholes completed as wells.

The Basal Chadron Sandstone, the aquifer which is host to the uranium mineralization, is bounded above and below by strata, which form aquicludes. The term "aquiclude" is used to describe strata capable of transmitting only minor amounts of fluid either vertically or horizontally. Typical values for vertical and horizontal permeability of "aquicludes" are in the range of 10^{-4} to 10^{-5} darcys (Todd, 1980), which is equivalent to a hydraulic conductivity of 10^{-7} to 10^{-8} cm/sec. The vertical hydraulic conductivities of the aquicludes calculated from pumping tests conducted in the CSA (discussed further in Section 2.7.2.3) are on the order of 10^{-11} cm/sec (Ferret Exploration of Nebraska, 1987). Laboratory analysis of cores from wells in the CSA indicates vertical hydraulic conductivities on the order of 10^{-10} to 10^{-11} cm/sec (Ferret Exploration of Nebraska, 1987).

The Upper/Middle Chadron sand occurs intermittently, and is underlain and overlain by hundreds of feet of low-permeability Chadron clays. The unit was monitored during the North Trend Pump Test because, where present, it is possible that it could contain recoverable water. However, no domestic or livestock wells in the North Trend Expansion Area are completed in this interval, and it is unlikely that this zone would be considered an "overlying aquifer". To be conservative, CBR chose to monitor a water level response in this interval. However, because of such limited production capacity in the Upper/Middle Chadron sand, the collection of representative groundwater samples could not be achieved. The wells did not produce sufficient water such that they could be adequately developed. Samples that were collected appeared to be impacted by drilling mud and cement.

In the upper part of the Brule Formation, sandstones and sandy siltstones are present which locally may be water bearing. However, these sandstones, siltstones, and clay stringers are difficult to correlate over any large distance, and are discontinuous lenses rather than laterally continuous strata. In the North Trend Area, private water wells are completed in this interval (see Section 2.2), and it is therefore the uppermost aquifer above the mined interval.

Figure 2.7-4: North Trend Regional Aquifer Cross Section Location Map

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Figure 2.7-5: North Trend Cross Section A-A'

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Figure 2.7-6: North Trend Cross Section B-B'

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Figure 2.7-7: North Trend Cross Section C-C'

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Figure 2.7-8: North Trend Cross Section D1-D1'

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Figure 2.7-9: North Trend Cross Section D2-D2'

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Figure 2.7-10: North Trend Cross Section E-E'

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Table 2.7-4: North Trend Pump Test Well Data and Cross Section Data

		Easting	Northing	TOC Elev	GL Elev	Casing Ht.	Bottom Brule	Top Mid Chadron	Bottom Mid Chadron	Top Basal Chadron	Top Pierre Shale
North	D-71	1,081,671.1	531,086.0		3,648.9		36	280	308	405	431
	D-69	1,081,875.6	530,498.7		3,652.8		36	275	284	413	439
	D-57	1,081,859.7	529,684.1		3,665.3		44	272	285	444	471
	T-211	1081556.19	529107.44		3666.47		47	270	295	442	490
	T-205	1081559.493	528710.35		3679.237		50	275	285	462	509
North - South Cross Section from the middle of Section 22 through Section 27 down to the middle of Section 34 T32N R 52W	T-209	1081533.912	528183.78		3679.773		60	270	284	493	527
	T-189	1081717.376	527738.07		3675.38		75	288	300	512	543
	T-216	1081713.165	527332.21		3677.565		75	302	326	543	558
	T-220	1082063.03	526836.69		3674.948		73	315	340	553	579
	T-218	1082053.79	526501.19		3668.89		56	330	345	567	583
	T-48	1082056.673	526140.59		3670.362		65	307	355	561	587
	T-130	1081840.767	525946.41		3672.661		42	315	350	537	610
	T-176	1081857.635	524844.05		3678.254		52	312	365	632	656
	T-174	1081955.57	524443.17		3674.022		47	318	362	664	688
	T-150	1081854.864	524041.97		3678.895		65	302	372	670	708
	T-145	1081854.596	523841.69		3679.205		65	305	375	626	689
	T-24	1081847.864	523637.10		3679.816		65	305	377	644	689
	T-69	1081636.60	523200.97		3683.6		55	295	380	628	698
	D-144	1,081,592.3	522,548.2		3,687.9		70	305	370	670	693
	CPW-2*	1081689	521626.3		3675.82		100	307	342	618	659
	C-197	1,081,482.3	521,942.6		3,688.2		72	310	354	609	671
	T-80	1081670.302	521633.07		3678.377		70	305	345	597	660
	C-181	1,081,557.1	521,134.6		3,657.6		67	285	310	598	630
	T-107	1081488.24	520720.51		3657.5		60	285	310	590	629

	T-106	1081399.095	520311.58		3660.693		70	287	307	569	621
	T-109	1081470.41	519304.14		3647.2		62	276	295	560	599
	So-3	1082777	516640.8		3655.7		40	195	255	545	583
	D140*	1083583	514877.6		3697		40	145	165	320	348
South	D133*	1084039	513075.9		3723.7		90	No data	No data	266	295
West	COW 2004-4	1080512.23	526200.97	3686.8	3686.0	0.8	70	367	390	589	645
	T-45	1080840.266	526195.72		3685.539		85	347	386	586	635
West to East Cross Section	T-46	1081246.405	526159.15		3680.201		85	320	380	578	622
	T-47	1081651.543	526159.50		3674.768		67	310	355	563	600
along the North side of Section 27 T32N R52W	T-48	1082056.673	526140.59		3670.362		65	307	355	561	587
	T-49	1082454.729	526113.09		3664.861		48	290	348	545	580
	T-50	1082851.45	526094.75		3659.473		55	287	345	555	576
	COW 2004-1	1085606.42	525988.48	3633.0	3631.9	1.1	50	310	325	536	550
	Jraben2	1089116	525824		3570		110	255	270	475	481
East	Fisher3*	1093593	525653		3590		60	No data	No data	165	175
West	T-82	1080377.726	521824.06		3689.506		67	290	325	598	650
	T-39	1080676.211	521810.14		3689.569		45	290	328	579	646
West to East Cross Section	C-167	1,080,978.5	521,749.8		3,690.3		77	300	334	616	649
	C-162	1,081,381.2	521,736.6		3,678.8		60	295	335	626	645
Along the South side of Section 27 T32N R52W	CPW-2*	1081689	521626.3		3675.82		100	307	342	618	659
	T-80	1081670.302	521633.07		3678.377		70	305	345	597	660
	T-81	1082070	521724.86		3676.078		54	315	345	625	661
	C-170	1,082,577.2	521,706.8		3,666.0		37	315	322	620	661
	T-92	1083065.239	521885.55		3666.041		58	325	345	639	675
East	T-93	1083464.293	521808.92		3663.462		77	330	342	644	691

West	D-107	1,079,790.2	530,303.8		3,695.5		70	295	315	445	506
Cross Section West	D-67	1,081,070.9	530,511.1		3,661.0		40	275	290	420	455
to East	D-69	1,081,875.6	530,498.7		3,652.8		36	275	284	413	439
Section 22 T 32N	C-237	1,082,829.0	530,335.1		3,643.8		42	260	285	401	436
R 52W	A-761	1,083,226.9	530,324.6		3,638.5		42	245	283	407	433
East	A-764	1,085,160.0	529,850.0		3,625.0		45	228	270	414	456
West	So-12	1080544	515886.3		3688.3		60	315	370	671	707
Cross Section West	So-13	1082001	516487.9		3664.1		40	315	345	626	647
to East along South	So-3	1082777	516640.8		3655.7		40	195	255	545	583
Side Section 34	Ha-6	1084172	516599.5		3663.3		10	155	170	393	421
T32N R52W	Ha-8*	1085309	516460.9		3681.6		30	128	140	292	323
East	Mo-1*	1086335	516539		3640		20	No data	No data	208	264
Northwest	CPW2*	1081689	521626.3		3675.82		100	307	342	618	659
NW-SE Cross	So-9	1082421	520762.7		3648		103	285	312	600	645
Section through	COW2*	1083807.09	519628.76	3654.0	3652.1	1.9	50	250	275	578	598
Sections 27, 34, 25	Ha-4	1085092	517860.5		3620		85	170	200	350	385
T32N R52 W	Mo-4*	1085741	517327		3680		90	No data	No data	320	360
Southeast	Mo-1*	1086335	516539		3640		20	No data	No data	208	264
West	So-12*	1080544	515886.3		3688.3		60	315	370	671	707
West to East Cross	City-2	1081209	514220.4		3671.1		70	No data	No data	520	595
Section, Section 3	Ha-22	1083028	513291.4		3694.6		20	No data	No data	230	288
T31N R52W	D-138	1083636	513072.8		3711.8		80	No data	No data	232	291
	D-133*	1084039	513075.9		3723.7		90	No data	No data	266	295
East											

Northeast	Fi1	1095856	531039		3570		80	No data	No data	242	250
Northeast-Southwest	Fi2	1095815	527813		3560		15	No data	No data	100	100
Cross Section	Fi3*	1093593	525653		3590		60	No data	No data	165	175
through Sections	Ah2	1091762	524166		3600		40	No data	No data	195	215
24,25,36,3	Rs2	1089402	521865		3590		30	No data	No data	154	178
T31 and 32N R52W	Rs1	1087407	519217		3615		40	No data	No data	152	172
	Mo4*	1085741	517327		3680		90	No data	No data	320	360
	Ha8*	1085309	516460.9		3681.6		30	128	140	292	323
	D140*	1083583	514877.6		3697		40	145	165	320	348
	City 1	1080560	513483.6		3679.8		175	245	255	592	632
Southwest	Golf 1	1079712	513055.5		3709.4		140	No data	No data	705	743
North Trend Pump Test Wells	COW 2004-1	1085606.42	525988.48	3633.0	3631.9	1.1	50	310	325	536	550
	COW 2004-2	1083807.09	519628.76	3654.0	3652.1	1.9	50	250	275	578	598
	COW 2004-3	1080497.45	521312.27	3684.5	3682.8	1.7	60	282	310	580	647
	COW 2004-4	1080512.23	526200.97	3686.8	3686.0	0.8	70	367	390	589	645
	COW 2004-5	1082950.491	523539.30	3671.04	3669.242	1.8	32	338	390	670	723
	CPW 2004-1	1081687.73	521629.85	3677.1	3675.3	1.8	37	307	342	618	658
	CPW 2004-2	1081697.12	521622.58	3680.1	3678.6	1.5	37	307	342	618	659
	BOW-2004	1081652.70	521638.30	3678.0	3676.4	1.6					

~~The Basal Chadron Sandstone, the aquifer which is host to the uranium mineralization, is bounded above and below by strata, which form aquicludes. The term "aquiclude" is used to describe strata capable of transmitting only minor amounts of fluid either vertically or horizontally. Typical values for vertical and horizontal permeability of "aquicludes" are in the range of 10^{-4} to 10^{-5} darcys (Todd, 1980), which is equivalent to a hydraulic conductivity of 10^{-7} to 10^{-8} cm/sec. The vertical hydraulic conductivities of the aquicludes calculated from pumping tests conducted in the CSA (discussed further in Section 2.7.2.3) are on the order of 10^{-11} cm/sec (Ferret Exploration of Nebraska, 1987). Laboratory analysis of cores from wells in the CSA indicates vertical hydraulic conductivities on the order of 10^{-10} to 10^{-11} cm/sec (Ferret Exploration of Nebraska, 1987).~~

~~The Upper/Middle Chadron sand occurs intermittently, and is underlain and overlain by hundreds of feet of low permeability Chadron clays. The unit was monitored during the North Trend Pump Test because, where present, it is possible that it could contain recoverable water. However, no domestic or livestock wells in the North Trend Expansion Area are completed in this interval, and it is unlikely that this zone would be considered an "overlying aquifer". To be conservative, CBR chose to monitor a water level response in this interval. However, because of such limited production capacity in the Upper/Middle Chadron sand, the collection of representative groundwater samples could not be achieved. The wells did not produce sufficient water such that they could be adequately developed. Samples that were collected appeared to be impacted by drilling mud and cement.~~

~~In the upper part of the Brule Formation, sandstones and sandy siltstones are present which locally may be water bearing. However, these sandstones, siltstones, and clay stringers are difficult to correlate over any large distance, and are discontinuous lenses rather than laterally continuous strata. In the North Trend Area, private water wells are completed in this interval (see Section 2.2), and it is therefore the uppermost aquifer above the mined interval.~~

Figures 2.7-11 through 2.7-14 present the location of all groundwater wells in the North Trend Expansion Area, as well as potentiometric surfaces for the Brule Formation, Basal Chadron Sandstone, and Middle Chadron sand, measured in February 2007. As shown on these maps, local groundwater flow within the Basal Chadron Sandstone is to the east-southeast, with a gradient of 0.0016 ft/ft (8.5 ft/mile). Groundwater flow in the Brule Formation is convergent with the White River. Based on water levels collected in June 2008, groundwater flow in the Brule Formation is directed to the southeast in the northern portion of the North Trend Area and to the northeast (parallel with flow in the White River) in the southern portion of the North Trend Area (Figure 2.7-12) with an average hydraulic gradient of 0.0081 ft/ft. As discussed in Section 2.7.2.1, historic groundwater flow in the Brule Formation south of the White River is to the northwest, toward the White River (Figure 2.7-2).

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Figure 2.7-11: Well Location Map, North Trend Area

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Figure 2.7-12: Local Water Level Map, Brule Sandstone, February 2007

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Figure 2.7-13: Local Water Level Map, Middle Chadron Sand, February 2007

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Figure 2.7-14 Local Water Level Map, Basal Chadron Sandstone, February 2007

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Potentiometric levels in the overlying Upper/Middle Chadron sand and Brule Formation are approximately 90 feet and 80 feet below that of the Basal Chadron (mined interval), respectively, indicating hydraulic isolation between the overlying units that were monitored and the Basal Chadron Sandstone.

Table 2.7-4 presents data for wells measured to construct the potentiometric maps; this data includes well locations as surveyed, well depths, and screened intervals. Water levels in each well were measured and recorded with In-Situ LevelTROLL transducer/dataloggers (Table 2.7-5).

Table 2.7-5: North Trend Pump Test Monitoring Information

Location ID	Monitoring Equipment	Serial Number	PSI
COW-5 (PW)	LevelTROLL	107167	100
COW-1	LevelTROLL	107145	30
COW-2	LevelTROLL	107156	30
COW-3	LevelTROLL	107139	30
COW-4	LevelTROLL	107140	30
CPW-2	LevelTROLL	107134	30
RC-2	LevelTROLL	107135	30
BOW-1	LevelTROLL	107058	30
BOW-2	LevelTROLL	107155	30
MCOW-1	LevelTROLL	107138	30
MCOW-2	LevelTROLL	107143	30
MCOW-3	LevelTROLL	107144	30
MCOW-4	LevelTROLL	107103	30

2.7.2.3 Aquifer Testing and Hydraulic Parameter Identification

Basal Chadron Aquifer tests were conducted in the North Trend Expansion Area in 2004/2005 and 2006. Initial testing activities at North Trend commenced in 2004; however, the results from the 2004 tests were not definitive. For this reason, CBR conducted a longer test with additional monitoring wells in June and July 2006. A summary of testing and field operations for the 2004/2005 events are presented in Table 2.7-6, and a comparison of North Trend data obtained through testing versus data from the CSA is presented in Table 2.7-7.

Table 2.7-6: Summary of North Trend Pump Test Activities, 2004 and 2005

Start Date	Test/Field Operations	Purpose/Description	Result
8/9/2004	Test 1 (old #5)	Initial NT test to assess hydraulics and provide permitting data	Infiltration to Brule; possible hydraulic communication between Basal Chadron and Upper/Mid Chadron in MCOW1
8/23/2004	Test 2 (old #5a)	Duplicate Test 1	Confirmed responses observed in Test 1
9/28/2004	MITs and sampling	CPW-2, COW-3, MCOW-1, BOW-1	All wells pass MIT; samples could not be obtained from MCOW-1
12/8/04 to 12/22/04	Re-plugging	CPW-1	CWP-1 drilled out and re-plugged
	Install new monitoring wells	MCOW-2, COW-5	MCOW-2, COW-5 successfully installed
	Modify discharge line	Extend line 2500' to the east	Line extended along drain and across field
3/9/2005	Test 3	Assess confinement (MCOW-2); assess aquifer (COW-5)	Infiltration to Brule eliminated; drawdown in MCOW-1 during pumping
4/13/2005	Re-abandon exploration holes	Holes T80 & T85 re-abandoned	Holes located, re-drilled and re-plugged
5/2/2005	Test 4a	Evaluate whether meaningful data could be obtained by flowing CPW2	No meaningful data obtained; significant background trend in MCOW-1
5/10/2005	Test 4b	Pump CPW2; evaluate response in MCOW wells	Possible rain directly into wells; significant background trend in MCOW-1; generator ran out of fuel
5/24/2005	Test 4c	As above	No useful data; equipment problems
6/6/2005	Test 5a	As above; 2 cycles pumping and recovery	MCOW1 drawdown during both pumping periods; heavy rain - possible flow directly into wells
6/24/2005	Test 5b	Slug tests to test hypothesis that rain caused increase in water levels during Test 5a	Slug tests confirmed that water levels in BOW and MCOWs had been affected by rain.

Table 2.7-7: Comparison of 2004-2005 Testing Results to the Existing License Area

	Existing License Area Tests #1-#4 (mean)	Test #5 North Trend 2004-2005 (mean)
Transmissivity (ft^2/day)	363	103
Formation Thickness (feet)	39.0	19.8
Hyd. Cond. (ft/day)	9.3	5.2
Storativity	9.7E-05	7.1E-05

The June/July 2006 North Trend Pump Test was conducted in accordance with a Test Plan submitted by Crow Butte Resources, Inc. (CBR) to the Nebraska Department of Environmental Quality (NDEQ) in June 2006. In accordance with the Plan, CBR installed the necessary wells and performed a pump test to evaluate hydrogeologic conditions in the vicinity of the proposed North Trend expansion area. The pump test was designed to assess:

- The degree of hydrologic communication between the Basal Chadron production zone pumping well and the surrounding production zone monitor wells;
- The presence or absence of hydrologic boundaries within the Production Zone aquifer over the test area;
- The hydrologic characteristics of the production zone aquifer within the test area; and,
- The degree of hydrologic isolation between the Production Zone and the overlying aquifers.

The production zone in North Trend is the Basal Chadron Sandstone. The majority of the wells monitored during this test were completed in the Basal Chadron. The exact definition of the "overlying aquifer" at North Trend is somewhat difficult to determine. As such, to assess hydrogeologic isolation between the Production Zone and the overlying sands, overlying monitor wells were installed in both a Middle/Upper Chadron sand and a sandy clay within the base of the shallow Brule Formation. Because the production zone (Basal Chadron sand) is underlain by the Pierre Shale, no underlying monitoring wells were installed.

For the 2006 test, 13 wells (Table 2.7-8) were monitored using automated equipment. The test was conducted by pumping well COW-5 at 16.4 gpm for 357 hours (14.9 days). More than 110 feet of drawdown was achieved in the pumping well during testing. All of the Basal Chadron wells showed adequate drawdown (e.g., greater than 1.3 feet), which confirms hydrologic communication within the production zone sand. Summary test results are presented in Tables 2.7-9 and 2.7-10.

The nearest overlying sand monitor well (MCOW-3; Upper/Middle Chadron sand completion) was approximately 43 feet away from the pumping well used in the 2006 Test (see Figures 2.7-4 and 2.7-11); the nearest shallow aquifer monitor well (BOW-2; Brule completion) was located 32 feet from the pumping well. No significant water level changes due to the pump test were observed in the overlying or shallow monitor wells. Test results are summarized in Tables 2.7-9 and 2.7-10. The test results demonstrate:

- The Basal Chadron monitor wells are in communication with the Basal Chadron production zone throughout the North Trend test area;
- The Basal Chadron Sandstone has been adequately characterized with respect to hydrogeologic conditions within the majority of the proposed North Trend Expansion Area;
- Adequate confinement exists between the Basal Chadron sand production zone and the overlying Middle/Upper Chadron sand, and the overlying Brule Formation throughout the central portion of Section 27 of the proposed North Trend Expansion Area; and,
- While additional future testing will be necessary prior to mining in part of the proposed license area, the 2006 testing is sufficient to proceed with Class III permitting and NRC licensing for North Trend.

The North Trend Hydrologic Testing Report that provides a detailed description of the testing activities and results is attached to this application as Appendix C. Well completion reports are included with that document.

Regional aquifer analysis data are also available. During the initial permitting and development activities within the CSA, two pumping tests were conducted in the central portion of the CSA to (1) assess the hydraulic characteristics of the Chadron Sandstone, and (2) demonstrate the confinement provided by the overlying and underlying aquicludes (the Brule-Chadron Formation and Pierre Shale, respectively). Those tests, referred to as Test #1 and Test #2, were performed in 1982 and 1987, respectively (Wyoming Fuel, 1983; Ferret Exploration of Nebraska, 1987). Test #3 was conducted in September 1996 (Harlan & Associates, Inc., 1996).

The results from those tests indicate that the Chadron Sandstone is relatively homogeneous and isotropic (i.e., the hydraulic conductivity [permeability] is consistent with respect to direction and location) within the CSA. This is consistent with regional geologic information that suggests that the nature and characteristics of the Brule and Chadron Formations, and the Pierre Shale are consistent within the Crawford Basin. The depositional environment of these sections has been confirmed by exploratory drilling in the North Trend Expansion Area.

The CSA 1995 Application for Renewal of USNRC License SUA-1534 states that a porosity of 29% was assumed for the Basal Chadron Sandstone for a first aquifer test.

Table 2.7-8: Summary of 2006 North Trend Pump Test Well Information

Well ID	Distance to PW	North	East	Town-ship & Range	Sect	TOC Elev. (ft; AMSL)	Surface Elev. (ft; AMSL)	Casing Height (ft)	Hole Depth (ft; bgs)	Casing Depth (ft; bgs)	Top Screen (ft; bgs)	Bottom Screen (ft; bgs)	Screen Length (ft)	Screen Interval (feet)	Cas-ing O.D. (in.)	28 Jun 2006 Static Water Elev. (ft; AMSL)
Basal Chadron Pumping Well																
COW-5 (PW)	0.00	523,541.90	1,082,946.00	T32N R52W	27	3,669.05	3,667.65	1.40	740	708	653	708	55	22	4.5	3,704.85
Basal Chadron Observation Wells																
COW-1	3,614.28	525,991.00	1,085,604.00	T32N R52W	27	3,633.77	3,632.57	1.20	580	557	537	557	20	10	4.5	3,699.81
COW-2	4,001.38	519,632.50	1,083,799.00	T32N R52W	34	3,654.52	3,653.22	1.30	620	594	569	594	25	15	4.5	3,704.41
COW-3	3,315.00	521,315.40	1,080,490.00	T32N R52W	27	3,685.33	3,684.63	0.70	670	646	596	646	50	33	4.5	3,710.59
COW-4	3,609.34	526,204.30	1,080,509.00	T32N R52W	27	3,689.04	3,687.94	1.10	670	645	585	645	60	41	4.5	3,705.30
CPW-2	2,291.19	521,626.30	1,081,689.00	T32N R52W	27	3,676.92	3,675.82	1.10	710	685	615	685	70	35	4.5	3,705.99
RC-2	6,634.66	516,911.30	1,082,714.00	T32N R52W	34	3,651.22	3,648.42	2.80	630	630	572	630	58	25	4.5	3,703.93
Brule Observation Wells																
BOW-1	2,301.76	521,642.20	1,081,644.00	T32N R52W	27	3,677.39	3,675.49	1.90	65	65	45	65	20	5	4.5	3,620.68
BOW-2	31.78	523,534.20	1,082,915.00	T32N R52W	27	3,668.73	3,667.93	0.80	59	59	22	59	37	10	4.5	3,608.57
Middle Chadron Observation Wells																
MCOW -1	2,268.07	521,627.10	1,081,729.00	T32N R52W	27	3,676.80	3,675.50	1.30	380	350	305	350	45	5	4.5	3,607.29
MCOW -2	2,323.47	521,681.10	1,081,552.00	T32N R52W	27	3,678.82	3,677.52	1.30	370	360	315	360	45	7	4.5	3,606.83
MCOW -3	43.45	523,582.40	1,082,951.00	T32N R52W	27	3,668.85	3,667.65	1.20	390	391	325	391	66	17	4.5	3,606.14
MCOW -4	1,280.16	523,634.60	1,081,671.00	T32N R52W	27	3,681.66	3,679.86	1.80	371	371	290	371	81	19	4.5	3,608.27

Table 2.7-9: Summary of 2006 North Trend Pump Test Results

Well	Distance from Pumping Well (feet)	Analytical Results	Test #6 Analytical Method	
			Theis	Theis Recovery
COW-5 (PW)	0.00	Transmissivity (ft^2/day)	NA	*
		Hyd. Cond. (ft/day)	NA	*
		Storativity	NA	*
COW-1	3,614.28	Transmissivity (ft^2/day)	42.0	NA
		Hyd. Cond. (ft/day)	1.6	NA
		Storativity	2.30E-05	NA
COW-2	4,001.38	Transmissivity (ft^2/day)	74.8	NA
		Hyd. Cond. (ft/day)	2.9	NA
		Storativity	7.05E-05	NA
COW-3	3,315.00	Transmissivity (ft^2/day)	71.5	NA
		Hyd. Cond. (ft/day)	2.8	NA
		Storativity	8.40E-05	NA
COW-4	3,609.34	Transmissivity (ft^2/day)	51.7	NA
		Hyd. Cond. (ft/day)	2.0	NA
		Storativity	3.43E-05	NA
CPW-2	2,291.19	Transmissivity (ft^2/day)	60.7	NA
		Hyd. Cond. (ft/day)	2.3	NA
		Storativity	4.55E-05	NA
RC-2	6,634.66	Transmissivity (ft^2/day)	58.2	NA
		Hyd. Cond. (ft/day)	2.2	NA
		Storativity	6.18E-05	NA

NA - Data not analyzed; pumping data were sufficient for analysis.
* Unable to analyze recovery data due to lack of check valve on top of pump.

Table 2.7-10: Summary of 2006 North Trend Pump Test Results vs. Existing License Area

	Existing License Area Tests #1-#4 (mean)	Test #5 North Trend 2004 & 2005 (mean)	Test #6 North Trend 2006 (mean)
Transmissivity (ft^2/day)	363	103	60
Formation Thickness (feet)	39.0	19.8	26
Hyd. Cond. (ft/day)	9.3	5.2	2.3
Storativity	9.7E-05	7.1E-05	5.3E-05

~~Regional aquifer analysis data are also available. During the initial permitting and development activities within the CSA, two pumping tests were conducted in the central portion of the CSA to (1) assess the hydraulic characteristics of the Chadron Sandstone, and (2) demonstrate the confinement provided by the overlying and underlying aquicludes (the Brule-Chadron Formation and Pierre Shale, respectively). Those tests, referred to as Test #1 and Test #2, were performed in 1982 and 1987, respectively (Wyoming Fuel, 1983; Ferret Exploration of Nebraska, 1987). Test #3 was conducted in September 1996 (Harlan & Associates, Inc., 1996).~~

~~The results from those tests indicate that the Chadron Sandstone is relatively homogeneous and isotropic (i.e., the hydraulic conductivity [permeability] is consistent with respect to direction and location) within the CSA. This is consistent with regional geologic information that suggests that the nature and characteristics of the Brule and Chadron Formations, and the Pierre Shale are consistent within the Crawford Basin. The depositional environment of these sections has been confirmed by exploratory drilling in the North Trend Expansion Area.~~

~~The CSA 1995 Application for Renewal of USNRC License SUA-1534 states that a porosity of 29% was assumed for the Basal Chadron Sandstone for a first aquifer test.~~

2.7.3 Surface Water and Groundwater Quality

Historical surface water quality data for the White River, assembled by EPA, are presented in Table 2.7-11a. Historical groundwater quality data from the CSA for the Brule Alluvium, Brule Formation, and Basal Chadron Formation are presented in Table 2.7-11b.

A monitoring program was conducted to establish baseline groundwater quality conditions in the North Trend Area. The program was conducted in 1996 and 1997, and includes samples from a Basal Chadron well (Well 81) and Brule well (Well 78) in the North Trend Expansion Area (Figure 2.7-11). The radiological results of baseline sampling for these wells are also discussed in section 2.9. Note that well 81 has since been abandoned.

Tables 2.7-12 and 2.7-13 summarize data obtained from these wells for four monitoring periods, obtained from October 1996 through June 1997 to assess seasonable variability in water quality. These data establish the groundwater conditions associated with the mineralized Basal Chadron Sandstone and Brule in the North Trend area, at a location immediately outside and northeast of the proposed License area. The data indicate that the TDS for the Chadron ranges from 1790 to 1820 mg/l, while the TDS for the Brule ranges from 423 to 479 mg/l. Major ion content in groundwater is slightly higher in the Basal Chadron than the Brule, as would be expected by the TDS values. Alkalinity and conductivity are higher in the Chadron than Brule, but neither formation shows there to be measurable concentrations of most trace metals. Measurable uranium ranging in concentration from <0.0003 to 0.006 mg/l was detected in Chadron groundwater. These Chadron samples also showed radium-226 concentrations ranging from 10.3 to 14.7 pCi/l, which is above the NDEQ MCL of 5 pCi/l. Measurable uranium was also present in all four Brule samples with a maximum concentration of 0.016 mg/l. Radium-226 was present in the Brule samples with a maximum concentration of 0.5 pCi/l. The concentrations of uranium and radium in the Brule aquifer at North Trend are directly in line with average concentrations at the CSA.

It is noted that gross alpha and beta analyses were not performed because uranium and radium were the anticipated compounds and were thus specifically included on the analyte list. Also, that the average values for all parameters presented on Tables 2.7-12 and 2.7-13 are almost identical to the individual sample values, and the sample value range for each parameter is relatively limited. Based on these data, there is little seasonable variability in water quality.

Table 2.7-11a: Historic White River Water Quality Data, 1968-1994*

PARAMETER	RESULTS										
	8/20/1968	5/6/1969	7/15/1969	5/24/1970	8/28/1970	8/5/1971	6/5/1972	10/2/1972	6/4/1973	9/23/1981	7/13/1994
NUMBER USED IN SAMPLE ACCOUNTING PROCEDURE	66	66	65	95	77	109	no data	no data	no data	1	1
TEMPERATURE, WATER (DEGREES CENTIGRADE)	21	18	28	18.5	21	19.5	22	12.5	17	no data	20
TEMPERATURE, AIR (DEGREES CENTIGRADE)	32	21	36	23	27	30	21	11.1	23	no data	no data
FLOW, STREAM, MEAN DAILY CFS	10	22	10	22	21	12	19	12	24	no data	no data
TURBIDITY, (JACKSON CANDLE UNITS)	41	62	10	45	337	5	36	4	4	no data	no data
SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	400	390	355	353	305	340	340	340	400	330	700
OXYGEN, DISSOLVED MG/L	7.4	8.5	6.9	7.8	7	8	8.1	9.6	7.9	no data	6.9
OXYGEN, DISSOLVED, PERCENT OF SATURATION	82.2321	89.4889	87.3453	82.106	77.7793	85.1096	92.0463	88.8907	81 .4491	no data	75
PH (STANDARD UNITS)	7.7	8.2	8.2	7.9	7	8.5	8.4	8.5	7.6	no data	8.3
ALKALINITY, TOTAL (MG/L AS CACO3)	208	108	180	184	168	176	192	200	189	188	no data
RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	258	270	250	250	220	250	240	260	no data	288	no data
NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	0.1	0.1	1	0.1	0.6	0.1	0.2	0.1	no data	no data	no data
PHOSPHATE, TOTAL (MG/L AS PO4)	0.8	0.1	0.5	0.2	0.3	0.1	0.2	0.1	no data	no data	no data
HARDNESS, TOTAL (MG/L AS CACO3)	176	148	168	160	156	172	160	172	172	no data	159
CALCIUM, DISSOLVED (MG/L AS CA)	39	35	51	50	52	46	51	56	no data	no data	no data
MAGNESIUM, DISSOLVED (MG/L AS MG)	10	1	10	9	6	14	8	8	no data	no data	no data
SODIUM, DISSOLVED (MG/L AS NA)	36	24	43	24	22	16	15	15	no data	no data	no data
SODIUM ADSORPTION RATIO	0.4	0.9	1.5	0.8	0.8	0.5	0.5	0.5	no data	no data	no data
POTASSIUM, DISSOLVED (MG/L AS K)	6	8	13	8	9	9	10	9	no data	no data	no data
CHLORIDE,TOTAL IN WATER MG/L	12	18	4	1	2	4	1	2	7	5	no data
HARDNESS, CA MG CALCULATED (MG/L AS CACO3)	138.563	91.513	168.527	161.912	154.552	172.514	160.291	172.776	no data	174.528	159.437

* Summaries of data collected are presented. See http://www.epa.gov/storet/updates.html, EPA' STORET database, for full data sets

Table 2.7-11b: Water Quality Summary; Brule Formation and Basal Chadron Sandstone

CONSTITUENT[1)]	BRULE FORMATION		CHADRON FORMATION		BRULE ALLUVIUM	
	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN
Calcium	7.1 - 98	48	11 - 41	20	67 - 74	70.6
Magnesium	0.3 - 16	6.6	0.8 - 7.2	3.2	6.4 - 10	8.7
Sodium	12 - 340	104	340 - 540	411	34 - 41	36.5
Potassium	4.1 - 15.9	9.9	7.0 - 19.8	12.4	10.3 - 13	11.1
Bicarbonate	137 - 627	364	308 - 411	368	299 - 364	321
Sulfate	1 - 23	10	254 - 620	407	11 - 20	16.3
Chloride	1.6 - 192	48	134 - 250	176	5 - 10	6.7
Specific Conductance (µmhos)	246 - 1481	714	1500 - 2500	1932	507 - 614	548
pH (pH units)	6.80 - 8.50	7.80	7.60 - 8.70	8.20	7.10 - 8.40	7.70
Uranium (mg/l)	0.001 - 0.021	0.0064	<0.001 - 2.40	0.092	0.006 - 0.022	0.015
Radium-226 (pCi/l)	0.1 - 3.0	0.7	0.1 - 619	53	0.4 - 18.3	2.5

[1)] Concentrations in mg/l, unless otherwise noted.

Table 2.7-12: Laboratory Analysis Report - Chadron Well W-81

	Units	Detection Limit	RESULTS 9/5/1996	12/13/1996	3/20/1997	6/26/1997	Average Value
Major Ions							
Calcium (Ca)	mg/L	1.0	29.4	28.9	29.1	30.9	29.6
Magnesium (Mg)	mg/L	1.0	5.4	5.33	5.2	5.2	5.3
Sodium (Na)	mg/L	1.0	555	568	561	582	567
Potassium (K)	mg/L	1.0	15.0	14.7	15.1	15.1	15.0
Carbonate (CO3)	mg/L	0.10	0	0	0	0	0
Bicarbonate (HCO3)	mg/L	0.10	399	404	398	401	401
Sulfate (SO4)	mg/L	1.0	740	744	743	720	737
Chloride (Cl)	mg/L	0.10	196	204	208	201	202
Ammonium (NH4) as N	mg/L	0.05	0.73	0.68	0.75	1	0.74
Nitrite (NO2) as N	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Nitrate (N03) as N	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Fluoride (F)	mg/L	0.10	1.24	1.21	1.22	1.24	1.23
Silica (S102)	mg/L	1.0	11.5	11.3	10.9	11.5	11.3
Non-Metals							
Total Dissolved Solids (TDS) @ 180°C	mg/L	1.0	1820	1810	1795	1790	1804
Conductivity	µmho/cm	1.0	2640	2750	2790	2710	2723
Alkalinity (CaCO3)	mg/L	1.0	327	331	326	329	328
pH	std. units	0.10	8.02	8.21	8	8.15	8.10
Trace Metals							
Aluminum (Al)	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Arsenic (As)	mg/L	0.001	< 0.001	< 0.001	0.002	< 0.001	<0.002
Barium (Ba)	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Boron (B)	mg/L	0.10	1.66	1.60	1.60	1.59	1.61
Cadmium (Cd)	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.01
Chromium (Cr)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
Copper (Cu)	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.01
Iron (Fe)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
Lead (Pb)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
Manganese (Mn)	mg/L	0.01	0.02	< 0.01	0.01	0.01	0.01
Mercury (Hg)	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.001

Table 2.7-12: Laboratory Analysis Report - Chadron Well W-81

			RESULTS				
Molybdenum (Mo)	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Nickel (Ni)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
Selenium (Se)	mg/L	0.001	< 0.001	0.175	< 0.001	< 0:001	<0.175
Vanadium (V)	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Zinc (Zn)	mg/L	0.01	0.02	0.01	0.02	< 0.01	<0.02
Radiometric							
Uranium (U nat)	mg/L	0.0003	< 0.0003	0.0060	<0.0003	0.0003	<0.0032
Radium 226 (Ra-226)	pCi/L	0.2	10.5	11.9	10.3	14.7	11.9
Radium Precision ±			0.4	0.6	0.6	1.3	
Quality Assurance Data		target range					
Anion	meq		27.55	27.94	27.93	27.31	27.68
Cation	meq		26.45	27.02	26.74	27.74	26.99
WYDEQ A/C Balance	%	-5 - +5	-2.04	-1.66	-2.18	0.77	-1.28
Calc TDS	mg/L		1754	1780	1773	1768	1769
TDS A/C Balance	dec. %	0.80 - 1.20	1.04	1.02	1.01	1.01	1.02

Table 2.7-13: Laboratory Analysis Report - Brule Well W-78

	Units	Detection Limit	RESULTS 10/11/1996	12/13/1996	3/20/1997	7/17/1997	Average Value
Major Ions							
Calcium (Ca)	mg/L	1.0	67.6	67.6	67.4	77.0	69.9
Magnesium (Mg)	mg/L	1.0	9.2	9.2	9.0	9.8	9.3
Sodium (Na)	mg/L	1.0	41.8	43.9	41.0	46.3	43.3
Potassium (K)	mg/L	1.0	16.6	16.7	16.1	16.9	16.6
Carbonate (CO3)	mg/L	0.10	0	0	0	0	0
Bicarbonate (HCO3)	mg/L	0.10	244	248	245	248	246
Sulfate (SO4)	mg/L	1.0	52.2	51.0	51.3	66.5	55.3
Chloride (Cl)	mg/L	0.10	26.9	27.0	27.2	31.9	28.3
Ammonium (NH4) as N	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
Nitrite (NO2) as N	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Nitrate (N03) as N	mg/L	0.10	6.12	5.66	5.76	5.47	5.75
Fluoride (F)	mg/L	0.10	0.38	0.35	0.38	0.35	0.37
Silica (S102)	mg/L	1.0	68.0	68.0	64.9	68.0	67.2
Non-Metals							
Total Dissolved Solids (TDS) @ 180°C	mg/L	1.0	423	432	479	443	436
Conductivity	µmho/cm	1.0	622	618	650	624	606
Alkalinity (CaCO3)	mg/L	1.0	203	201	203	202	200
pH	std. units	0.1	8.22	7.91	7.90	7.98	7.89
Trace Metals							
Aluminum (Al)	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Arsenic (As)	mg/L	0.001	0.005	0.003	0.006	0.007	0.005
Barium (Ba)	mg/L	0.10	0.20	0.20	0.19	0.20	0.20
Boron (B)	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Cadmium (Cd)	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.01
Chromium (Cr)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
Copper (Cu)	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.01
Iron (Fe)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
Lead (Pb)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
Manganese (Mn)	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	<0.01
Mercury (Hg)	mg/L	0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.001
Molybdenum (Mo)	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Nickel (Ni)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05

Table 2.7-13: Laboratory Analysis Report - Brule Well W-78

			RESULTS				
Selenium (Se)	mg/L	0.001	0.018	0.018	0.015	0.017	0.017
Vanadium (V)	mg/L	0.10	< 0.10	< 0.10	< 0.10	< 0.10	<0.10
Zinc (Zn)	mg/L	0.01	0.04	0.02	0.02	0.03	0.02
Radiometric							
Uranium (U nat)	mg/L	0.0003	0.0123	0.0069	0.014	0.016	0.0123
Radium 226 (Ra-226)	pCi/L	0.2	<0.2	0.5	0.3	<0.2	0.4
Radium Precision ±				0.1	0.2		
Quality Assurance Data		target range					
Anion	meq		6.30	6.31	6.29	6.75	6.41
Cation	meq		6.41	6.50	6.33	7.13	6.59
WYDEQ A/C Balance	%	-5 - +5	0.81	1.53	0.38	2.73	1.36
Calc TDS	mg/L		432	433	425	465	439
TDS A/C Balance	dec. %	0.80 - 1.20	1.01	0.98	1.02	1.03	1.01

Based on similar regional deposition, the North Trend Expansion Area ore body is expected to be similar mineralogically and geochemically to that of the CSA. The ore bodies in the two areas are within the same geologic unit (i.e. Basal Chadron Sandstone) and have the same mineralization source (see Section 2.6). The sites are separated by only a few miles, and the cause of mineral deposition in the two areas appears to be similar (see Section 2.6). Neither site is anticipated to be affected by any recharge or other processes that would uniquely affect each area, so the groundwater characteristics of the CSA mineralized zone are presumed representative of that in the North Trend Expansion Area. Tables 2.7-14a through 2.7-14c are the Baseline and Restoration Values for Mine Units 1-3 in the CSA area (additional data for MU 1-9 are presented in Attachment 6.1[A]). The values in these tables are expected to be representative of the geochemical characteristics of the North Trend Expansion Area ore body. The North Trend Expansion Area ore body, the outline of which is presented on Figure 2.7-11, is considered a zone of distinct water quality characteristics primarily due to the presence of relatively concentrated uranium and radium in the zone when compared to the concentration of these parameters outside of the zone (e.g. Tables 2.7-12 vs. Tables 2.7-14a-c).

Available groundwater data for both the Brule and Chadron do not indicate that there are any documented flow rate variations or recharge issues that would impact groundwater quality. There are no surface water ponds within the area, and only limited stream flow (see Section 2.7.1). The Brule, while considered an overlying aquifer, is not an extensive or exceptionally productive system. The available monitoring data (Table 2.7-3) do not indicate any seasonality or pumping effects by domestic wells within this zone. With respect to the Basal Chadron Sandstone, there are no domestic wells completed within this interval in the immediate North Trend area, and there is no information to indicate that there are recharge or flow rate issues associated with the Basal Chadron Sandstone that would affect groundwater quality.

During the course of mining the water quality is expected to change as outlined in Table 2.7-15. The chemicals used in the mining and recovery process will include sodium bicarbonate, an oxidizer such as oxygen, carbon dioxide, and chloride for elution. As a result, the greatest changes in water quality are expected to be in alkalinity, bicarbonate, chloride, sodium, conductivity, and TDS. Significant increases are also likely to occur in calcium concentrations as a result of ion exchange with clays. The oxidant will cause significant increases in uranium, vanadium, and radium and minor increases in trace metals such as copper, arsenic, molybdenum and selenium. The genesis of the ore body and the facies of the host rock at North Trend are similar to that of the CSA so it is probable the change in water quality at North Trend will be similar to that experienced at the CSA. Historic restoration activities at the CSA have demonstrated the ability to successfully restore groundwater to established restoration standards. As indicated in Section 2.7.1, Spring Creek and an unnamed creek are within the North Trend Expansion

Table 2.7-14a: Baseline and Restoration Values for CSA Mine Unit 1

Baseline and Restoration Values for CSA Mine Unit 1	Groundwater Standard	MU-1 Baseline (Primary Standard)	MU-1 Standard Deviation	MU-1 NDEQ Restoration Value
Ammonium (mg/l)	10	<0.372		10
Arsenic (mg/l)	0.05	<0.00214		0.05
Barium (mg/l)	1	<0.1		1
Cadmium (mg/l)	0.01	<0.00644		0.005
Chloride (mg/l)	250	203.9	38	250
Copper (mg/l)	1	<0.017		1
Fluoride (mg/l)	4	0.686	0.04	4
Iron (mg/l)	0.3	<0.0441		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.011		0.05
Molybdenum (mg/l)	1	<0.0689		1
Nickel (mg/l)	0.15	<0.0340		0.15
Nitrate (mg/l)	10	<0.050		10
Lead (mg/l)	0.05	0.0315		0.05
Radium (pCi/L)	5	229.7	177.1	584
Selenium (mg/l)	0.01	<0.00323		0.05
Sodium (mg/l)	N/A	412	19.2	4120
Sulfate (mg/l)	250	356.2	9.4	375
Uranium (mg/l)	5	0.0922	0.089	5
Vanadium (mg/l)	0.2	<0.0663		0.2
Zinc (mg/l)	5	<0.036		5
pH (Std. Units)	6.5 - 8.5	8.46	0.2	6.5 – 8.5
Calcium (mg/l)	N/A	12.5	3.2	125
Total Carbonate (mg/l)	N/A	351	31.1	585
Potassium (mg/l)	N/A	12.5	1.5	125
Magnesium (mg/l)	N/A	3.2	0.8	32
TDS (mg/l)	N/A	1170.2	47.6	1170.2

Table 2.7-14b: Baseline and Restoration Values for CSA Mine Unit 2

Baseline and Restoration Values for CSA Mine Unit 2	Groundwater Standard	MU-2 Baseline (Primary Standard)	MU-2 Standard Deviation	MU-2 NDEQ Restoration Value
Ammonium (mg/l)	10	0.37	0.07	10
Arsenic (mg/l)	0.05	<0.001		0.05
Barium (mg/l)	1	<0.1		1
Cadmium (mg/l)	0.005	<0.007		0.005
Chloride (mg/l)	250	208.6	30.8	250
Copper (mg/l)	1	<0.013		1
Fluoride (mg/l)	4	0.67	0.04	4
Iron (mg/l)	0.3	<0.045		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.01		0.05
Molybdenum (mg/l)	1	<0.073		1
Nickel (mg/l)	0.15	<0.037		0.15
Nitrate (mg/l)	10	<0.039		10
Lead (mg/l)	0.05	<0.035		0.05
Radium (pCi/L)	5	234.5	411.8	1058
Selenium (mg/l)	0.05	<0.001		0.05
Sodium (mg/l)	N/A	410.8	18.2	4108
Sulfate (mg/l)	250	348.2	10.3	369
Uranium (mg/l)	5	0.046	0.037	5
Vanadium (mg/l)	0.2	<0.07		0.2
Zinc (mg/l)	5	<0.026		5
pH (Std. Units)	6.5 - 8.5	8.32	0.2	6.5 – 8.5
Calcium (mg/l)	N/A	13.4	2.4	134
Total Carbonate (mg/l)	N/A	366.9	13.3	585
Potassium (mg/l)	N/A	12.6	2.5	126
Magnesium (mg/l)	N/A	3.5	0.4	35
TDS (mg/l)	N/A	1170.4	41	1170.4

Table 2.7-14c: Baseline and Restoration Values for CSA Mine Unit 3

Baseline and Restoration Values for CSA Mine Unit 3	Groundwater Standard	MU-3 Baseline (Primary Standard)	MU-3 Standard Deviation	MU-3 NDEQ Restoration Value
Ammonium (mg/l)	10	<0.329		10
Arsenic (mg/l)	0.05	<0.001		0.05
Barium (mg/l)	1	<0.1		1
Cadmium (mg/l)	0.005	<0.01		0.005
Chloride (mg/l)	250	197.6	16.7	250
Copper (mg/l)	1	<0.0108		1
Fluoride (mg/l)	4	0.719	0.05	4
Iron (mg/l)	0.3	<0.05		0.3
Mercury (mg/l)	0.002	<0.001		0.002
Manganese (mg/l)	0.05	<0.01		0.05
Molybdenum (mg/l)	1	<0.1		1
Nickel (mg/l)	0.15	<0.05		0.15
Nitrate (mg/l)	10	<0.0728		10
Lead (mg/l)	0.05	<0.05		0.05
Radium (pCi/L)	5	165	222.5	611
Selenium (mg/l)	0.05	<0.00115		0.05
Sodium (mg/l)	N/A	428	27.6	4280
Sulfate (mg/l)	250	377	13.4	404
Uranium (mg/l)	5	0.115	0.158	5
Vanadium (mg/l)	0.2	<0.1		0.2
Zinc (mg/l)	5	<0.0131		5
pH (Std. Units)	6.5 - 8.5	8.37	0.3	6.5 – 8.5
Calcium (mg/l)	N/A	13.3	3.1	133
Total Carbonate (mg/l)	N/A	358.7	24.8	592
Potassium (mg/l)	N/A	13.9	4	139
Magnesium (mg/l)	N/A	3.5	0.9	35
TDS (mg/l)	N/A	1183	47.4	1183

Table 2.7-15: Anticipated Changes in Water Quality During Mining

Analyte	Units	Average Ore Zone Water Quality: Pre-Mining (Well W-007)	Typical Water Quality During Mining at CSA
Alkalinity, Total as CaCO3	mg/L	328	1,600
	mg/L	0	<1.0
Bicarbonate as HCO3	mg/L	401	2,050
Calcium	mg/L	29.6	77
Chloride	mg/L	202	600
Fluoride	mg/L	1.23	0.6
Magnesium	mg/L	5.3	23
Ammonia as N	mg/L	0.74	<0.05
Nitrate+Nitrite as N	mg/L		0.46
Potassium	mg/L	15.0	35
Silica	mg/L	11.3	21
Sodium	mg/L	567	1,310
Sulfate	mg/L	737	900
Conductivity	umhos/cm	2,723	6,000
pH	s.u.	8.1	7.8
TDS	mg/L	1,804	4,080
Aluminum	mg/L	<0.10	<0.1
Arsenic	mg/L	<0.002	0.06
Barium	mg/L	<0.10	<0.1
Boron	mg/L	1.61	1.1
Cadmium	mg/L	<0.01	<0.005
Chromium	mg/L	<0.05	<0.05
Copper	mg/L	<0.01	0.04
Iron	mg/L	<0.05	<0.030
Lead	mg/L	<0.05	<0.05
Manganese	mg/L	0.01	0.05
Mercury	mg/L	<0.001	<0.001
Molybdenum	mg/L	<0.10	0.5
Nickel	mg/L	<0.05	<0.05
Selenium	mg/L	<0.175	0.07
Uranium	mg/L	<0.0032	44
Vanadium	mg/L	<0.10	2.5
Zinc	mg/L	<0.02	0.02
Radium 226	pCi/L	11.9	1,090

Area, and are northern tributaries of the White River. Both of the creeks are ephemeral and therefore could not be sampled on a seasonal basis for a period of one or more years. The White River is present to the south of the North Trend Expansion Area, and is perennial.

2.7.4 WATER USE INFORMATION

As discussed previously in Section 2.2, local water use is very limited. Isolated household wells are completed in the Brule Formation, and the city of Crawford uses two wells completed in the Brule outside the North Trend Expansion Area (see Figure 2.2-4). One well completed in the Basal Chadron is used for household purposes (Well No. 61; approximately 1.5 miles southeast of the expansion area boundary).

2.7.5 CONCEPTUAL MODELING OF SITE HYDROLOGY

Tables 2.6.1 and 2.6.2 present the regional and local stratigraphic columns within the North Trend area. As shown in these figures, the principal aquifers within the North Trend area are the Basal Chadron Sandstone, intermittent Upper/Middle Chadron sand, a sandy interval in the Brule Formation, and rarely, alluvial deposits. The Basal Chadron Sandstone is isolated from underlying sandstone intervals by more than 1,500 feet of thick Pierre Shale. Overlying confinement between the Basal Chadron and the Upper/Middle Chadron sand is provided by more than 200 feet of clay and shale in the Middle Chadron interval. Additional Overlying confinement above the Basal Chadron Sandstone is provided by more than 300 feet of clay and shale in the Brule Formation and the Upper Chadron.

Water level data presented in Figures 2.7-12, 2.7-13, and 2.7-14 show each saturated zone to have distinct elevations, with the Basal Chadron Sandstone water elevations approximately 80 to 90 feet higher than overlying units (Brule and Upper/Middle Chadron sand) indicating confined conditions within the Basal Chadron. Water level data indicate that the Brule is unconfined. Water level data support hydrologic isolation of the Basal Chadron Sandstone with respect to the other water-bearing intervals of interest in the North Trend Expansion Area. Ground water production rates within the Brule and Upper/Middle Chadron sands are low to exceptionally low.

The geochemical groundwater characteristics of the Brule and Chadron further indicate that the two zones are not naturally interconnected. For example, Table 2.7-11b shows that sulfate, sodium, and chloride concentrations as well as specific conductance significantly differ between the Brule and Basal Chadron Sandstone.

Groundwater information (Figure 2.7-12) indicates that groundwater within the Brule flows in a general east/northeastern direction in the North Trend Expansion Area with a gradient of about 0.005 ft/ft, toward the White River. This interval, in all likelihood, is

dissected by the White River, which is either gaining from the Brule or losing to the Brule, depending upon the season. Alluvial deposits along the margins of the White River may offer limited groundwater storage depending on river levels. Recharge to the Brule likely occurs directly at or immediately north of North Trend, as geologic maps indicate this interval subcrops in the North Trend Expansion Area.

The Basal Chadron Sandstone outcrops approximately 10 miles north of the North Trend Expansion Area, where recharge occurs. Potentiometric maps (Figure 2.7-14) indicate groundwater flow within the Basal Chadron is predominantly to the east in the North Trend Expansion Area with a gradient of approximately 0.0016 ft/ft (8.5 ft/mile). This flow is roughly concurrent with the local dip on the top of the Basal Chadron sand. The Basal Chadron sand is over 500 feet below the base of the White River.

There is no identified hydraulic communication between the Basal Chadron and the White River. However, a distinct structural feature occurs in the general area of the White River (see Section 2.6.2), a monocline or fold within the Pierre, Chadron and Brule Formations, possibly caused by movement along a fault that is present at depth, but which terminates before transecting these near surface formations. Along this feature, the orientation and dip of the Chadron changes from dipping to the southeast to the northwest.

Regional data regarding flow in the Basal Chadron are limited. Based on those data, the structural feature does not appear to dramatically impact flow in the Basal Chadron Sandstone. Additional investigations to be conducted during development of North Trend are expected to provide detailed information regarding the impact of this feature on regional and local flow in the Basal Chadron.

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Replacement Pages for Section 2.9
Background Radiological Characteristics

Replace All of Section 2.9, pages 2.9-1 through 2.9-54

Note: This section was revised with major changes, so a red-line document was not considered useful

2.9 BACKGROUND RADIOLOGICAL CHARACTERISTICS

2.9.1 Introduction

This section discusses the preoperational radiological monitoring program in the vicinity of the NTEA. The results of this program, in comparison with the operational monitoring program that will be implemented during satellite operations, will be used to determine the effects on the environment, if any, of the proposed North Trend Satellite Facilities.

The NTEA environmental baseline monitoring program was designed to meet the criteria outlined in the Reg. Guide 4.14. Alternatives to specific requirements of the guide were developed and implemented. The primary basis for the alternate procedures was that Reg. Guide 4.14 was developed to address uranium "milling" operations producing yellowcake and the proposed satellite facility is a "wet" process that limits a number of concerns addressed in Reg. Guide 4.14. For example, there are limited air particulate and radon emissions due to lack of ore and overburden piles, tailings pond(s), yellowcake drier, and less disturbance area. Therefore, the preoperational radiological monitoring plan will present baseline data that will be used to assess potential impacts resulting from the operation of the Three Crow Satellite Facility, a typical uranium in situ leach facility.

Initial background radiological monitoring in the NTEA was performed over a period of one year from July 1996 to June 1997. As part of this 1996 monitoring program, samples were collected and analyzed for the concentration of radionuclides in the pre-mining environment. As stated above, this program was designed to meet the criteria outlined in the Reg. Guide 4.14 and was described in a CBR preoperational environmental monitoring plan (RTG 1996). The 1996 North Trend environmental monitoring program included sampling of air for radon, groundwater, soils, and vegetation and monitoring for direct gamma radiation. The 1996 monitoring program was designed to supplement the extensive environmental monitoring conducted for the current Crow Butte facility and area since 1981. Coordination of the two programs allowed more comprehensive characterization and provides regional data.

In addition to the baseline data collected in 1996, CBR completed a supplementary monitoring program of the NTEA between July 2004 and June 2005. The purpose of this monitoring was to incorporate the guidance contained in Reg. Guide 1569 and to update and confirm the data collected in 1996. The 2004 North Trend environmental monitoring program included sampling of the air for radon and air particulates, groundwater, surface water, sediment, soils, and monitoring for direct gamma radiation.

In 2009, the NRC advised CBR that the preoperational and operational monitoring (completed data collection and planned monitoring) for CBR's proposed NTEA was not complete since it did not sufficiently adhere to Reg. Guide 4.14. Therefore, the NTEA preoperational and operational monitoring plans conducted in 1996, 2004 and 2005 have

been revised to more closely adhere to NRC guidance on the NTEA monitoring program.

The results of the NTEA preoperational radiological monitoring for the years 1996, 2004 and 2005 are presented in this section. The results are organized by environmental media to allow ready comparison of monitoring data collected during both periods. In addition, as discussed above, the updated preoperational baseline monitoring plan for additional NTEA sampling is presented. The revised monitoring plan for additional sampling will collect 12 months of preoperational monitoring data for all environmental media. Once the data have been collected and analyzed, the results will be reported to the NRC.

The NTEA preoperational monitoring data collected to date indicate that the existing background concentrations of the radionuclides of interest are in the range of baseline data previously collected by CBR for the current license area.

The results of the NTEA preoperational radiological monitoring are organized by environmental media to allow ready comparison of monitoring data collected during both periods. A discussion of the scope of the monitoring program precedes the presentation of the data.

2.9.2 Baseline Air Monitoring

2.9.2.1 Selection of Air Monitoring Locations

2.9.2.1.1 1996-1997 and 2004-2005 Air Monitoring Locations

Reg. Guide 4.14 recommends that preoperational air monitoring should be conducted continuously at a minimum of three locations at or near the site boundary. Further, if there are residences or occupiable structures within 10 kilometers of the site, a continuous outdoor air sample should be collected at or near the structure with the highest predicted airborne radionuclide concentration. A continuous air sample should also be collected at a remote location that represents background conditions.

Five air monitoring locations were installed in 1996 as follows:

- One sample at the nearest affected residence to the projected location of the satellite facility (location NE-1); and
- Four samples at the approximate 1996 North Trend Expansion license boundary locations (locations NE-2 through NE-5).

An existing background sampler was used for the TCEA. This background location was identified as AM-6, which is used as the background control location for the current Crow Butte operation. AM-6 is located on the eastern edge of the City of Crawford and is approximately one mile from the southern boundary of the NTEA. CBR based the sample locations for the radon air monitoring program on the projected satellite facility

location and license boundaries available in 1996. The sample locations for the radon air monitoring program were also based on the meteorological data available for the area.

Figure 2.9-1 contains a map of the NTEA showing the 1996 - 1997 monitoring locations. As noted, the air monitoring locations were designated as NE-1 (nearest residence); NE-2, NE-3, NE-4, and NE-5 (boundaries); and AM-6 (background control).

Data sources for the meteorological conditions are the Climatological Summary for Chadron, Nebraska and a CBR on-site monitoring station which was located near the current Crow Butte facility. The CBR MET Station is located approximately 3 miles southeast of the southeast corner of the NTEA license boundary (1093605 Easting 503789 Northing).

The MET station on the current Crow Butte license area monitored temperature, precipitation, evaporation, wind speed and direction, and the standard deviation of the wind direction. The local meteorological station was operated from April 1982 through April 1984 during initial permitting for the current Crow Butte licensed area. From this information joint frequency data was compiled. Further information on meteorological conditions is contained in Section 2.5.

Sample locations for the boundary and nearest resident samples were based upon the prevailing wind direction and the projected satellite facility location. As can be seen in the wind rose presented in Section 2.5 for the current Crow Butte license area, the local wind direction is predominantly from south-southwest direction approximately 45 percent of the time. Winds can also be from the northeast. The boundary sample locations were determined based upon this data.

In general, monitoring conducted in 2004 was an update of the 1996 monitoring. However, several changes were made to the air monitoring locations to more accurately provide boundary data based on the revised license boundaries, a revised satellite facility location, and to monitor additional nearby residences. Seven monitoring locations were used in the 2004 program. Following is a summary of the changes made to the air monitoring locations:

NE-1 was located at the entrance to a nearby residence that was determined in 1996 to be the nearest affected residence for a potential satellite facility. This monitoring location was determined to be the most affected residence and was not changed for the 2004 monitoring. However, the location was redesignated as AM-9 to be consistent with the air monitoring location designations used for the current license area (i.e., AM-1 through AM-8 are currently in use).

- NE-2 was moved approximately ½ mile north from the 1996 location to more accurately measure the north license boundary and to monitor conditions near a nearby residence. NE-2 was redesignated AM-10.

- NE-3 was determined to be unnecessary due to the location of AM-10 at the north boundary and was not monitored in 2004.
- NE-4 was moved approximately ½ mile east to a nearby residence that is in close proximity to the proposed North Trend Satellite Facility location. NE-4 was redesignated AM-12.
- NE-5 was redesignated AM-11 and was used to monitor the west license boundary.
- New monitoring location AM-13 was established near the southwest corner of the proposed license boundary to monitor conditions near a residence and immediately north of the City of Crawford.
- New monitoring location AM-14 was established near the southeast corner of the proposed license boundary to monitor conditions near several residences and immediately north of the City of Crawford.
- The background location was again identified as AM-6, which is used as the background control location for the current licensed operation.

Figure 2.9-2 contains a map of the NTEA showing the 2004 - 2005 monitoring locations.

2.9.2.1.2 Additional Air Monitoring Locations

CBR will monitor for air particulate, radon and gamma parameters at five (5) sampling points: AM-22, AM-23, AM-24, AM-25 and AM-26. The sampling locations are described in **Table 2.9-1** and shown at locations at or near the NTEA license boundary in **Figure 2.9-3**.

Sample points AM-22, AM-23 and AMT-24 are located downwind of three wind rose sectors shown to have the predominant wind direction (S, SSW and SW) for data collected at the CBR MET station. Sample point AM-25 shall be located near the nearest residence located near the license boundary approximately one-half mile east of proposed satellite facility. Sample point AM-26 will be located to the west of the license boundary in the direction of the least predominant wind direction, which will serve as the background sampling location for the NTEA.

2.9.2.2 Radon Gas Monitoring Program

Reg. Guide 4.14 recommends radon gas samples be collected at each of the air particulate monitoring stations (5 or more sample points). Continuous samples for at least one week per month representing about the same time of the month should be performed. Analysis is as radon gas.

2.9.2.2.1 1996 - 2005 Radon Gas Monitoring

Air monitoring in 1996 involved radon gas sampling performed at quarterly intervals at air monitoring locations NE-1 through NE-5 and AM-6. Monitoring was performed using RadTrak® Type DRNF outdoor air radon detectors. RadTrak® cups contain a sensitized chip covered with a selectively permeable material allowing only the infiltration of radon. The sensitized chip records alpha disintegrations from radon daughters, allowing determination of average radon concentrations. The analysis of quarterly sampling has a sensitivity of 30 pCi/l-days.

Air monitoring in 2004 involved radon gas sampling performed at semiannual intervals using RadTrak® Type DRNF outdoor air radon detectors. The semiannual interval was chosen to ensure that monitoring results meet the lower limit of detection (LLD) requirement of 0.2 pCi/l (2×10^{-10} μCi/ml) from Reg. Guide 4.14 and to be consistent with the semiannual intervals approved by the NRC for the current operational monitoring.

Air monitoring for radon gas was performed for the NTEA during the third and fourth quarters of 1996 and the first and second quarters of 1997. A duplicate RadTrak® detector was installed at location NE-5 as a quality control measure and is denoted "NE-5 (D)" in the results.

The results of the 1996 - 1997 radon sampling are presented in **Table 2.9-2**. This table gives the concentration of radon in air that was obtained at the air monitoring stations. The average values were consistent for all five monitoring stations with mean values ranging from 0.53×10^{-9} to 0.93×10^{-9} μCi/ml.

The results of the 2004 and 2005 radon sampling are presented in **Table 2.9-3**. This table gives the concentration of radon in air that were obtained at the seven air monitoring stations on a semiannual basis for the twelve month period beginning with the third quarter of 2004. Two duplicate RadTrak® detectors were installed at locations AM-10 and AM-13 as a quality control measure and are denoted as "AM-10 (D)" and "AM-13 (D)" in the results.

The average values for the twelve month period were consistent for all seven monitoring stations with mean values ranging from 0.2×10^{-9} to 0.65×10^{-9} μCi/ml. Note that the average for AM-14 (0.2×10^{-9} μCi/ml) is based on a single monitoring result for the first half of 2005 since the detector for the second half of 2004 was missing at the end of the monitoring period.

Figure 2.9-4 is a plot of the results of radon monitoring from the North Trend air monitoring locations from January 1991 through June 2005, including the background station AM-6 for comparison.

Quality of Air Measurements

The accuracy of monitoring data is critical to ensure that the preoperational air monitoring program precisely reflects air quality. Reg. Guide 4.14 specifies the following lower limits of detection (LLD):

Radionuclide	Recommended LLD µCi/ml	Actual LLD µCi/ml
Radon-222	2×10^{-10}	3×10^{-10} (1996 - 1997 data) 2×10^{-10} (2004 - 2005 data)

Note that Landauer does not provide the LLD on the analytical report. The LLD for Radtrak® detectors is a function of the exposure time and the area of the cup that is analyzed by Landauer.

2.9.2.2.2 Additional Radon Gas Monitoring

Sample Location

Radon-222 will be monitored at the same location as the air particulate monitoring locations described in **Table 2.9-1 (Figure 2.9-3)**. Collectively, the sampling locations are referred to as the Air Monitor Stations.

Sample Method

Monitoring will be performed continuously using Landauer Radtrak Type DRNF Dosimeters. This detector is an alpha-track radon gas detector using Landauer's Track-Etch® process and is designed to monitor radon exposure for three months to one year, providing a long-term average concentration over time. Landauer service includes the RadTrak detector and a comprehensive analysis.

The RadTrak radon detectors will be supplied to CBR by the vendor in aluminum bags to prevent radon exposure before deployment. The detectors will not be stored or deployed in any area in which the temperature may exceed 160°F. There is no low temperature limit.

After opening the aluminum bag to remove and deploy the detector, the Data Sheet provided with the detectors will be filled in with the serial number, date installed and the location information. A detector field canister will be maintained at the air monitor station, and the detector will be placed in the canister facing down. The canister may be placed at any desired height, but is typically 3 to 6 feet from the ground to prevent undue influence from radon emanation from the soil at the sample location. Efforts will be made to place the canister in a location that will be safe from tampering or animal damage.

At the end of a 6-month monitoring period (Semi-annual), the removal date on the Data Sheet for each detector will be entered as it is removed from the detector canister. A

gold adhesive seal, which is provided with the shipment, will be placed over all of the holes on the top of the detector. This will effectively stop the monitoring period. Any unusual conditions encountered will also be noted on the Data Sheet. The detector that has been removed will be immediately replaced with a new detector.

The exposed detectors will be returned to the aluminum bag for shipment back to Landauer. The open end of the aluminum bag will be folded several times and sealed with tape or staples. If the aluminum bag is misplaced, the cups may be wrapped in aluminum foil for shipment. A copy of the Data Sheet will be included with the detectors when they are returned to Landauer for analysis.

Sample Frequency

Radon gas sampling will be performed at semiannual intervals using RadTrak® Type DRNF outdoor air radon detectors. The semiannual interval was chosen to ensure that monitoring results meet the lower limit of detection (LLD) requirement of 0.2 pCi/l (2 x 10^{-10} μCi/ml) from Reg. Guide 4.14 and to be consistent with the semiannual intervals approved by the NRC for the current operational monitoring.

Sample Analysis

Landauer will process and conduct an analysis of the radon detector. The results are reported as radon-222.

For this method, the detector is a small piece of special plastic or film inside a small container. Air being tested diffuses through a filter covering a hole in the container. When alpha particles from radon and its decay products strike the detector, they cause damage tracks. At the end of the test the container is sealed and returned to a laboratory for reading (EPA 2010).

The plastic or film detector is treated to enhance the damage tracks and then the tracks over a predetermined area are counted using a microscope or optical reader. The number of tracks per area counted is used to calculate the radon concentration of the site tested (EPA 2010).

Landauer does not provide the LLD on the analytical result report. The LLD for Track-Etch® detectors is a function of the exposure time and the area of the cup that is analyzed by Landauer. The LLD will be determined in consultation with Landauer before monitoring is performed. If the LLD is above the NRC requirements from Regulatory Guide 4.14, it may be reduced by either employing a longer sampling time or requesting that Landauer analyze a larger portion of the Track-Etch® cup.

Analysis Frequency

Analysis will include each detector reading for samples collected on a semi-annual basis.

Reporting Monitoring Data

CBR will report the following information for the Track-Etch Cup: average Radon concentration (uCi/ml), accuracy (uCi/ml), Lower Limit of Detection (LLD) (uCi/ml) and effluent concentration limit (ECL).

Quality of Air Measurements

The accuracy of monitoring data is critical to ensure that the preoperational air monitoring program precisely reflects air quality. Regulatory Guide 4.14 specifies the following lower limits of detection (LLD):

Radionuclide	Recommended LLD µCi/ml
Radon-222	2×10^{-10}

Note that Landauer does not provide the LLD on the analytical report. The LLD for Radtrak® detectors is a function of the exposure time and the area of the cup that is analyzed by Landauer.

2.9.2.3 Air Particulate Monitoring Program

2.9.2.3.1 2004 – 2005 Air Particulate Monitoring

For the 1996 baseline monitoring program, CBR determined that air particulate monitoring was not appropriate for the NTEA. Therefore, air particulate monitoring was not carried out.

For the 2004 monitoring period, CBR determined in discussions with NRC staff that it would be useful to add a baseline preoperational air particulate monitoring station at the north end of the NTEA to provide additional regional background radiological information. This air monitoring station was designated as AM-10 (**Figure 2.9-2**). Data from this station may be compared with air particulate data from AM-6, which is located south of the NTEA and has been monitored since 1982 as a background location for the current license area.

The airborne particulate samples were collected on the inlet filter of a regulated vacuum pump on a Type A/E 47 mm glass fiber filter paper. The low volume air samplers employed were the Eberline RAS-1 system that consists of a vacuum pump, an airflow regulator, a rotameter-type airflow indicator, and filter paper holder. The RAS-1 samplers were placed in protective enclosures that provided protection from the elements while allowing unimpeded sampling of the ambient air.

Clean filters were installed in the filter holder at the beginning of each sampling period. The pump flow rate was adjusted as necessary. The filter replacement schedule was determined based on the dust loading at a particular location. In general, samplers were

run for one to two weeks without a significant reduction in the flow rate due to dust loading.

At the end of the calendar quarter, the composite filter samples for AM-6 and AM-10 were submitted to the contract laboratory for radiometric analysis using CBR's standard chain of custody procedures discussed in CBR's Safety, Health, Environment and Quality Management System (SHEQMS) Volume VI, *Environmental Manual* (CBR 2010a). The filters were composited according to location. The composite samples were analyzed for the concentrations of natural uranium, radium-226, and lead-210. Thorium-230 was not selected for analysis as recommended in Reg. Guide 4.14 based on the current NRC-approved Crow Butte operational air particulate monitoring program. Thorium-230 is not typically released through the *in situ* leach mining process and was not a radionuclide of concern.

The flow rate on the RAS-1 pumps was calibrated at six-month intervals using accepted calibration methods in order to ensure the accuracy of the volume of air sampled. Records of sampler calibration are available on file at the Crow Butte facility.

As discussed with the NRC staff in 2004, CBR proposed not to perform operational air particulate monitoring at AM-10 due to the absence of proposed operations that could be a source of airborne radioactive particulates. CBR continued airborne particulate sampling at the air monitoring stations AM-1 through AM-8 to monitor drying and packaging operations at the current Crow Butte facility.

Air particulate monitoring for the NTEA was performed at locations AM-6 (background) and AM-10 (north boundary) during the third and fourth quarters of 2004 and the first and second quarters of 2005 (**Figure 2.9-2**). The results of the air particulate sampling are presented in **Table 2.9-4**. This table gives the concentrations of natural uranium, radium-226, and lead-210 in air samples at the air monitoring stations.

Quality of Air Measurements

The accuracy of monitoring data is critical to ensure that the preoperational air monitoring program precisely reflects air quality. Regulatory Guide 4.14 specifies the following lower limits of detection (LLD):

Radionuclide	Recommended LLD µCi/ml	Actual LLD µCi/ml
Natural Uranium	1×10^{-16}	1×10^{-16}
Radium-226	1×10^{-16}	1×10^{-16}
Lead-210	2×10^{-15}	2×10^{-15}

Note that Landauer does not provide the LLD on the analytical report. The LLD for Radtrak® detectors is a function of the exposure time and the area of the cup that is analyzed by Landauer.

2.9.2.3.2 Additional Air Particulate Monitoring

Sample Location

CBR will collect continuous air particulate samples at five (5) sampling points: AM-22, AM-23, AM-24, AM-25 and AM-26. The sampling locations are described in **Table 2.9-1** and shown at locations at or near the NTEA license boundary in **Figure 2.9-3**.

As specified in Reg. Guide 4.14, sample points AM-22, AM-23 and AM-24 are located downwind of three wind rose sectors showing the primary wind directions (S, SSW and SW) which will have the highest predicted concentrations of airborne particulates (**Figure 2.5-3**). Sample point AM-25 shall be located near the nearest residence located near the license boundary approximately one-half mile east of proposed satellite facility. Sample point AM-26 will be located to the east of the license boundary in the direction of the least predominant wind direction, which will serve as the background sampling location for the NTEA.

Sample Method

The airborne particulates will be collected on the inlet filter of a regulated vacuum pump on a Type A/E 47 mm glass fiber filter paper. The low volume air samplers employed will be the Eberline RAS-1 system or equivalent that consists of a vacuum pump, an airflow regulator, a rotameter-type airflow indicator, and filter paper holder. The samplers will be placed in protective enclosures that provide protection from the elements while allowing unimpeded sampling of the ambient air. An hour meter will be installed to allow accurate determination of the sampler run time between filter change outs.

Clean filters will be installed in the filter holder at the beginning of the sampling period. The pump flow rate is adjusted, if necessary and the required information (i.e., start time and date, flow rate, hour meter reading, sampler name) are recorded on the Sampling Record. The filter replacement schedule will be determined based on the dust loading at a particular location. In general, samplers can run for one to two weeks without a significant reduction in the flow rate due to dust loading. If sampling records indicate that dust loading at a particular sampling location is affecting the flow rate, the filter replacement frequency may need to be increased.

As each filter is removed at the end of the sampling period, the filter will be folded in half with the exposed surface to the inside to retain the solid material deposited on the filter. Care will be taken to ensure that the filter is not damaged during removal in order that particulate matter retained on the filter is not lost. The exposed filter will be placed in a sample envelope that is stored in an appropriate container by sample location. The necessary information (i.e., stop time and date, flow rate, hour meter reading, sampler name, comments) will be recorded on a Sampling Record. The hour meter, which totalizes the time that the pump has operated, will be read and recorded. This information will be used to estimate the amount of time that a monitoring site may have

been inoperable due to a malfunction or significant power outage and allows a more accurate determination of the volume of air filtered.

The flow rate on the RAS-1 pumps will be calibrated at six-month intervals in order to ensure the accuracy of the volume of air sampled. The calibration is accomplished following the instructions contained in CBR's SHEQMS Volume IV, *Health Physics Manual* (CBR 2010b).

Sample Frequency

Sample collection will be continuous using a continuous sampler operation with filter change weekly or more often as required by dust loading.

Sample Analysis

- Type of Analysis

At the end of the calendar quarter, the composite filter samples will be submitted to the contract laboratory for radiometric analysis using CBR's standard Chain of Custody Procedures as discussed in CBR's *Environmental Manual* (CBR 2010a). The filters will be composited according to location. The composite samples will be analyzed for the concentrations of natural uranium, radium-226, thorium-230 and lead-210. The actual volume of air filtered at each station for the quarter is also forwarded to the contract laboratory with the filters.

The results of air particulate monitoring will be recorded in the CBR environmental record system to determine trends at particular locations.

- Analysis Frequency

Quarterly composites of weekly samples.

Reporting Monitoring Data

As required by Reg. Guide 4.14, CBR will report the following information for each radionuclide: concentration (uCi/ml), error estimate (uCi/ml), Lower Limit of Detection (LLD) (uCi/ml) and percent maximum permissible concentration (MPC).

Quality of Air Measurements

The accuracy of monitoring data is critical to ensure that the preoperational air monitoring program precisely reflects air quality. Regulatory Guide 4.14 specifies the following lower limits of detection (LLD):

Radionuclide	Recommended LLD µCi/ml
Natural Uranium	1×10^{-16}
Radium-226	1×10^{-16}
Radon-222	2×10^{-10}
Lead-210	2×10^{-15}

2.9.3 Baseline Groundwater Monitoring

Reg. Guide 4.14 requires wells to be sampled around the future tailings disposal area, with at least three wells hydrologically down gradient from the disposal area and one well located hydrologically up gradient from the tailings disposal area to serve as a control or background location. At least three of the down gradient wells should be located on other sides of the tailings disposal area. These requirements are not applicable to the proposed in situ leach satellite facility since there is no such tailings disposal area(s).

CBR will install three monitor wells hydrologically down gradient, and one well up gradient of the proposed evaporation ponds. These evaporation ponds are designed to handle liquid wastewaters. These up gradient and down gradient monitor wells will be installed during the operational phase once the exact locations of the ponds and other assets have been finalized. In addition, the evaporation ponds will have an operational leak detection system to assure there is no migration beyond the liners.

Reg. Guide 4.14 requires that wells with two kilometers of the tailing disposal area that are or could be used for potable water supplies or watering of stock or crop irrigation should be monitored. In lieu of this non-applicable requirement (i.e., tailings disposal area), CBR monitors selected wells within or adjacent to the license boundary (see discussions below). This monitoring is more applicable due to nature of the in situ leach operations and the presence of onsite monitor wells that are used to detect migration of any process fluids from the production areas.

This section focuses on the results of groundwater monitoring of radiological parameters. Groundwater monitoring results for nonradiological parameters are presented in Section 2.7.

2.9.3.1 1996/1997 – 2004/2005 Baseline Groundwater Monitoring

CBR conducted a water user survey in 1996 to identify and locate all private water supply wells within a 2-mile radius of the proposed North Trend license boundary. The water user survey determined the location, depth, casing size, depth to water, and flow rate of all wells within the area that were (or could be) used for domestic, agricultural, or livestock uses. Based on the data collected during the well user survey, CBR selected five representative wells in the NTEA for quarterly groundwater monitoring for selected

radionuclides. The wells were chosen based on proximity to the proposed mining operation, use, and distribution throughout the expansion area.

The well locations are shown on **Figure 2.2-4**. This section will discuss the results of the radiometric analyses. Information on the selected wells including formation, depth, and usage is shown in **Table 2.9-5**.

CBR updated the water user survey for the current license area, the North Trend area, and the City of Crawford in 2004. CBR conducted groundwater sampling at the same five private wells in the third and fourth quarters of 2004 and the first and second quarters of 2005. The wells were sampled on a quarterly basis for natural uranium, thorium-230, radium-226, lead-210, and polonium-210. The wells were also sampled for uranium and radium-226 during the third quarter of 2005. In addition, a well installed in the Chadron formation for hydrologic testing was sampled for water quality parameters as discussed in Section 2.7.

The 1996 sampling program began in the third quarter of 1996 with quarterly samples taken for one year. Additional monitoring was performed on a quarterly basis for one year beginning in the third quarter of 2004. The samples were collected at a discharge point close to the well and preserved following applicable EPA Guidelines (CBR 2010a). The 1996 samples were not filtered and the results represent the total concentration of the radionuclides. The 2004 samples were filtered and the results represent the dissolved concentration of the radionuclides. The primary analytical laboratory in 1996 and 2004 was Energy Laboratories in Casper, Wyoming. Some wells were also sampled for water quality parameters. The results of those analyses are discussed in Section 2.7.

Table 2.9-6 contains the results of the analyses for radionuclides for all private wells sampled for the NTEA during 1996 – 1997 and 2004 - 2005. Results are for concentrations of natural uranium, thorium-230, radium-226, lead-210, and polonium-210 with the exception of the first quarter of 2005, when an error in the chain of custody resulted in no analysis for thorium-230, polonium-210, and lead-210.

The results of the analyses indicate concentrations of the radionuclides are within the expected ranges for naturally occurring background in the area. The concentration of uranium in the wells completed in the Brule Formation within the NTEA ranged from <0.2 to 31.1 x 10^{-9} μCi/ml (<0.0003 to 0.05 mg/l). The concentration of radium-226 in these same wells ranged from <0.2 to 1.3 x 10^{-9} μCi/ml with the majority of the wells below the detection level.

One well within the NTEA (W-81) was completed in the Chadron Formation. This well was used by a local resident for irrigation purposes. The uranium results for well W-81 varied between <0.2 to 8.8 x10^{-9} μCi/ml. Radium-226 in this well was consistently above the detection level with a maximum concentration of 13.5 x 10^{-9} μCi/ml. Several other radionuclides were above detection levels on individual samples. These results are

consistent with baseline sampling performed on Chadron wells in the current license area. Following the baseline collection period, the owner of well W-81 had the well plugged and abandoned due to well maintenance problems and does not intend to replace the well with another well in the Chadron formation.

Groundwater sampling was conducted as per sampling procedures identified in CBR's, *Environmental Manual* (CBR 2010a). Field parameters (pH and specific conductivity) were analyzed by CBR personnel using portable, calibrated instruments following procedures in this manual. The field measurements were performed in accordance with the manufacturer's recommendations. Samples collected for laboratory analyses were submitted to CBR's contract laboratory, using chain-of-custody procedures that meet established CBR procedures and NDEQ and EPA requirements. For sampling events such as sampling private or monitor wells, CBR requests the required number of sample containers for the sampling event. Energy Labs then provides coolers, sample containers, required preservatives, Chain of custody forms, plastic bags for containers and ice, and shipping papers.

Quality of Groundwater Measurements

The accuracy of monitoring data is critical to ensure that the water monitoring program precisely reflects water quality.

In addition to recommending the use of approved analytical methods for water quality measurements (contained in 40 CFR 136), the NRC also specifies analytical quality requirements in Reg. Guide 4.14 for the following lower limits of detection (LLD) in water:

Radionuclide	Recommended LLD µCi/ml	Actual LLD µCi/ml
Natural Uranium	2×10^{-10}	2×10^{-10}
Thorium-230	2×10^{-10}	2×10^{-10}
Radium-226	2×10^{-10}	2×10^{-10}
Polonium-210	1×10^{-9}	1×10^{-9}
Lead-210	1×10^{-9}	1×10^{-9}

2.9.3.2 Future Preoperational Baseline Groundwater Monitoring

Preoperational monitoring of CBR monitor wells (discussed in Section 2.7) and designated private water supply wells (W-77, W-78), W-83 and W-107) was conducted for quarters 3 and 4 of 1996, first and second quarters of 1997, third and fourth quarters of 2004 and first, second and third quarters of 2005. No additional preoperational monitoring for these wells is planned until project construction activities commence. Data collection in 1996/1997 and 2004 and 2005 resulted in quarterly sampling for two preoperational 12-month sampling periods.

When construction commences, CBR will begin monitoring of private water supply wells located within 1 km of the NTEA permit boundary that are completed in the Brule Formation. Monitoring of these wells will be subject to well owner approval. Monitoring of these wells will be a component of the NTEA operational groundwater monitoring program (see Section 5.7.7).

2.9.4 Baseline Surface Water Monitoring

Surface water sampling in Reg. Guide 4.14 calls for sampling of surface water passing through the project site or offsite surface waters that may be subject to drainage from potentially contaminated areas or that could be affected by a tailings impoundment failure. Grab samples are to be collected and analyzed on a: monthly basis for suspended and dissolved natural uranium, radium-226 and thorium-230; and on a semi-annual basis for lead-210 and polonium-210.

Surface water sampling in Reg. Guide 4.14 also requires samples from each large onsite body of water or offsite impoundments that may be subject to direct surface drainage from potentially contaminated areas that could be affected by a tails impoundment failure. Grab samples are to be collected on a quarterly basis with samples analyzed for suspended and dissolved natural uranium, radium-226 and thorium-230. Semiannually, samples should be analyzed for suspended and dissolved lead-210 and polonium-210.

As previously stated above, the North Trend operations will not have a tailings impoundment. In lieu of the above-referenced Reg. Guide 4.14 guidance for tailings impoundments, CBR will monitor existing surface water features that may be subject to drainage from potentially contaminated areas associated with the satellite facility operations (i.e., processing building, wellfield operations, evaporation ponds, chemical storage and other associated support facilities).

2.9.4.1 2004 – 2005 Baseline Surface Water Monitoring

There are no private surface water impoundments at or within the NTEA license boundary, nor or there any offsite (outside of license boundary) surface impoundments subject to direct drainage from potentially contaminated areas associated with the North Trend operations. Therefore, no surface water samples were required.

Surface water is discussed in Section 2.7.1, where the nearby river, streams and drainages are identified and discussed. Water samples were only collected from the White River due to the lack of measurable flow at the other nearby drainages. The streams and drainages are typically dry except for rainfall and snowfall runoff flow and occasional springs. No opportunities were identified to allow for sampling of these ephemeral drainages.

The White River is located south of the NTEA, with the river flowing in close proximity to the southern end of the NTEA project boundary (**Figure 2.9-5**). CBR performed

preoperational monitoring on the White River at sampling locations W-1, and W-2, as shown in **Figure 2.9-5**. The purpose of these sampling locations is for establishing baseline conditions of the White River in the vicinity of the NTEA. W-1 is located approximately 2.63 miles upstream of the south end of the North Trend site boundary where the White River crosses through the site boundary. The location of W-1 is such that it is suitable for use as an upstream sample location. W-2 is located approximately 4.42 miles downstream of W-1 and is located approximately 0.94 miles upstream of where the White River flows along the southeast corner of the NTEA site boundary. W-2 is located such that measurements are representative of river conditions in close proximity to the proposed project boundary. Any releases to the surface within the project boundary that would have the highest potential of reaching the White River, due to being in closer proximity to the river, would be between W-1 and W-2 (**Figure 2.9-5**).

These sample locations, plus sampling location W-3, were also used for preoperational monitoring associated with the current CBR operations. W-3 was located approximately 5.84 miles upstream of W-2 and is located approximately 2 miles outside of the NTEA Area of Review (AOR). Results for initial baseline sampling conducted during studies for this current license area were previously reported to the NRC (Ferret 1987). W-3 was not used for NTEA preoperational monitoring due to the distance from the NTEA (e.g. approximately 5.54 miles upstream of W-2).

During sampling of two sampling stations on the White River (W-1 and W-2) in 2004 and 2005 for NTEA baseline monitoring, all samples were analyzed for the concentration of natural uranium, thorium-230, radium-226, lead-210 and polonium-210 with the exception of the first and third quarters of 2005 when an error in the chain of custody resulted in no analysis for thorium-230, polonium-210 and lead-210 (**Table 2.9-7**). There were a total of 5 sampling quarters in 2004 and 2005, with 3 of these quarters having analytical results for these latter parameters for each of the W-1 and W-2 sampling locations. All 6 of the individual results for W-1 and W-2 (3rd and 4th quarter, 2004 and second quarter, 2005) for thorium-230, polonium-210 and lead-210 were <0.02, <1.0 and <0.10 uCi/ml x 10^{-9}, respectively. RA-226 levels were also consistent for all of the 9 quarterly sampling periods (<0.2 uCi/ml x 10^{-9}). There was little variation in the natural uranium levels for W-1 for 9 quarters (3.6 to 5.0 uCi/ml x $10^{-9)}$. It was the opinion of CBR that since all of the sample results were less than the detection limit for three quarters, and there was little variation in the other radiological parameters, the analytical results appeared to be representative of the White River at W-1 and W-2. Additional sampling did not appear to be warranted.

Grab samples were taken for each sample collected. The collection of surface water samples was as specified in CBR's *Environmental Manual* (CBR 2010a). Sampling procedures were consistent with EPA surface water sampling procedures (EPA 1994).

Surface water sampling was conducted as per sampling procedures identified in CBR's *Environmental Manual* (CBR 2010a). Samples collected for laboratory analyses were

submitted to CBR's contract laboratory, using chain-of-custody procedures that meet established CBR procedures and NDEQ and EPA requirements.

Quality of Surface Water Measurements

The accuracy of monitoring data is critical to ensure that the water monitoring program precisely reflects water quality.

In addition to recommending the use of approved analytical methods for water quality measurements (contained in 40 CFR 136), the NRC also specifies analytical quality requirements in Reg. Guide 4.14 for the following lower limits of detection (LLD) in water:

Radionuclide	Recommended LLD µCi/ml	Actual LLD µCi/ml
Natural Uranium	2×10^{-10}	2×10^{-10}
Thorium-230	2×10^{-10}	2×10^{-10}
Radium-226	2×10^{-10}	2×10^{-10}
Polonium-210	1×10^{-9}	1×10^{-9}
Lead-210	1×10^{-9}	1×10^{-9}

2.9.4.2 Additional Surface Water Sampling Program

Sample Location

The following ephemeral streams drainage channels and river are present in and around the NTEA:

- Spring Creek
- Unnamed Creek
- Hall Canal
- White River

Surface water samples will be collected from these ephemeral stream drainage channels subject to the seasonal nature of flow in these features. Any flow in these channels is due to snowmelt and runoff, as well as isolated springs. These stream drainages remain dry for most of the year and flow may occur during early spring or periods of heavy rains.

Spring Creek is located at the north end of the license boundary and Unnamed Creek at the south end of the boundary **(Figure 2.9-5).** The Spring Creek sampling locations will be located at or near the point the ephemeral drainages enter the NTEA license boundary and at or near the point the drainage exits the boundary.

Surface water samples for Unnamed Creek will be collected at or near the point the drainage enters the NTEA license boundary and a point just prior to the confluence with the White River (confluence point is within NTEA license boundary) (**Figure 2.9-5**).

Hall Canal crosses and exits the NTEA license boundary at the northwest corner of the boundary and again near the southeast corner of the boundary (**Figure 2.9-5**). Samples will be collected at or near the locations where the canal enters the boundary (2 samples) and exits the boundary (2 samples).

The White River flows through the southeast corner of the license boundary. This is the major river in the area and continuous flow can be expected. Surface water samples will be collected from the White River at or near the NTEA designated surface water sampling points W-1 and W-2 noted in **Figure 2.9-5**. These sampling points serve as the upgradient (W-1) and downgradient (W-2) locations of the river for the NTEA site.

Note: There are no private surface water impoundments at or within the NTEA license boundary, nor or there any offsite (outside of license boundary) surface impoundments subject to direct drainage from potentially contaminated areas associated with the North Trend operations. Therefore, no surface water samples are required.

Sample Method

Grab samples will be taken for each sample point. The collection of surface water samples will be as specified in CBR's *Environmental Manual* (CBR 2010b). Sampling procedures will be consistent with EPA surface water sampling procedures (EPA 1994).

The direct method of sampling will typically be used for sampling the White River, and as feasible (based on available flow) area streams. This method is applicable due to the shallow depth of the river and streams and involves collection of the water sample directly into the sample container.

This direct method includes the following basic steps:

1. Sampling will proceed so as not to disturb fine sands and silts that may affect the analyses. Sampling will proceed from downstream to upstream locations in order to avoid disturbed constituents being included in the sample(s). Approach the sampling location from a down flow direction, with the sampler facing upstream to collect the sample without disturbing the sediment. Special care will be taken within three or four feet of the actual sampling location so as not to disturb fine sands and silts that may affect analyses.
2. The collector will submerse the closed sample container below the water surface, opens the bottle to collect the sample and then caps the bottle while sub-surface. The sampling bottle may be rinsed two times by the sample water prior to sampling.

3. When using the direct method, pre-preserved sample bottles will not be used as the collection method may dilute the concentration of preservation necessary for proper sample preservation. For pre-preserved containers, a separate sample container will be used to collect the sample, with the collected sample transferred to the sample container.
4. Once a sample is collected, the following procedures will be followed:
    - Preserve the sample if appropriate, or use pre-preserved sample bottles.
    - Cap container and place it on ice in a cooler.
    - All pertinent data will be recorded in the site log book and on a field data sheet.
    - The Chain-of-Custody form will be completed.
    - Custody seals will be attached to the cooler prior to shipment.
5. All field and shipping records will be retained. For example, characteristics (e.g., size, depth, flow) of the water body, sample location, time, date, name of collector and other pertinent information. The sample container will be labeled with pertinent information.

Sample Frequency

The number of grab samples to be collected per monthly sampling event is as follows:

- Spring Creek (2 sampling locations)
- Unnamed Creek (2 sampling locations)
- Hall Canal (4 sampling locations)
- White River (4 sampling locations)

For clarification, see discussions under Sample Location discussed above. Sampling in the ephemeral streams is subject to available flow. During early spring and periods of regional heavy rainfall, CBR will inspect the channels in the NTEA and surrounding area to determine whether such flow is available for sampling. Inspections and observations will be recorded in a designated field log book.

Sample Analysis

For 12 consecutive months, surface water samples will be analyzed for suspended and dissolved natural uranium, ra-226, and th-230. Semi-annually, samples will be analyzed for suspended and dissolved pb-210 and po-210. Since it is highly likely that flow will not be present in the ephemeral drainage channels for every month of the year, available samples will be analyzed for suspended and dissolved natural uranium and ra-226 as well as pb-210 and po-210. CBR will continue to conduct such analysis until satisfactory

semi-annual analyses for pb-210 and po-210 have been completed as best as possible (i.e., first and second half of the 12 month sampling period).

Analysis Frequency

Quarterly analysis for samples collected for suspended and dissolved natural uranium, ra-226, and th-230.

Semiannual analysis for samples collected and analyzed for suspended and dissolved pb-210 and po-210.

Reporting Monitoring Data

As required by Reg. Guide 4.14, CBR will report the following information for each radionuclide: concentration (uCi/ml), error estimate (uCi/ml), and Lower Limit of Detection (LLD).

Quality of Surface Water Measurements

The accuracy of monitoring data is critical to ensure that the water monitoring program precisely reflects water quality.

In addition to recommending the use of approved analytical methods for water quality measurements (contained in 40 CFR 136), the NRC also specifies analytical quality requirements in Reg. Guide 4.14 for the following lower limits of detection (LLD) in water:

Radionuclide	Recommended LLD µCi/ml	Actual LLD µCi/ml
Natural Uranium	2×10^{-10}	2×10^{-10}
Thorium-230	2×10^{-10}	2×10^{-10}
Radium-226	2×10^{-10}	2×10^{-10}
Polonium-210	1×10^{-9}	1×10^{-9}
Lead-210	1×10^{-9}	1×10^{-9}

2.9.5 Baseline Vegetation Monitoring

Reg. Guide 4.14 recommends sampling of grazing areas near the site in different sectors that will have the highest predicted air particulate concentrations during the milling operations. Samples should be collected three (3) times during the grazing season with samples analyzed for natural uranium, radium-226, thorium-230, lead-210 and polonium-210.

2.9.5.1 1996 Baseline Vegetation Monitoring

CBR conducted vegetation sampling in and near the current licensed area beginning in 1982 through 1998. Preoperational and operational vegetation sampling was conducted

at the primary air monitoring stations (AM-1 through AM-8) during this period. In 1996, vegetation samples were obtained once during the grazing season from the five North Trend air monitoring locations (NE-1 through NE-5) and analyzed for natural uranium, thorium-230, radium-226, lead-210, and polonium-210.

As part of the preoperational radiological monitoring program, vegetation samples were collected at the five monitoring stations (NE-1 through NE-5). These samples were collected during the third quarter of 1996 and analyzed for the concentrations of natural uranium, thorium-230, radium-226, lead-210 and polonium-210.

The results of the analyses are presented in **Table 2.9-8**. The vegetation sample at each monitoring station was a composite sample of the vegetation present in proportion to occurrence. Concentrations for natural uranium ranged from 2.8 E^{-6} to 5.5 E^{-6} µCi/kg. Concentrations for thorium-230 ranged from 1.6 E^{-5} to 3.2 E^{-5} µCi/kg. Concentrations for radium-226 ranged from 2.5 E^{-6} to 8.3 E^{-6} µCi/kg. Concentrations for lead-210 ranged from 2.0 E^{-5} to 1.2 E^{-4} µCi/kg. Concentrations for polonium-210 ranged from <3.5 E^{-7} to 1.5 E^{-5} µCi/kg. These results are similar to historical baseline vegetation monitoring performed in the project area by CBR.

Vegetation sampling was conducted as per sampling procedures identified in CBR's *Environmental Manual* (CBR 2009b). Samples collected for laboratory analyses were submitted to CBR's contract laboratory, using chain-of-custody procedures that meet established CBR procedures and NDEQ and EPA requirements.

Quality of Vegetation Measurements

The accuracy of monitoring data is critical to ensure that the vegetation monitoring program precisely reflects radionuclide concentrations. Regulatory Guide 4.14 specifies the following lower limits of detection (LLD):

Radionuclide	Recommended LLD µCi/kg (wet)	Actual LLD µCi/kg (wet)
Natural Uranium	2×10^{-7}	6.9×10^{-8}
Thorium-230	2×10^{-7}	6.9×10^{-8}
Radium-226	5×10^{-8}	6.9×10^{-8}
Polonium-210	1×10^{-6}	3.5×10^{-7}
Lead-210	1×10^{-6}	3.5×10^{-7}

Note that all recommended LLDs were met with the exception of radium-226. The actual LLD of 6.9×10^{-8} was slightly above the recommended LLD of 5×10^{-8}. The recommended LLD was not met due to inadequate sample size. However, all measured radium-226 values were well above the recommended LLD and the error estimate was at or near the 10% of the reported value recommended by the NRC.

2.9.5.2 Additional Baseline Vegetation Sampling

Sample Location

CBR selected three vegetation sampling locations located on the northern site boundary (**Figure 2.9-6**). These sampling sites were selected due to being located downwind of the satellite facility in the three predominant wind direction sectors.The predominant wind direction is from the following quadrants (S, SSW and SW), so sample points were selected on the three predominant prevailing wind quadrants.

Sample Method

When obtaining vegetation grab samples at a selected location, mainly grasses or leafy plants that would normally be used as forage by domestic and wild animals as opposed to woody plants such as sagebrush, will be used. Samples will be comprised mainly of stems, leaves, and fruit and will be representative of the current year's growth. The plants will be cut with a trimmer within a few inches of the ground and placed in a sample bag until the bag contains a minimum of 8-10 kilograms (wet weight) of vegetation. Any root material will not be included. The sample will be representative of dominant vegetation present at the sample location.

The plastic bags must be weighed and clearly labeled at the time of sampling with a permanent marker, identifying the project location, sample site, and the sample date. The sample wet weight and type of analytical method to be used for the various analyses will be clearly identified on the COC to the contract laboratory. Vegetation samples will be submitted to the contract laboratory as quickly as possible.

Due to the very low detection limits required for the analysis of radionuclides in vegetation and the low concentrations of radionuclides typically present, a relatively large volume of vegetation will be sampled. A minimum of 8-10 kilograms (wet weight) of vegetation will be needed in order that the radionuclide detection limits can be met. This amount of air-dried vegetation typically will fill one large plastic garbage bag.

Sample Frequency

Samples will be collected three times for three areas during the grazing season, for a total of nine samples.

Sample Analysis

Sample analysis of individual samples will consist of natural uranium, ra-226, th-230, pb-210 and po-210.

Analysis Frequency

Sample analysis will be conducted for each set of samples collected three times in the grazing season.

Quality of Vegetation Measurements

Regulatory Guide 4.14 specifies the lower limits of detection (LLD) as shown in Section 2.9.5.1.

2.9.6 Food (Crops and Livestock)

Reg. Guide 4.14 recommends that crops, livestock, etc. raised within three kilometers (km) (~1.86 miles) of the mill site be sampled at the time of harvest or slaughter. The NRC has indicated that other food sources should be explored for sampling, such as private gardens in the area (e.g., sampling a variety of available garden plants). Grab samples should be analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. Livestock should include a variety of animals present in the area, including cattle, sheep, pigs, fowl, etc.

There were no crop sampling conducted during 1996/1997 and 2004/2005 sampling periods for other environmental media presented in this section. The reason for the decision that such sampling was not applicable for the satellite facility as discussed in Section 2.9.1. However, the NRC has since advised the uranium in situ industry that such sampling is applicable to a uranium in situ satellite facility. Therefore, based on guidance from the NRC, the TCEA preoperational and operational monitoring program for NTEA have been revised to more closely adhere to NRC guidance on the NTEA monitoring program.

Sampling Location

The preoperational baseline plan will provide for a survey of a three (3) km area around the centerpoint of the satellite facility as to the availability of crops, livestock, fowl and other applicable sources for sampling. This will determine the types of crops grown in the area, number and types of livestock, availability of gardens, etc. The predominant wind direction collectively is from the S, SSW and SW, so initial efforts will be to collect samples in areas downwind of these predominant prevailing wind directions (Primary Sampling Area). In **Figure 2.9-7** a distance of 3 km has been shown with 16 sampling quadrants.

Efforts will first be made to collect crop and livestock samples from the quadrants located downwind of the 3 predominant wind direction quadrants. These proposed sampling areas are shaded. If efforts to locate crops or livestock are unsuccessful, this area will be expanded to include the other quadrants (Secondary Sampling Areas), prioritizing sampling efforts based on the next most predominant wind directions **(Figure 2.9-7)**.

The survey within the three km radius of the TCEA Satellite Facility will also be made for the presence of private gardens, with the priority on locating such gardens downwind from the TCEA in the predominant wind direction. The nearest resident is not located in

the Primary Sampling Area, but CBR will determine whether this resident has a garden or livestock, and if so, efforts will be made to collect samples from these sources.

As discussed above, CBR will survey the area for the presence of crops and livestock, and when found, will seek approval from the owner(s) to collect samples at the time of harvest or slaughter. Efforts will be made to collect samples prior to start of construction in order to be able to compare to samples collected during operations.

Sample Collection

A minimum of three types of crops and livestock will be sampled, depending on the availability.

Crop sampling will be conducted as described for vegetation sampling in Section 2.9.5.2.

Livestock samples will be rinsed with distilled water and placed in heavy-duty bags (e.g., Ziploc bags). Sampling of livestock will involve sampling and analysis of tissues such as bone, muscle, liver and kidney for each species (e.g., cattle and bison). Sampling targets would be identified and an agreement made with the owner as to a sampling program acceptable to both parties.

Each individual animal tissue will be placed in a separate bag. Specimens will be placed inside ice chests containing sufficient ice to keep the fish or tissues preserved during temporary storage and transportation to the laboratory. Plastic bags will be clearly labeled at the time of sampling with a permanent marker, identifying applicable information such unique sample number, date, time of collection, collection location, animal species, sex, type of tissue, name of the collector, etc. A field log book will be maintained including this and any other applicable information. As available, information should be obtained as to the length of time an animal has been located in the TCEA area.

For any identified gardens within 3 km, CBR will seek approval from the garden owner to be able to collect samples from at least three garden items being grown. Sampling of available gardens would involve sampling of leafy tissues and fruits, etc., following the basic procedures for vegetation in Section 2.9.5.2. The plants' fruits, such as tomatoes, squash, cucumbers, zucchini and peppers, will be sampled to collected the edible portions as wells as the plant's leafy and stem parts.

A chain of custody form will be completed in the field and the container tracked from the field until delivery to the laboratory. The type of analytical method to be used will be clearly identified on the chain of custody to the contract laboratory.

Crop samples will be collected as per CBR's *Environmental Manual* (CBR 2010a).

Sample Frequency

Samples for crops and livestock will be obtained one time at the time of harvest or slaughter.

Analysis Frequency

Each grab sample will be analyzed one time.

Sample Analysis

Samples would be analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210.

Quality of Vegetation Measurements

The accuracy of monitoring data is critical to ensure that the fish monitoring program precisely reflects radionuclide concentrations. Regulatory Guide 4.14 specifies the following lower limits of detection (LLD):

Radionuclide	Recommended LLD µCi/kg (wet)
Natural Uranium	2×10^{-7}
Thorium-230	2×10^{-7}
Radium-226	5×10^{-8}
Polonium-210	1×10^{-6}

2.9.7 Fish

Reg. Guide 4.14 requires that fish be collected, if available, from lakes, streams in the project site area that may be subject to seepage or direct surface runoff from potentially contaminated areas or that could be affected by a tailings impoundment failure. Fish should be collected and sampled and analyzed semiannually for natural uranium, radium-226, thorium-230, lead-210 and polonium-210.

As previously stated above, the North Trend operations will not have a tailings impoundment. In lieu of the above-referenced Reg. Guide 4.14 guidance for tailings impoundments, CBR will collect fish samples from water bodies potentially subject to direct surface runoff from potentially contaminated areas associated with the satellite facility operations (i.e., processing building, wellfield operations, evaporation ponds, chemical storage and other associated support facilities). There are no surface impoundments subject to drainages from the satellite operations; therefore fish will not be collected from surface impoundments. Fish will be collected from surface drainages as discussed below.

2.9.7.1 1996 – 2005 Sampling Period

No fish samples were collected from the White River during the 1996 and 2005 sampling periods. Spring Creek and Unnamed Creek may only flow during spring runoff, generally following winters with above average snowfall. The majority of the time these streams are dry. Therefore, collection of fish was not a valid option.

2.9.7.2 Additional Fish Sampling Program

CBR will carry out a fish sampling program as part of the preoperational baseline monitoring program.

Collection Location

Spring Creek and Unnamed Creek may only flow during spring runoff, generally following winters with above–average snowfall. The majority of the time these streams are dry. Therefore, collection of fish is not considered a valid and meaningful option. In lieu of no water samples, sediment samples will be collected as discussed in Section 2.9.9.

Fish will be collected from the White River at or near the NTEA designated surface water sampling points W-1 and W-2 noted in **Figure 2.9-5**. The locations of the upstream and downstream endpoints of the collection reaches will be recorded using a hand-held GPS unit.

Collection Method

Prior to fish collection, a detailed sampling plan shall be prepared and adhered to. The Nebraska Game and Parks Commission will be consulted. The collection of fish for scientific purposes requires a Scientific and Educational Permit issued by the Nebraska Game and Parks Commission (NGPC). This required permit will be obtained prior to any collection activities. No endangered or threatened species or any species which may be so designated in the future will be collected. Such species will be immediately released.

Initially seining will be used to collect fish. Seining is a common method for sampling fish communities in streams and small rivers such as the White River. The sample points serve as the upgradient and downgradient sampling points for the White River in relation the NTEA site. Any major releases from the NTEA would have the potential for reaching the stretch of the White River between these two points.

If seining is not successful, then other collection methods such as electrofishing and fish traps will be used.

If feasible, two target species will be collected at each collection point, one being a predator species and the other either a forage or a bottom-feeder species. This of course

will depend on the success of the collection efforts. Specimens from different families may include Catostomidae (suckers), Centrarchidae (sunfish, bass and crappie), Cyprinidae (minnows, shiners, chubs and daces) and Salmonidae (rainbow, brown and brook trout).

Any sampling method used will be consistent with procedures of the U.S. Geological Survey (USGS 1993).

A work table will be set up near the river bank where the fish are collected. The table will be covered with plastic sheeting and kept clean during processing of the fish/tissue specimens. All fish collected will be identified, counted, measured for total length/weight and a determination made of general health conditions

Where feasible (e.g., fish size and tissue quantity), separate tissues will be collected from specimens for radionuclide analysis. Tissues will consist of bone, liver and muscle. The levels of uranium-series radionuclides in fish tissue are generally highest in bone, followed by skin, liver, gonad and muscle (Swanson S.M. 1985, Elsenbud M. 1987). For smaller fish, such as minnows, whole body radionuclide analysis will be conducted. Radionuclide uptake has been reported to not vary with fish age, size or sex (Swanson S.M. 1985).

Fish species captured and that are to be used for sample analysis will be sacrificed, with whole fish specimens rinsed with distilled water and placed in heavy-duty bags (e.g., Ziploc bags). Selected fish will be filleted in a manner to collected muscle tissue, bone and liver samples. Each individual fish or tissue will be placed in a separate bag. Specimens will be placed inside ice chests containing sufficient ice to keep the fish or tissues preserved during temporary storage and transportation to the laboratory. If a problem is encountered with being able to collect enough sample for analysis (e.g., liver), then fish tissues of the same species may be composited.

Plastic bags will be clearly labeled at the time of sampling with a permanent marker, identifying applicable information such unique sample number, date, time of collection, collection location, fish species, type of tissue, name of the collector, etc. A field log book will be maintained including this information as well as other information such as description of river conditions (e.g. water depth, water temperature, type of substrate, etc.), GPS reading, fish measurements, weather conditions, etc.

A chain of custody form will be completed in the field and the container tracked from the field until delivery to the laboratory. The type of analytical method to be used will be clearly identified on the chain of custody to the contract laboratory. CBR's chain of custody procedures will be followed.

Sample Frequency

Fish shall be collected semiannually for two times prior to construction activities. Collections will occur in the early spring and late summer.

Sample Analysis

Fish samples (whole and individual tissues) will be analyzed for the following parameters: natural uranium, radium-226, thorium-230, lead-210 and polonium-210.

Analysis Frequency

Analysis will be performed on all individual samples collected for a total of two samples (semiannual).

Quality of Fish Measurements

The accuracy of monitoring data is critical to ensure that the fish monitoring program precisely reflects radionuclide concentrations. Regulatory Guide 4.14 specifies the following lower limits of detection (LLD):

Radionuclide	Recommended LLD µCi/kg (wet)
Natural Uranium	2×10^{-7}
Thorium-230	2×10^{-7}
Radium-226	5×10^{-8}
Polonium-210	1×10^{-6}

2.9.8 Baseline Soil Monitoring

Reg. Guide 4.14 recommends soil samples are collected as follows:

- Up to 40 samples surface soil samples would be collected at 300-meter intervals to a distance of 1500 meters in each of eight directions from the center of the milling area. Surface soil samples would be collected to a depth of 5 cm using consistent sampling methods. Sample would be conducted once prior to construction and repeated for locations disturbed by excavation, leveling or contouring. All samples would be analyzed for radium-226, and 10% of the samples analyzed for natural uranium, thorium-230 and lead-210.
- Five or more surface soil samples (to a depth of 5 cm) would be collected at the same locations used for air particulate samples. Samples would be collected once prior to construction. Samples would be analyzed for natural uranium, radium-226, thorium-230 and lead-210.
- Five subsurface samples collected at the center point location and art distances of 750 meters in each of four directions. Subsurface soil samples would be collected to a depth of one meter and divided into three equal sections for analysis. Samples would be collected once prior to construction and repeated for locations disturbed by construction. All samples would be analyzed for radium-226 and one set of the samples analyzed for natural uranium, thorium-230, and lead-210.

2.9.8.1 1996 – 2006 Soil Sampling Program

In 1996, CBR collected soil samples once from each of the air monitoring locations (NE-1 through NE-5 and AM-6) and analyzed for natural uranium and radium-226. Soil samples were collected from the top 15 centimeters of soil.

In 2006, soil samples were also obtained from each of the air monitoring locations (AM-9 through AM-14) and analyzed for natural uranium, radium-226, and lead-210. Soil samples were collected from the top 5 and 15 centimeters of soil as required by Reg. Guide 1569.

Vegetative roots, rocks and other debris were removed from the soil samples. The samples were sent to Energy Laboratories in Casper, Wyoming for analysis. The results of analysis of the soil samples are presented in **Table 2.9-9.**

In addition to the samples at the air monitoring locations, surface soil samples were obtained from the proposed plant and restricted area location to determine baseline concentrations of the radionuclides of interest.

In 2004, six soil samples (five-point composite samples) were collected from the proposed satellite processing area and analyzed for natural uranium and radium-226. The samples were collected by removing vegetation and compositing four grab samples spaced approximately 18 inches from a center point sample in each of four compass directions. The sample depth interval was 0-15 cm. Radium-226 soil concentrations ranged from 7.0×10^{-7} to 9.0×10^{-7} μCi/g with a mean concentration of $7.8 \times 10^{-7} \pm 7.5 \times 10^{-8}$ μCi/g. Natural uranium soil concentrations ranged from 6.1×10^{-7} to 7.1×10^{-6} μCi/g with a mean concentration of $6.5 \times 10^{-7} \pm 4.5 \times 10^{-8}$ μCi/g. Analytical results for these soil samples are presented in **Table 2.9-10**.

The general location of the proposed satellite facility in relation to the current Crow Butte facility and the locations of the six soil samples are shown on **Figures 2.9-8** and **2.9-9** respectively. **Figure 2.9-8** shows the sampled area is south of the currently proposed satellite area but soil characteristics in the general area should not change significantly and the sampled area remains representative of the general area. Once the final site for the satellite area is established, a gamma survey and possibly additional soil sampling of the area will be conducted.

Quality of Soil Measurements

The accuracy of monitoring data is critical to ensure that the soil monitoring program precisely reflects radionuclide concentrations. Reg. Guide 4.14 specifies the following lower limits of detection (LLD):

Radionuclide	Recommended LLD µCi/g	Actual LLD µCi/g
Natural Uranium	2×10^{-7}	2×10^{-8}
Radium-226	2×10^{-7}	2×10^{-8}

2.9.8.2 Additional Soil Monitoring Program

CBR will conduct additional soil sampling as part of the preoperational monitoring program.

Sample Location

Surface soil grab samples will be collected at two different designated locations:

a. Discrete soil samples will be collected along transects radiating in 8 compass directions from the center of the satellite production facility at 300 meter intervals (**Figure 2.9-6**). Four transect lines will be approximately 1500 meters in length, resulting in the collection of 5 samples per transect for a total of 21 samples (includes a sample at the centerpoint). Four of the transects will have a distance of les than 1500 meters due to the distance to the permit boundary, resulting in a total of 10 additional samples. This will result in a total of 31 samples versus up to 40 specified in Reg. Guide 4.14.

b. Five or more samples at the same locations of the air particulate matter samplers (**Figure 2.9-3**).

Sample Method

Soil samples (Grab) will be obtained with a clean auger, spade, or shovel. At the sampling location, the vegetation will be removed and a grab soil sample of the top 5 cm (2 inches) of soil will be collected. Samples will be placed in appropriate plastic bags. The amount of sample will be sufficient to provide the laboratory with at least 50 grams of soil. This quantity of sample is necessary to meet the LLD requirements. Any non-soil material such as rocks, sticks, vegetation, and large amounts of roots will be removed from the sample. As much as possible of the air in the bag will be removed and the bag sealed.

Plastic bags will be clearly labeled at the time of sampling with a permanent marker, identifying the project location, sample site, name of the sampler, the depth interval of the sample (i.e., 0-5 cm"), and the sample date and time. The type of soil extraction method to be used for the various chemical analyses will be clearly identified on the

chain of custody to the contract laboratory. Soil samples will be submitted to the contract laboratory within 7 days of collection.

Soil samples will be collected as per CBR's *Environmental Manual* (CBR 2010a).

Sample Frequency

Sampling will be conducted once prior to construction, and repeated for locations disturbed by excavation, leveling or contouring.

Sample Analysis

Samples collected at 300-meter intervals to a distance of 1500 meters: radium-226 with 10% of the samples analyzed for natural uranium, thorium-230 and lead-210.

Samples collected at locations of air particulate samplers: natural uranium, radium-226, thorium-230 and lead-210.

Analysis Frequency

Sample analysis will be performed on individual samples collected prior to construction and for any repeated sampling due to disturbance by excavation, leveling or contouring.

2.9.8.3 Subsurface Samples

Sample Location

Samples will be collected at the center point of the production satellite facilities and at distances of 750 meters in each of 4 directions, for a total of 5 samples (**Figure 2.9-6**).

Sample Method

Soil samples (Grab) will be obtained with a clean hand-coring auger. At the sampling location, the vegetation will be removed and soil samples collected in 15-cm increments to a depth of 105 centimeters or until rocks prevent further coring device penetration. Samples will be divided into three equal sections for analysis.

Samples will be placed in appropriate plastic bags. The amount of sample will be sufficient to provide the laboratory with at least 50 grams of soil. This quantity of sample is necessary to meet the LLD requirements. Any non-soil material such as rocks, sticks, vegetation, and large amounts of roots will be removed from the sample. As much of the air in the bag, as reasonably possible, will be removed and the bag sealed.

Plastic bags will be clearly labeled at the time of sampling with a permanent marker, identifying the project location, sample site, name of the sampler, the depth interval of the sample (i.e., 0-15 cm"), and the sample date and time. The type of soil extraction method to be used for the various chemical analyses will be clearly identified on the

chain of custody to the contract laboratory. Soil samples will be submitted to Energy Laboratories, Inc. in Casper, Wyoming within 7 days of collection.

Sample Frequency

Samples will be collected once prior to construction of the satellite facilities. Sample collection will be repeated for locations disturbed by construction.

Sample Analysis

All samples will be analyzed for radium-226 and one set of samples analyzed for natural uranium, thorium-230 and lead-210.

Analysis Frequency

Sample analysis will be performed on individual samples once prior to construction.

Quality of Soil Measurements

The accuracy of monitoring data is critical to ensure that the soil monitoring program precisely reflects radionuclide concentrations. Reg. Guide 4.14 specifies the following lower limits of detection (LLD):

Radionuclide	Recommended LLD µCi/g
Natural Uranium	2×10^{-7}
Radium-226	2×10^{-7}

2.9.9 Baseline Sediment Sampling

Sediments of lakes, reservoirs, and flowing bodies of surface water may become contaminated as a result of direct liquid discharges, wet surface deposition, or from runoffs associated with contaminated soils. Because of various chemically and physically binding interactions with radionuclides, sediments serve as integrating media that are important to environmental monitoring.

Reg. Guide 4.14 recommends that sediment samples be collected from sediments of surface water passing through the project site or offsite surface waters that may be subject to drainage from potentially contaminated areas or that could be affected by a tailings impoundment failure. Samples are to be collected once following spring runoff and late summer following a period of extended low flow. Samples are to be analyzed for natural uranium, radium-226, thorium-230, and lead-210.

As stated above, the North Trend operations will not have a tailings impoundment. In lieu of the above-referenced Reg. Guide 4.14 guidance for tailings impoundments, CBR will collect sediment samples from water bodies potentially subject to direct surface runoff from potentially contaminated areas associated with the satellite facility

operations (i.e., processing building, wellfield operations, evaporation ponds, chemical storage and other associated support facilities). There are no surface impoundments subject to drainages from the satellite operations; therefore sediment samples will not be collected from surface impoundments. Fish will be collected from surface drainages as discussed below.

2.9.9.1 2004 and 2006 Sediment Monitoring Program

Sediments in the White River were sampled as part of the NTEA preoperational baseline monitoring program in 2004 and 2006. Sediment samples were collected at the same locations as surface water samples (**Figure 2.9-5**). Sediment samples were obtained at locations W-1 and W-2 during the fourth quarter of 2004 and the fourth quarter of 2006. These sediments were analyzed for the concentration of natural uranium, radium-226, and lead-210. Analysis of thorium-230 in sediments was discontinued by CBR in 1998 with the concurrence of the NRC staff. The results from the analysis of the sediment samples are listed in **Table 2.9-11**.

Historical sediment sampling by CBR in connection with the current license area began in May 1982 and has continued on an annual basis. Results from sediment sampling for the NTEA are comparable with the results of the historical sampling.

Quality of Sediment Measurements

The accuracy of monitoring data is critical to ensure that the sediment monitoring program precisely reflects radionuclide concentrations. Reg. Guide 4.14 specifies the following lower limits of detection (LLD):

Radionuclide	Recommended LLD µCi/g	Actual LLD µCi/g
Natural Uranium	2×10^{-7}	2×10^{-8} (1996 samples) 1×10^{-8} (2004 samples) 2×10^{-7} (2006 samples)
Thorium-230	2×10^{-7}	2×10^{-8}
Radium-226	2×10^{-7}	2×10^{-8} (1996 samples) 2×10^{-7} (2004 and 2006 samples)
Lead-210	2×10^{-7}	1×10^{-7} (1996 samples) 1×10^{-6} (2004 samples) 2×10^{-7} (2006 samples)

2.9.9.2 Additional Sediment Monitoring Program

CBR will conduct additional sediment sampling as part of the NTEA preoperational baseline monitoring program.

Sample Location

Sediment samples will be collected from the following ephemeral stream drainage channels and river flowing through the area:

- Spring Creek (2 sampling locations)
- Unnamed Creek (2 sampling locations)
- Hall Canal (4 sampling locations)
- White River (4 sampling locations)

Spring Creek is located at the north end of the license boundary and Unnamed Creek at the south end of the boundary **(Figure 2.9-5).** The White River flows through the southeast corner of the license boundary. Locations are depicted in **Figure 2.9-5.**

The Spring Creek sampling locations will be located at or near the point the ephemeral drainages enter the NTEA license boundary and at the point the drainage exits the boundary.

Sediment samples for Unnamed Creek will be collected at or near the point the drainage enters the NTEA license boundary and a point just prior to the confluence with the White River (confluence point is within NTEA license boundary).

Hall Canal crosses and exits the NTEA license boundary at the northwest corner of the boundary and again near the southeast corner of the boundary. Samples will be collected at or near the locations where the canal enters the boundary (2 samples) and exits the boundary (2 samples).

Surface water samples will be collected from the White River at the NTEA designated surface water sampling points W-1 and W-2 noted in **Figure 2.9-5**.

Note: There are no private surface water impoundments at or within the NTEA license boundary. Therefore, no sediment samples are required.

Sampling Method

At each of the sampling locations (**Figure 2.9-5**), four sediment sub-samples will be collected with a hand trowel, core sampler or other applicable sampling device. Any vegetation, rocks or other debris will be removed. The samples will be collected at equal distances along a transect spanning the width of the lowest portion of the ephemeral streams and across the White River channels. The four sub-samples at each sampling location will be composited (thoroughly mixed) in order to collect a representative sample so that the average radionuclide concentration across the stream/river beds are obtained.

Composite samples will placed in a heavy duty plastic bag (double bagged), water decanted, excess air removed from the bag and re-sealed. The laboratory will require a minimum of 50 grams to meet the LLD requirements. The sample bags containing the composite samples will be pre-labeled with the sample identification number, sample location, collection date, time, name of collector. A field log book will also be filled out with this information and any applicable field observations, e.g., flow, etc. A chain of custody form will be completed and the sample submitted to the laboratory.

CBR's sediment sampling procedures can be found in CBR's *Environmental Manual* (CBR 2009b).

Sample Frequency

Sediment samples will be completed once following spring runoff and late summer following period of extended low flow (total of two sampling events).

Sample Analysis

Samples will be analyzed for natural uranium, radium-226, thorium-230 and lead-210.

Analysis Frequency

Sample analysis will be performed on all individual samples collected two times: once following spring runoff and late summer following period of extended low flow.

Reporting Monitoring Data

As required by Reg. Guide 4.14, CBR will report the following information for each soil and sediment radionuclide: concentration (uCi/g), error estimate (uCi/g, and Lower Limit of Detection (LLD) (uCi/g).

Quality of Sediment Measurements

The accuracy of monitoring data is critical to ensure that the sediment monitoring program precisely reflects radionuclide concentrations. Regulatory Guide 4.14 specifies the following lower limits of detection (LLD):

Radionuclide	Recommended LLD µCi/g
Natural Uranium	2×10^{-7}
Thorium-230	2×10^{-7}
Radium-226	2×10^{-7}
Lead-210	2×10^{-7}

2.9.10 Baseline Direct Radiation Monitoring

Reg. Guide 4.14 recommends direct radiation measurements be collected at 150-meter intervals to a distance in each of 8 directions from the centerpoint of the milling area or at a point equidistant from the milling area and tailings disposal area. Since there is no tailings disposal area, CBR used the satellite facility as the centerpoint. Samples are to be collected once prior to construction and repeated for areas disturbed by site preparation or construction. Gamma exposure rate is to be derived, using passive integrating device such as a thermoluminescent detector (TLD), pressurized ionization chamber, or a properly calibrated portable survey instrument.

The preoperational baseline radiation monitoring program includes routine monitoring of direct radiation levels at the air monitoring stations.

2.9.10.1 2004 – 2005 Direct Radiation Monitoring Program

The preoperational baseline radiation monitoring program included routine monitoring of direct radiation levels at the air monitoring stations. The preoperational direct gamma radiation program was designed to meet the guidance provided in Reg. Guide 4.14. NRC guidance recommends a combination of direct gamma radiation measurements and exposure measurements made with integrating devices (i.e., thermoluminescent detectors or TLDs) during preoperational monitoring. Direct measurements are made in areas where process facilities will be located during site characterization.

2.9.10.1.1 Integrated Radiation Monitoring Results

As part of the preoperational monitoring program for the NTEA, the gamma radiation in the environment around the area was measured. CBR conducted direct radiation monitoring at the five North Trend air monitoring locations (NE-1 through NE-5) during the 1996 monitoring program (**Figure 2.9-1**). However, the control badge was stored in an area with high background radiation during this time and the results from the 1996 monitoring are not comparable with the more recent monitoring.

CBR conducted direct gamma radiation monitoring at the revised air monitoring locations (AM-9 though AM-14) in 2004 and 2005 (**Figure 2.9-2**). Monitoring was conducted by placing environmental thermoluminescent dosimeters (TLDs) provided by Thermo NUtech on a quarterly basis at the monitoring locations. Lithium fluoride chips were used and housed in rugged containers to provide protection from the weather. The containers or monitors were placed at the predetermined monitoring locations approximately one meter above ground level. They were exchanged with new monitors on a quarterly basis and the exposed monitors were returned to the vendor for processing. These devices provide an integrated exposure for the period between annealing and processing. The results were reported in mrem per week.

Table 2.9-12 summarizes the environmental direct gamma monitoring results from the NTEA.

The average background gamma level in the Western Great Plains has been reported to be 0.014 mR/hr (NRC 1979), which corresponds well to the results obtained with the TLD gamma monitors.

2.9.10.1.2 Direct Gamma Radiation Measurement Results

Direct gamma radiation measurements were conducted at the proposed satellite processing area in May 2004 A rectangular area approximately 190 feet long by 70 feet wide (0.3 acres) was surveyed using a Ludlum Model 44-10 2-inch by 2-inch sodium iodide (NaI) detector coupled to a Ludlum Model 2221 ratemeter/scaler and a Trimble ProXRS GPS survey unit. The detector was carried approximately 18 inches above the ground surface. Survey personnel walked the area at a rate of approximately 2.5 feet per second with a transect spacing of approximately 10 feet. The survey system automatically logged individual gamma count rates with a corresponding coordinate every two seconds. A total of 422 measurements were collected and are presented in **Figure 2.9-9**. In addition, exposure rate measurement were collected at each satellite processing area soil sample location described in Section 2.9.8.1 using a Ludlum Model 19 μR meter. Summary data for the gamma direct gamma radiation measurements are presented in **Table 2.9-13**.

2.9.10.2 Additional Direct Radiation Monitoring Program

CBR will conduct additional direct radiation monitoring as part of the preoperational baseline monitoring program. The monitoring plan will be consistent with Reg. Guide 4.14 (NRC 1980), Reg. Guide 3:46 (NRC 9182), NUREG-1569 (NRC 2002), as well as radiological survey guidelines outlined in MARSSIM, the Multi-Agency Radiation Survey and Site Investigation Manual (NRC 2000).

2.9.10.2.1 Direct Gamma Measurements

Sample Location

Direct gamma measurements will be made along transects radiating in 8 compass directions from the center of the satellite production facility at 300 meter intervals (**Figure 2.9-6**). Four transect lines will be approximately 1500 meters in length, resulting in the collection of 5 measurements per transect for a total of 21 samples (includes a measurement at the centerpoint). Four of the transects will have a distance of less than 1500 meters due to the distance to the permit boundary, resulting in a total of 10 additional measurements. This will result in a total of 31 measurements versus up to 40 specified in Reg. Guide 4.14.

Measurements will also be collected at each of the air particulate monitor stations (5 sites) (**Figure 2.9-3**).

Sample Method

Direct gamma radiation measurements will be conducted at the above referenced sampling locations utilizing a Ludlum Model 44-10 2-inch by 2-inch sodium iodide (NaI) detector coupled to a Ludlum 2221 ratemeter/scaler and a Trimble ProVRS GPS survey meter. The detector will be carried approximately 18 inches above the ground surface. Survey personnel will walk the designated transects shown in Figure 2.9-6 and any other designated areas to be monitored at a rate of approximately 2.5 feet per second with a transect spacing of approximately 10 feet. The survey system will automatically log individual gamma count rates with a corresponding coordinate every two seconds.

A Ludlum Model 19 uR meter will be used for exposure rate measurements at soil sample locations described in Section 2.9.8.

Correlations between soil samples, sodium iodide readings and energy independent exposure rate measurements will be performed during soil sampling and gamma surveys if areas of the site exhibit significantly different gamma count rates.

Sample Frequency

Gamma measurements will be made once prior to construction and repeated for areas disturbed by site preparation and construction.

Sample Analysis

The Na I detector and accompanying rate meter/scaler measure the rate that gamma rays interact with the detector in counts per minute (cpm).

Instrument Calibration and Maintenance

Instruments used for radiological measurements are calibrated and maintained as required in CBR's *Health Physics Manual* (CBR 2010b). Routine maintenance and calibration for all radiological survey instruments and samplers is based upon the recommendations contained in NRC Reg. Guide 4.15 (NRC 2007).

The manufacturer or a qualified accredited vendor shall calibrate portable survey instruments, counter/scalers, mass flow meters and/or dry cell calibrators, and calibration sources. Calibration shall be performed as recommended in ANSI N323 and ANSI N323A. Instruments must be tested for range, sensitivity, linearity, detection limit and response to overload. The specific calibration requirements for various types of instruments are given in CBR's *Health Physics Manual* (CBR 2010b).

Calibration frequency is annual or at the frequency recommended by the manufacturer, whichever is more frequent. Calibration frequency may be more frequent subject to the instrument being subjected to extreme operational conditions, hard usage, multi-shift use or corrosive environments. The details of instrument calibrations, including calibration

records and record retention, are discussed in CBR's *Health Physics Manual* (CBR 2010b)..

Reporting of Monitoring Data

Measurement results will be reported as follows:

- Ludlum Model 44-10 NaI Detector with Ludlum 2221: Counts per Minute (CPM)
- Ludlum Model 19: gamma exposure rate (uR/hr) and error estimate (uR/hr)

A statistical summary of the GPS-based gamma-ray count survey rates will be presented in tabular form.

2.9.10.2.2 Integrated Radiation Monitoring

Sample Location

Measurements will also be collected at each of the air particulate monitor stations (5 sites) (**Figure 2.9-1**).

Sample Method

Landauer InLight EX9 dosimeter, an aluminum oxide Optically Stimulated Luminescence (OSL) dosimeter will be used for integrated radiation monitoring. The EX9 dosimeter has a minimum detectable dose of nominally 0.1 mrem ambient dose equivalent. The gross and net dosage reported, and the minimum detectable dose for the batch is shown on each report. The EX9 OSL dosimeter fully meets ANSI N545 performance, testing, and procedural specifications.

The dosimeters will be supplied by the vendor before the end of each quarter. Each shipment of dosimeters will contain a control dosimeter that measures exposure rates during processing and shipping of the dosimeters and a deployment dosimeter that measures exposure rates while deploying the dosimeters. Before deployment of the dosimeters, the control dosimeter must be placed in a storage area with a low ambient background gamma dose rate. The deployment dosimeter will also be placed in the storage area after the dosimeters are deployed.

The dosimeters will be deployed at the beginning of each quarter. The dosimeters will be clipped onto each survey location with the fastener provided with the dosimeter. Each dosimeter will have a tag with an identification number. When exchanging the dosimeters, the dosimeter will be replaced with the corresponding dosimeter identification number.

After the dosimeters are collected, care will be taken to ensure that they are not exposed to any additional gamma radiation or x-rays. Once the dosimeters are collected, they will

be returned to the vendor in the original box with the provided shipping label. This label cautions against exposure to radioactive materials or x-rays while in transit.

Sample Frequency

Once prior to site construction, quarterly change of OSL detectors for a 12-month period, as per discussions in *Sample Method* above.

Sample Analysis

Landauer's Inlight System dosimeters measure radiation exposure with aluminum oxide detectors ($Al2O_3$:C) read out by optically stimulated luminescence (OSL) technology. This read out process uses a light emitting diode (LED) array to stimulate the detectors, and the light emitted by the OSL material is detected and measured by a photomultiplier tube (PMT) using a high sensitivity photon counting system (Landauer 2010). The amount of the light released during optical stimulation is directly proportional to the radiation dose and the intensity of stimulation light. A dose calculation algorithm is applied to the measurement to determine gamma exposure rates.

For this environmental monitoring, Landauer reports a "net" dose result to account for background doses that is calculated by subtracting only that fraction of the control badge dose that corresponds with the amount of time the field badges are not actually deployed at the site. The end result is a gamma exposure rate.

Analysis Frequency

Once for each quarterly sample.

Reporting of Monitoring Data

CBR will report the following information for each measurement: gamma exposure rate (mrem/qtr) and error estimate (mrem/gtr).

2.9.11 Preoperational Baseline Monitoring Program Summary

The TCEA preoperational baseline monitoring program discussed in this section is summarized in **Table 2.9-14**.

2.9.12 References

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Table 2.9-1 Location Description of Atmospheric Particulate, Gamma and Radon Sampling Locations

Sample Point No.	Location [a]	Parameter
AM-22	NE ¼ of NW ¼ 42.6684759 -103.4225746 Section 15 T31 N R52W	Airborne Particulates Gamma Radon
AM-23	SW ¼ of SW ¼ 42.6540476 -103.4027564 Section 14 T31N R52W	
Am-24	SW ¼ of SW ¼ 42.6538108 -103.3833159 Section 13 T31N R52W	
AM-25	SE ¼ of NE ¼ 42.6395644 -103.4026159 Section 27 T31N R52W	
AM-26	SW ¼ of SW ¼ 42.6400393 -103.4416481 Section 21 T31N R52 W	

[a] Source: Earth Point. 2010. Township and Range - Public Land Survey System on Google Earth. [Webpage]. Located at: http://www.earthpoint.us/Townships.aspx. Accessed on: May 08, 2010.

Table 2.9-2 Ambient Atmospheric Radon-222 Concentration North Trend Expansion Area (1996 – 1997)

Third Quarter 1996			
Location	**Date**	**Concentration µCi/ml x 10^{-9}**	**Error Estimate µCi/ml x 10^{-9}**
NE-1	7/2/96 - 10/1/96	0.6	0.13
NE-2	7/2/96 - 10/1/96	1.2	0.17
NE-3	7/2/96 - 10/1/96	0.7	0.12
NE-4	7/2/96 - 10/1/96	0.9	0.14
NE-5	7/2/96 - 10/1/96	0.9	0.11
NE-5 (D)	7/3/96 - 10/1/96	0.7	0.11
AM-6	7/1/96 – 10/1/96	0.8	0.09
Fourth Quarter 1996			
Location	**Date**	**Concentration µCi/ml x 10^{-9}**	**Error Estimate µCi/ml x 10^{-9}**
NE-1	10/1/96 - 1/2/97	0.6	0.15
NE-2	10/1/96 - 1/2/97	1.0	0.13
NE-3	10/1/96 - 1/2/97	0.7	0.13
NE-4	10/1/96 - 1/2/97	0.7	0.14
NE-5	10/1/96 - 1/2/97	1.0	0.13
NE-5 (D)	10/1/96 - 1/2/97	0.7	0.12
AM-6	10/1/96 - 1/2/97	0.8	0.10
First Quarter 1997			
Location	**Date**	**Concentration µCi/ml x 10^{-9}**	**Error Estimate µCi/ml x 10^{-9}**
NE-1	1/2/97 - 4/1/97	0.8	0.14
NE-2	1/2/97 - 4/1/97	1.0	0.13
NE-3	1/2/97 - 4/1/97	0.5	n/a
NE-4	1/2/97 - 4/1/97	0.7	0.11
NE-5	1/2/97 - 4/1/97	0.5	0.09
NE-5 (D)	1/2/97 - 4/1/97	0.3	0.07
AM-6	1/2/97 - 4/1/97	0.3	0.05

Table 2.9-2 Ambient Atmospheric Radon-222 Concentration North Trend Expansion Area (1996 – 1997)

Second Quarter 1997			
Location	**Date**	**Concentration $\mu Ci/ml \times 10^{-9}$**	**Error Estimate $\mu Ci/ml \times 10^{-9}$**
NE-1	4/1/97 - 7/1/97	0.7	0.15
NE-2	4/1/97 - 7/1/97	0.9	0.14
NE-3	4/1/97 - 7/1/97	0.8	0.12
NE-4	4/1/97 - 7/1/97	1.0	0.13
NE-5	4/1/97 - 7/1/97	1.0	0.13
NE-5 (D)	4/1/97 - 7/1/97	1.0	0.12
AM-6	4/1/97 - 7/1/97	0.7	0.09

Mean 1996 – 1997 Radon Concentration		
Location	**Mean Concentration $\mu Ci/ml \times 10^{-9}$**	**Standard Deviation $\mu Ci/ml \times 10^{-9}$**
NE-1	0.675	0.09
NE-2	0.93	0.25
NE-3	0.60	0.20
NE-4	0.78	0.15
NE-5	0.65	0.19
NE-5 (D)	0.53	0.15
AM-6	0.65	0.24

Table 2.9-3 Ambient Atmospheric Radon-222 Concentration North Trend Expansion Area (2004 – 2005)

Second Half 2004			
Location	**Date**	**Concentration (μCi/ml) x 10^{-9}**	**Error Estimate (μCi/ml) x 10^{-9}**
AM-6 (Bkgd)	7/1/04 - 1/3/05	0.2	0.04
AM-9 (NE-1)	7/1/04 - 1/3/05	0.6	0.06
AM-10	7/1/04 - 1/3/05	0.5	0.05
AM-10 (D)	7/1/04 - 1/3/05	0.6	0.06
AM-11 (NE-5)	7/1/04 - 1/3/05	0.5	0.05
AM-12	7/1/04 - 1/3/05	0.4	0.04
AM-13	7/1/04 - 1/3/05	0.5	0.05
AM-13 (D)	7/1/04 - 1/3/05	0.7	0.06
AM-14	7/1/04 - 1/3/05	Detector Cup Missing	N/A
First Half 2005			
Location	**Date**	**Concentration (μCi/ml) x 10^{-9}**	**Error Estimate (μCi/ml) x 10^{-9}**
AM-6 (Bkgd)	1/3/05 – 7/5/05	0.3	0.04
AM-9 (NE-1)	1/3/05 – 7/5/05	0.5	0.05
AM-10	1/3/05 – 7/5/05	0.6	0.06
AM-10 (D)	1/3/05 – 7/5/05	0.4	0.05
AM-11 (NE-5)	1/3/05 – 7/5/05	0.5	0.05
AM-12	1/3/05 – 7/5/05	0.5	0.05
AM-13	1/3/05 – 7/5/05	0.5	0.05
AM-13 (D)	1/3/05 – 7/5/05	0.6	0.06
AM-14	1/3/05 – 7/5/05	0.2	0.03

Table 2.9-3 Ambient Atmospheric Radon-222 Concentration North Trend Expansion Area (2004 – 2005) (Continued)

Location	Mean Concentration $\mu Ci/ml \times 10^{-9}$
AM-6 (Bkgd)	*0.25*
AM-9 (NE-1)	0.55
AM-10	0.55
AM-10 (D)	0.50
AM-11 (NE-5)	0.50
AM-12	0.45
AM-13	0.50
AM-13 (D)	0.65
AM-14	0.2

Table 2.9-4 Airborne Particulate Concentrations North Trend Expansion Area (2004 - 2005)

Location	Radionuclide	Date	Concentration µCi/ml	Error Estimate µCi/ml	LLD µCi/ml
Third Quarter 2004					
AM-6	Uranium	7/1/04 - 10/01/04	<1.00 E^{-16}	N/A	1.00 E^{-16}
	Radium 226		1.21 E^{-16}	1.11 E^{-16}	1.00 E^{-16}
	Lead 210		1.93 E^{-14}	2.11E^{-15}	2.00 E^{-15}
AM-10	Uranium	7/1/04 – 10/1/04	<1.00 E^{-16}	N/A	1.00 E^{-16}
	Radium 226		<1.00 E^{-16}	N/A	1.00 E^{-16}
	Lead 210		1.01 E^{-14}	1.93 E^{-15}	2.00 E^{-15}
Fourth Quarter 2004					
AM-6	Uranium	10/1/04 – 1/3/05	1.05 E^{-16}	N/A	1.00 E^{-16}
	Radium 226		<1.00 E^{-16}	N/A	1.00 E^{-16}
	Lead 210		1.92 E^{-14}	1.07 E-15	2.00 E^{-15}
AM-10	Uranium	10/1/04 – 1/3/05	1.28 E^{-16}	N/A	1.00 E^{-16}
	Radium 226		<1.00 E^{-16}	N/A	1.00 E^{-16}
	Lead 210		1.48 E^{-14}	9.65 E^{-16}	2.00 E^{-15}
First Quarter 2005					
AM-6	Uranium	1/3/05 – 4/1/05	1.05 E^{-16}	N/A	1.00 E^{-16}
	Radium 226		<1.00 E^{-16}	N/A	1.00 E^{-16}
	Lead 210		1.84 E^{-14}	1.45 E^{-15}	2.00 E^{-15}
AM-10	Uranium	1/3/05 – 4/1/05	1.78 E^{-16}	N/A	1.00 E^{-16}
	Radium 226		<1.00 E^{-16}	N/A	1.00 E^{-16}
	Lead 210		1.83 E^{-14}	1.38 E^{-15}	2.00 E^{-15}

Table 2.9-5 Private Wells Sampled Within the North Trend Expansion Area

Well Number	Formation	Estimated Depth (ft)	Use
W-77	Brule	61	Agricultural
W-78	Brule	98	Domestic
W-81	Chadron	630	Agricultural
W-83	Brule	50	Domestic
W-107	Brule	100	Domestic

Table 2.9-6 Private Well Monitoring - Third Quarter 1996

Location	Radionuclide	Date	Concentration µCi/ml x 10^{-9}	Error Estimate µCi/ml x 10^{-9}	LLD µCi/ml x 10^{-9}
Chadron Well					
W-81	U-Nat	9/5/1996	8.8		0.2
	Th-230		10.8	1.0	0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
Brule Wells					
W-77	U-Nat	9/9/1996	31.1		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
W-78	U-Nat	9/5/1996	16.2		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		13.5	1.2	1.0
	Po-210		<1.0		1.0
W-83	U-Nat	9/9/1996	19.5		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
W-107	U-Nat	9/9/1996	10.8		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0

Table 2.9-6 Private Well Monitoring - Fourth Quarter 1996 (Continued)

Location	Radionuclide	Date	Concentration µCi/ml x 10^{-9}	Error Estimate µCi/ml x 10^{-9}	LLD µCi/ml x 10^{-9}
Chadron Well					
W-81	U-Nat	12/10/1996	<0.2		0.2
	Th-230		<0.2		0.2
	Ra-226		13.5	1.1	0.2
	Pb-210		12.9	4.5	1.0
	Po-210		3.3	0.7	1.0
Brule Wells					
W-77	U-Nat	12/10/1996	15.6		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
W-78	U-Nat	12/10/1996	7.45		0.2
	Th-230		<0.2		0.2
	Ra-226		0.4	0.2	0.2
	Pb-210		<1.0		1.0
	Po-210		1.4	0.4	1.0
W-83	U-Nat	12/10/1996	10.8		0.2
	Th-230		<0.2		0.2
	Ra-226		0.4	0.2	0.2
	Pb-210		2.5	1.2	1.0
	Po-210		<1.0		1.0
W-107	U-Nat	12/10/1996	8.12		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0

Table 2.9-6 Private Well Monitoring - First Quarter 1997 (Continued)

Location	Radionuclide	Date	Concentration µCi/ml x 10^{-9}	Error Estimate µCi/ml x 10^{-9}	LLD µCi/ml x 10^{-9}
Chadron Well					
W-81	U-Nat	3/11/1997	<0.2		0.2
	Th-230		<0.2		0.2
	Ra-226		10.9	1.0	0.2
	Pb-210		4.9	0.6	1.0
	Po-210		<1.0		1.0
Brule Wells					
W-77	U-Nat	3/11/1997	18.3		0.2
	Th-230		1.2	0.6	0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
W-78	U-Nat	3/11/1997	10.2		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
W-83	U-Nat	3/11/1997	14.9		0.2
	Th-230		1.0	0.5	0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
W-107	U-Nat	3/12/1997	6.09		0.2
	Th-230		<0.2		0.2
	Ra-226		0.5	0.1	0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0

Table 2.9-6 Private Well Monitoring - Second Quarter 1997 (Continued)

Location	Radionuclide	Date	Concentration µCi/ml x 10^{-9}	Error Estimate µCi/ml x 10^{-9}	LLD µCi/ml x 10^{-9}
Chadron Well					
W-81	U-Nat	6/16/1997	<0.2		0.2
	Th-230		<0.2		0.2
	Ra-226		12.7	1.1	0.2
	Pb-210		<1.0	1.2	1.2
	Po-210		12.4	1.2	1.0
Brule Wells					
W-77	U-Nat	6/16/1997	17.9		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		1.7	0.1	1.0
W-78	U-Nat	6/16/1997	10.7		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		2.0	0.1	1.0
W-83	U-Nat	6/16/1997	15.5		0.2
	Th-230		<0.2		0.2
	Ra-226		1.3	0.2	0.2
	Pb-210		<1.0		1.0
	Po-210		5.2	0.2	1.0
W-107	U-Nat	6/16/1997	8.9		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		8.6	0.3	1.0

Table 2.9-6 Private Well Monitoring - Third Quarter 2004 (Continued)

Location	Radionuclide	Date	Concentration µCi/ml x 10^{-9}	Error Estimate µCi/ml x 10^{-9}	LLD µCi/ml x 10^{-9}
Chadron Well					
W-81	U-Nat	7/30/2004	0.7		0.2
	Th-230		<0.2		0.2
	Ra-226		10.6	1.7	0.2
	Pb-210		<1.0		1.0
	Po-210		<2.7		2.7
Brule Wells					
W-77	U-Nat	7/30/2004	15		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<2.7		2.7
W-78	U-Nat	7/30/2004	9.6		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		1.4	0.8	1.0
	Po-210		<2.7		2.7
W-83	U-Nat	7/30/2004	16		0.2
	Th-230		<0.2		0.2
	Ra-226		0.8	0.7	0.2
	Pb-210		<1.0		1.0
	Po-210		<2.7		2.7
W-107	U-Nat	7/30/2004	8		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<2.7		2.7

Table 2.9-6 Private Well Monitoring - Fourth Quarter 2004 (Continued)

Location	Radionuclide	Date	Concentration µCi/ml x 10^{-9}	Error Estimate µCi/ml x 10^{-9}	LLD µCi/ml x 10^{-9}
Chadron Well					
W-81	U-Nat	11/17/2004	0.77		0.2
	Th-230		<0.2		0.2
	Ra-226		11.4	~1.2	0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
Brule Wells					
W-77	U-Nat	11/17/2004	16		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
W-78	U-Nat	11/11/2004	9.3		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
W-83	U-Nat	11/17/2004	16		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
W-107	U-Nat	12/10/1996	8		0.2
	Th-230		<0.2		0.2
	Ra-226		0.7	0.4	0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0

Table 2.9-6 Private Well Monitoring - First Quarter 2005 (Continued)

Location	Radionuclide	Date	Concentration µCi/ml x 10^{-9}	Error Estimate µCi/ml x 10^{-9}	LLD µCi/ml x 10^{-9}
Chadron Well					
W-81	U-Nat	3/5/2005	0.7		0.2
	Ra-226		11.0	1.2	0.2
Brule Wells					
W-77	U-Nat	3/4/2005	20		0.2
	Ra-226		<0.2		0.2
W-78	U-Nat	3/4/2005	20		0.2
	Ra-226		<0.2		0.2
W-83	U-Nat	3/4/2005	20		0.2
	Ra-226		<0.2		0.2
W-107	U-Nat	3/4/2005	8		0.2
	Ra-226		<0.2		0.2

Note: Due to an error on the chain of custody, the groundwater samples for the first quarter 2005 were not analyzed for thorium-230, lead-210, and polonium-210.

Table 2.9-6 Private Well Monitoring - Second Quarter 2005 (Continued)

Location	Radionuclide	Date	Concentration µCi/ml x 10^{-9}	Error Estimate µCi/ml x 10^{-9}	LLD µCi/ml x 10^{-9}
Chadron Well					
W-81	U-Nat	5/27/2005	0.7		0.2
	Th-230		<0.2		0.2
	Ra-226		9.2	1.6	0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
Brule Wells					
W-77	U-Nat	5/27/2005	17		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
W-78	U-Nat	5/27/2005	12		0.2
	Th-230		<0.2		0.2
	Ra-226		0.6	0.6	0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
W-83	U-Nat	5/27/2005	18		0.2
	Th-230		<0.2		0.2
	Ra-226		0.6	0.6	0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
W-107	U-Nat	5/27/2005	8.7		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0

Table 2.9-6 Private Well Monitoring - Third Quarter 2005 (Continued)

Location	Radionuclide	Date	Concentration µCi/ml x 10^{-9}	Error Estimate µCi/ml x 10^{-9}	LLD µCi/ml x 10^{-9}
Chadron Well					
W-81	U-Nat	9/16/2005	1.2		0.2
	Ra-226		10.2	1.2	0.2
Brule Wells					
W-77	U-Nat	9/16/2005	18		0.2
	Ra-226		<0.2		0.2
W-78	U-Nat	9/16/2005	12		0.2
	Ra-226		<0.2		0.2
W-83	U-Nat	9/16/2005	19		0.2
	Ra-226		0.2	0.4	0.2
W-107	U-Nat	9/16/2005	8.9		0.2
	Ra-226		<0.2		0.2

Table 2.9-7 Surface Water Monitoring (2004 – 2005)

Location	Radionuclide	Date	Concentration µCi/ml x 10^{-9}	Error Estimate µCi/ml x 10^{-9}	LLD µCi/ml x 10^{-9}
Third Quarter 2004					
W-1	U-Nat	7/30/2004	3.6		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
W-2	U-Nat	7/30/2004	4.2		0.2
	Th-230		<0.2		0.2
	Ra-226		1.0	0.7	0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
Fourth Quarter 2004					
W-1	U-Nat	11/11/2004	4.0		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
W-2	U-Nat	11/11/2004	4.3		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0

Table 2.9-7 Surface Water Monitoring (2004 – 2005) (Continued)

Location	Radionuclide	Date	Concentration µCi/ml x 10^{-9}	Error Estimate µCi/ml x 10^{-9}	LLD µCi/ml x 10^{-9}
First Quarter 2005					
W-1	U-Nat	3/4/2005	5.0		0.2
	Ra-226		<0.2		0.2
W-2	U-Nat	3/4/2005	5.0		0.2
	Ra-226		<0.2		0.2
Second Quarter 2005					
W-1	U-Nat	5/27/2005	4.5		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
W-2	U-Nat	5/27/2005	4.7		0.2
	Th-230		<0.2		0.2
	Ra-226		<0.2		0.2
	Pb-210		<1.0		1.0
	Po-210		<1.0		1.0
Third Quarter 2005					
W-1	U-Nat	9/16/2005	4.6		0.2
	Ra-226		<0.2		0.2
W-2	U-Nat	9/16/2005	4.9		0.2
	Ra-226		<0.2		0.2

Note: Due to an error on the chain of custody, the groundwater samples for the First Quarter 2005 were not analyzed for thorium-230, lead-210, and polonium-210.

Table 2.9-8 Vegetation Monitoring (1996)

Location	Radionuclide	Date	Concentration µCi/kg	Error Estimate µCi/kg	LLD µCi/kg
NE-1	U-Nat	7/23/1996	2.8 E^{-06}		6.9 E^{-08}
	Th-230		1.7 E^{-05}	1.0 E^{-05}	6.9 E^{-08}
	Ra-226		2.5 E^{-06}	4.0 E^{-07}	6.9 E^{-08}
	Pb-210		2.0 E^{-05}	2.2 E^{-06}	3.5 E^{-07}
	Po-210		<3.5 E^{-07}		3.5 E^{-07}
NE-2	U-Nat	7/23/1996	3.0 E^{-06}		6.9 E^{-08}
	Th-230		1.8 E^{-05}	1.2 E^{-05}	6.9 E^{-08}
	Ra-226		3.2 E^{-06}	4.6 E^{-07}	6.9 E^{-08}
	Pb-210		1.2 E^{-04}	2.0 E^{-06}	3.5 E^{-07}
	Po-210		<3.5 E^{-07}		3.5 E^{-07}
NE-3	U-Nat	7/23/1996	3.8 E^{-06}		6.9 E^{-08}
	Th-230		1.6 E^{-05}	7.0 E^{-06}	6.9 E^{-08}
	Ra-226		2.5 E^{-06}	4.0 E^{-07}	6.9 E^{-08}
	Pb-210		3.2 E^{-05}	2.5 E^{-06}	3.5 E^{-07}
	Po-210		<3.5 E^{-07}		3.5 E^{-07}
NE-4	U-Nat	7/23/1996	4.5 E^{-06}		6.9 E^{-08}
	Th-230		2.5 E^{-05}	1.1 E^{-05}	6.9 E^{-08}
	Ra-226		5.5 E^{-06}	5.6 E^{-07}	6.9 E^{-08}
	Pb-210		2.3 E^{-05}	2.3 E^{-06}	3.5 E^{-07}
	Po-210		9.2 E^{-07}	3.4 E^{-07}	3.5 E^{-07}
NE-5	U-Nat	7/23/1996	5.5 E^{-06}		6.9 E^{-08}
	Th-230		3.2 E^{-05}	1.3 E^{-05}	6.9 E^{-08}
	Ra-226		8.3 E^{-06}	6.9 E^{-08}	6.9 E^{-08}
	Pb-210		3.0 E^{-05}	2.5 E^{-06}	3.5 E^{-07}
	Po-210		1.5 E^{-05}	1.7 E^{-06}	3.5 E^{-07}

Table 2.9-9 Soil Sampling - Air Monitoring Locations (1996 – 2006)

Location	Radionuclide	Date	Concentration µCi/g x 10^{-6}	Error Estimate µCi/g x 10^{-6}	LLD µCi/g x 10^{-6}
1996 Sample Results (15 centimeter sample depth)					
NE-1	U-Nat	7/24/1996	0.33		0.02
	Ra-226		1.05	0.17	0.02
NE-2	U-Nat	7/24/1996	0.51		0.02
	Ra-226		0.89	0.16	0.02
NE-3	U-Nat	7/24/1996	0.26		0.02
	Ra-226		0.41	0.11	0.02
NE-4	U-Nat	7/24/1996	0.32		0.02
	Ra-226		0.78	0.15	0.02
NE-5	U-Nat	7/24/1996	0.95		0.02
	Ra-226		1.01	0.16	0.02
AM-6	U-Nat	7/24/1996	0.33		0.02
	Ra-226		1.05	0.17	0.02

Table 2.9-9 Soil Sampling - Air Monitoring Locations (1996 - 2006) (Continued)

Location	Radionuclide	Date	Concentration µCi/g x 10^{-6}	Error Estimate µCi/g x 10^{-6}	LLD µCi/g x 10^{-6}
2006 Sample Results (15 centimeter sample depth)					
AM-9	U-Nat	12/15/2006	0.45		0.2
	Ra-226		0.75	0.099	0.2
	Pb-210		0.75	0.19	0.2
AM-10	U-Nat	12/15/2006	0.38		0.2
	Ra-226		0.48	0.081	0.2
	Pb-210		0.58	0.18	0.2
AM-11 (NE-5)	U-Nat	12/15/2006	0.44		0.2
	Ra-226		0.58	0.088	0.1
	Pb-210		<0.2		0.2
AM-12	U-Nat	12/15/2006	0.53		0.2
	Ra-226		0.78	0.1	0.2
	Pb-210		0.74	0.18	0.2
AM-13	U-Nat	12/15/2006	0.32		0.2
	Ra-226		0.47	0.079	0.2
	Pb-210		<0.2		0.2
AM-14	U-Nat	12/15/2006	0.42		0.2
	Ra-226		0.47	0.081	0.2
	Pb-210		0.88	0.19	0.2

Table 2.9-9 Soil Sampling - Air Monitoring Locations (1996 – 2006) (Continued)

Location	Radionuclide	Date	Concentration µCi/g x 10^{-6}	Error Estimate µCi/g x 10^{-6}	LLD µCi/g x 10^{-6}
2006 Sample Results (5 centimeter sample depth)					
AM-9	U-Nat	12/15/2006	0.47		0.2
	Ra-226		0.68	0.095	0.2
	Pb-210		1.2	0.21	0.2
AM-10	U-Nat	12/15/2006	0.4		0.2
	Ra-226		0.56	0.086	0.2
	Pb-210		0.84	0.19	0.2
AM-11 (NE-5)	U-Nat	12/15/2006	0.48		0.2
	Ra-226		0.61	0.091	0.2
	Pb-210		<0.2		0.2
AM-12	U-Nat	12/15/2006	0.51		0.2
	Ra-226		0.75	0.099	0.2
	Pb-210		0.61	0.18	0.2
AM-13	U-Nat	12/15/2006	0.34		0.2
	Ra-226		0.58	0.089	0.2
	Pb-210		<0.2		0.2
AM-14	U-Nat	12/15/2006	0.42		0.2
	Ra-226		0.41	0.076	0.2
	Pb-210		0.83	0.19	0.2

Table 2.9-10 Soil Sampling - Proposed Satellite Processing Area (2004)

Location	Radionuclide	Date	Concentration µCi/g x 10^{-6}	Error Estimate µCi/g x 10^{-6}	LLD µCi/g x 10^{-6}
2004 Sample Results (0-15 centimeter sample depth)					
Sat-1	U-Nat	5/05/2004	0.61		0.02
	Ra-226		0.9	0.1	0.02
Sat-2	U-Nat	5/05/2004	0.68		0.02
	Ra-226		0.8	0.1	0.02
Sat-3	U-Nat	5/05/2004	0.61		0.02
	Ra-226		0.7	0.1	0.02
Sat-4	U-Nat	5/05/2004	0.71		0.02
	Ra-226		0.9	0.1	0.02
Sat-5	U-Nat	5/05/2004	0.68		0.02
	Ra-226		0.8	0.1	0.02
Sat-6	U-Nat	5/05/2004	0.61		0.02
	Ra-226		0.7	0.1	0.02

Table 2.9-11 Sediment Sampling Results (2004 – 2006)

Location	Radionuclide	Date	Concentration µCi/g x 10^{-6}	Error Estimate µCi/g x 10^{-6}	LLD µCi/g x 10^{-6}
2004 Sample Results					
W-1	U-Nat	11/11/2004	0.04		0.01
	Ra-226		0.3	0.06	0.2
	Pb-210		<1.0		1.0
W-2	U-Nat	11/11/2004	0.04		0.01
	Ra-226		0.3	0.06	0.2
	Pb-210		<1.0		1.0
2006 Sample Results					
W-1	U-Nat	12/15/2006	0.46		0.2
	Ra-226		0.35	0.069	0.2
	Pb-210		<0.2		0.2
W-2	U-Nat	12/15/2006	0.56		0.2
	Ra-226		0.57	0.086	0.2
	Pb-210		<0.2		0.2

Table 2.9-12 Environmental Thermoluminescent Detector Results (2004 – 2005)

Location	Dates	Gamma Exposure Rate (mrem/qtr)	Standard Deviation (mrem/qtr)	95% Confidence Interval (mrem/qtr)
2004 - 2005				
AM-9	7/1/2004 – 10/1/2004	9	1.3	1.6
	10/1/2004 – 1/1/2005	1	1.3	1.6
	1/1/2005 – 4/1/2005	6	2.1	2.6
	4/1/2005 – 7/1/2005	8	3.2	3.9
AM-10	7/1/2004 – 10/1/2004	12	.9	1.1
	10/1/2004 – 1/1/2005	4	3.0	3.7
	1/1/2005 – 4/1/2005	7	1.8	2.2
	4/1/2005 – 7/1/2005	3	3.5	4.4
AM-11 (NE-5)	7/1/2004 – 10/1/2004	12	.9	1.1
	10/1/2004 – 1/1/2005	3	1.3	1.7
	1/1/2005 – 4/1/2005	7	1.2	1.5
	4/1/2005 – 7/1/2005	0	4.6	5.7
AM-12	7/1/2004 – 10/1/2004	6	.9	1.1
	10/1/2004 – 1/1/2005	0	2.9	3.5
	1/1/2005 – 4/1/2005	5	1.1	1.4
	4/1/2005 – 7/1/2005	2	2.7	3.3
AM-13	7/1/2004 – 10/1/2004	11	1.3	1.6
	10/1/2004 – 1/1/2005	3	1.3	1.6
	1/1/2005 – 4/1/2005	6	1.5	1.9
	4/1/2005 – 7/1/2005	5	1.9	2.3
AM-14	7/1/2004 – 10/1/2004	9	1.2	1.5
	10/1/2004 – 1/1/2005	0	1.1	1.4
	1/1/2005 – 4/1/2005	8	0.8	1.0
	4/1/2005 – 7/1/2005	6	3.3	4.1
AM-6 (Bkgd)	7/1/2004 – 10/1/2004	10	1.3	1.6
	10/1/2004 – 1/1/2005	9	1.2	1.5
	1/1/2005 – 4/1/2005	8	2.1	2.6
	4/1/2005 – 7/1/2005	15	9.7	12.1

Table 2.9-13 Gamma Survey Results for Proposed Satellite Processing Area (2004)

Location	Dates	Gamma Exposure Rate (µR/hr)*	Standard Deviation (µR/hr)	95% Confidence Interval (µR/hr)
2004				
SAT-1	5/05/2004	19	NA	NA
SAT-2	5/05/2004	17	NA	NA
SAT-3	5/05/2004	17	NA	NA
SAT-4	5/05/2004	17	NA	NA
SAT-5	5/05/2004	18	NA	NA
SAT-6	5/05/2004	17	NA	NA
Satellite Processing Area	5/05/2004	15.1	0.9	1.76

*Gross count rate data was converted to estimated exposure rates using the correlation information in Section 6.3 of the Wellfield Decommissioning Plan for Crow Butte Uranium Project, June 2004.

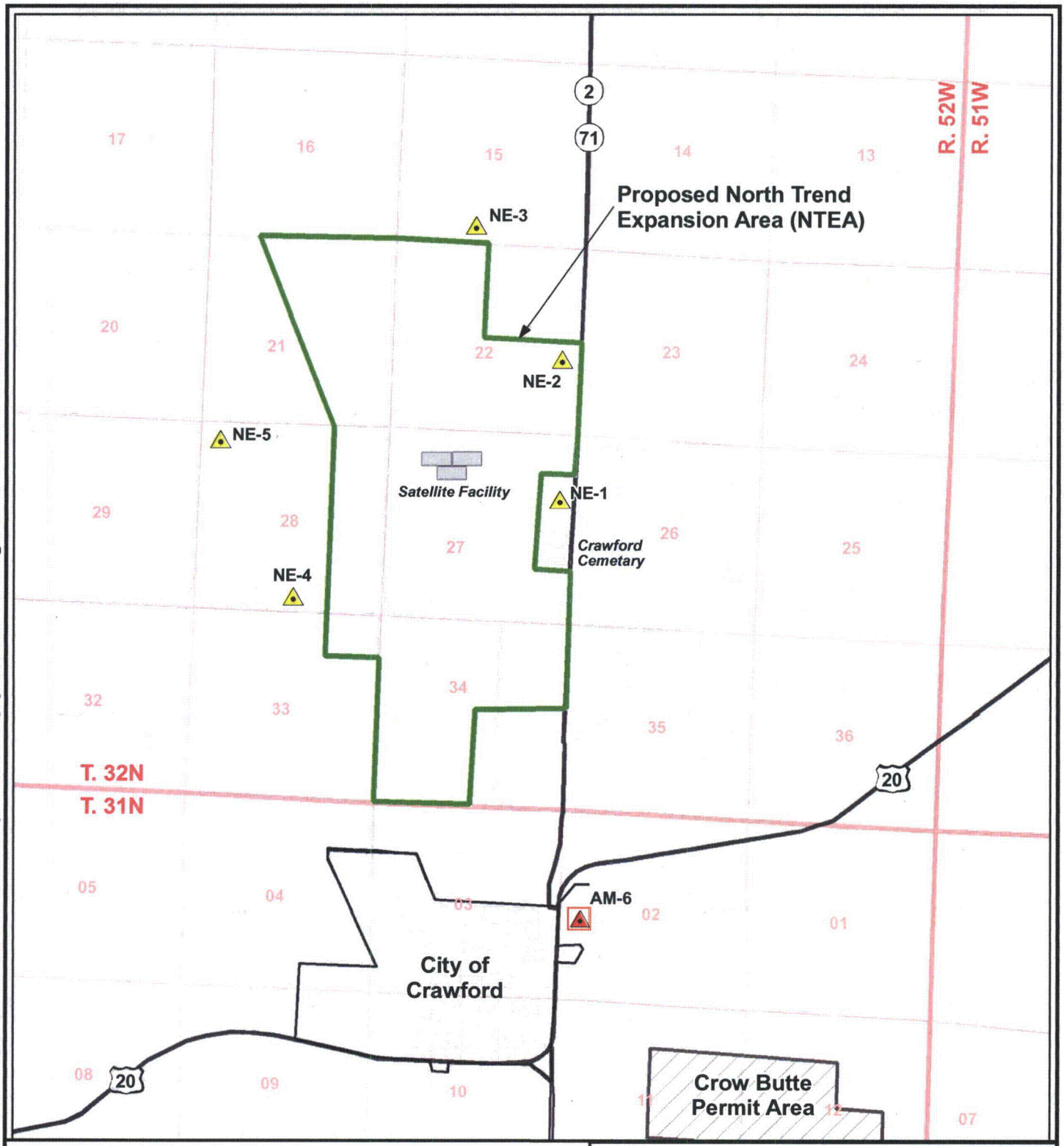
Table 2.9-14 North Trend Expansion Area Additional Preoperational Monitoring Program

	Sample Collection				Sample Analysis	
Type of Sample	Number	Location	Method	Frequency	Frequency	Type of Analysis
Air Particulates	3	Near license boundary	Continuous	Weekly filter change	Quarterly composites of weekly samples	Natural uranium, Ra-226, Th-230, and Pb-210
	1	Nearest Resident	Continuous	Weekly filter change	Quarterly composites of weekly samples	Natural uranium, Ra-226, Th-230, and Pb-210
	1	Control background location east of NTEA License Boundary	Continuous	Weekly filter change	Quarterly composites of weekly samples	Natural uranium, Ra-226, Th-230, and Pb-210
Radon Gas	3	Near NTA northern boundary	Continuous using RadTrak Type DRNF	Quarterly	Quarterly	Rn-222
	1	Nearest Resident	Continuous using RadTrak Type DRNF	Quarterly	Quarterly	Rn-222
	1	Control background location east of NTEA License Boundary	Continuous using RadTrak Type DRNF	Quarterly	Quarterly	Rn-222
Groundwater	1	Wells within the NTEA license boundary (W-77, W-78, W-83, and W-107	Grab	Quarterly	Quarterly	Suspended & Dissolved Natural Uranium, Ra-226, Th-230, Th-230 Pb-210 & Po-210
Surface Water	2	White River (W-1 and W-4)	Grab	Quarterly	Quarterly	Suspended & Dissolved Natural Uranium, Ra-226, & Th-230
			Grab	--	Semiannually	Suspended & Dissolved Pb-210 & Po-210
	3 [a]	Spring Creek, Unnamed Creek, and Hall Canal	Grab	Quarterly	Quarterly	Suspended & Dissolved Natural Uranium, Ra-226, & Th-230
			Grab	--	Semiannually	Suspended & Dissolved Pb-210 & Po-210
Vegetation	3	Grazing areas near the site in different sectors that will have the highest predicted air particulate concentrations during milling operations	Grab	3 times during grazing season	3 Times	Natural Uranium, Ra-226, Th-2320, Pb-210, & Pb-210
Food	3	Crops	Grab	Time of Harvest or Slaughter	1	Natural Uranium, Ra-226, Th-230, Pb-210, & Po-210
	3	Livestock			1	
	3	Private Garden Vegetables			1	

Table 2.9-14 North Trend Expansion Area Additional Preoperational Monitoring Program

	Sample Collection				Sample Analysis	
Type of Sample	Number	Location	Method	Frequency	Frequency	Type of Analysis
Fish	2	Collection of fish from White River (W-1 & W-2)	Grab	Semiannually	2	Natural Uranium, Ra-226, Th-230, Pb-210, & Po-210
Surface Soil [b]	Up to 40	300 meter intervals to a distance of 1500 meters in each of 8 directions from centerpoint of satellite facility; additional transects through wellfields	Grab	Once prior to construction. Repeat for location disturbed by excavation, leveling or contouring	1	All samples for Ra-226, 10% of samples natural uranium, Th-230 & Pb-210
	5	Same location used for collection of air particulates	Grab	Once prior to construction	1	Natural Uranium, Ra-226, Th-230 & Pb-210
Subsurface Soil [c]	5	At centerpoint of satellite facility & at distances of 750 meters in each of 4 directions	Grab	Once prior to construction. Repeat for location disturbed by construction,	1	Ra-226 (all samples) Natural Uranium, Th-203 & Pb210 (one set of ssamples)
Sediment	2 from each stream	Up and down gradient samples from Spring Creek, Unnamed Creek, Hall Canal & White River (W-1 & W-2)	Grab (Composite samples)	Once following spring runoff & late summer following period of extended low flow	2	Natural Uranium, Ra-226, Th-230 & Pb-210
Direct Radiation (Survey)	Up to 80	150 meter intervals to a distance of 1500 meters in each of 8 directions from centerpoint of satellite facility	Grab	Once prior to construction. Repeat for areas disturbed by site preparation or construction	1	Gamma exposure using sodium iodide scintillometer
Direct Radiation (Continuous)	5	Same location used for collection of air particulates	Grab	Once prior to construction	1	Gamma exposure using a continuous integrating device

[a] Two from surface water that could be impacted by project operations.
[b] Surface soil samples collected to a depth of 5 cm using a consistent technique.
[c] Subsurface soil samples collected to a depth of 1 meter; samples divided into 3 equal sections for analysis.



LEGEND

Air Sampling Location

- Radon, Gamma
- Radon, Gamma, Air Particulates (Control Station)

0 1,500 3,000

Scale in Feet

PROJECTION: NAD_1927_STATE_PLANE_ NEBRASKA_NORTH_FIPS_2601

N

W — E

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FIGURE 2.9-1
1996 - 1997 NORTH TREND PREOPERATIONAL RADIOLOGICAL AMBIENT AIR SAMPLING LOCATIONS

PROJECT: CO001396.00001 MAPPED BY: JC CHECKED BY: JEC

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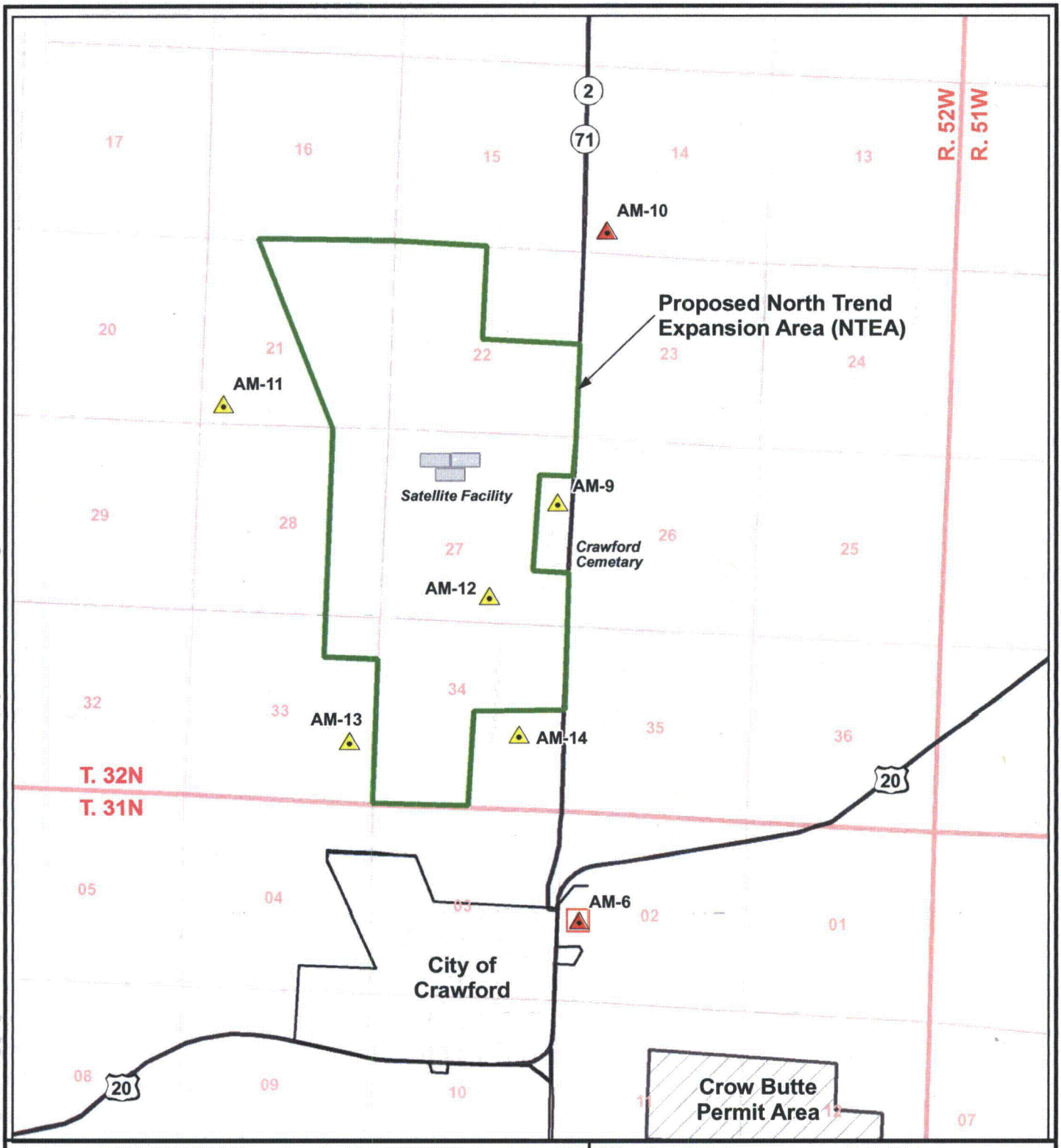

LEGEND

Air Sampling Location

- Radon, Gamma
- Radon, Gamma, Air Particulates
- Radon, Gamma, Air Particulates (Control Station)

0 1,500 3,000
Scale in Feet

PROJECTION:
NAD_1927_STATE_PLANE_
NEBRASKA_NORTH_FIPS_2601

N
W — E

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FIGURE 2.9-2
2004 - 2005 NORTH TREND
PREOPERATIONAL RADIOLOGICAL
AMBIENT AIR SAMPLING LOCATIONS

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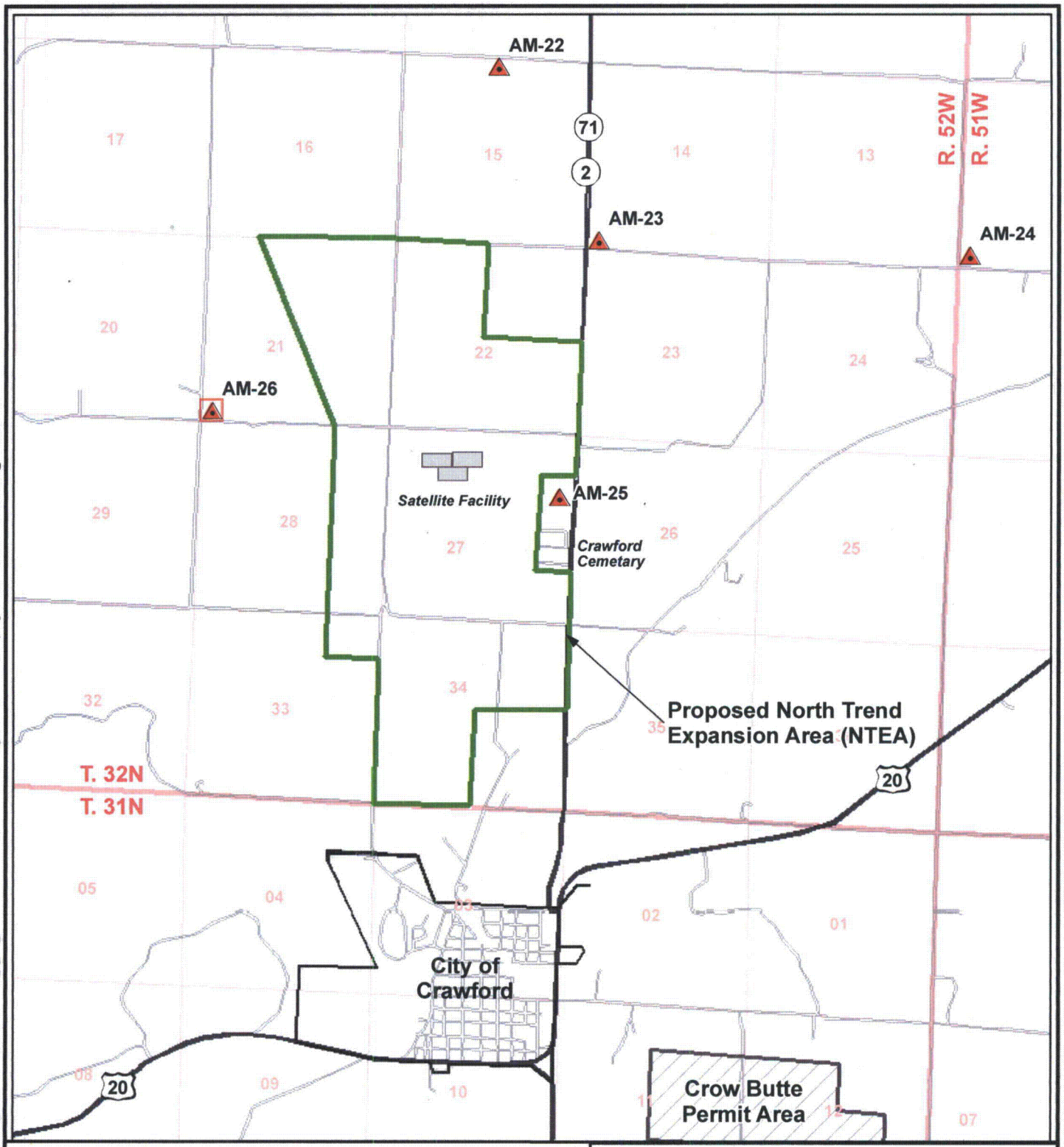

LEGEND

Air Sampling Location

- Radon, Gamma, Air Particulates
- Background Sampling Location

0 1,500 3,000
Scale in Feet

N
W — E

PROJECTION:
*NAD_1927_STATE_PLANE_*
NEBRASKA_NORTH_FIPS_2601

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FIGURE 2.9-3
ADDITIONAL NORTH TREND
PREOPERATIONAL RADIOLOGICAL
AMBIENT AIR SAMPLING LOCATIONS

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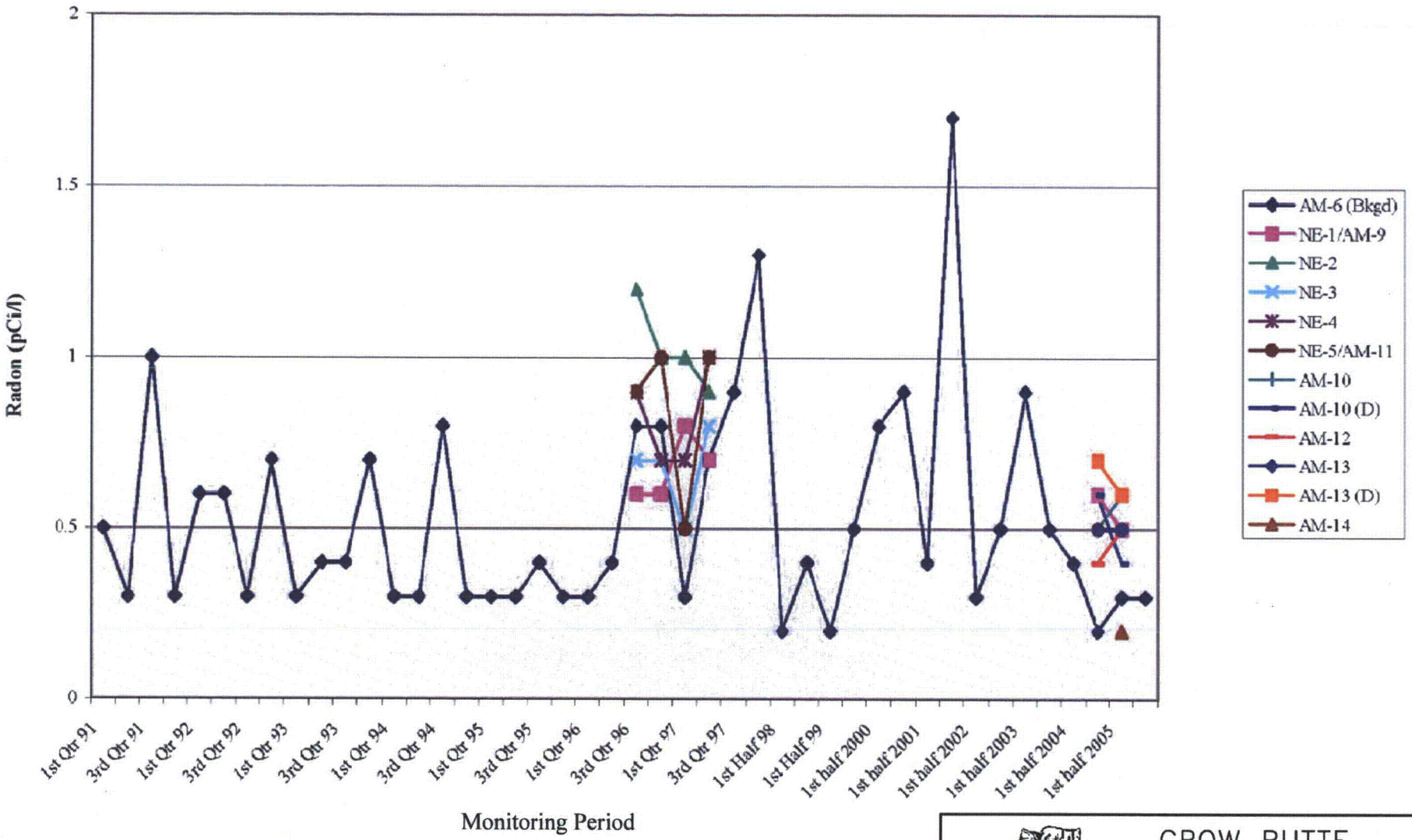

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FIGURE 2.9-4
NORTH TREND PREOPERATIONAL RADON MONITORING TRENDS
(Qtr. 1 1991 - Qtr.2 2005)

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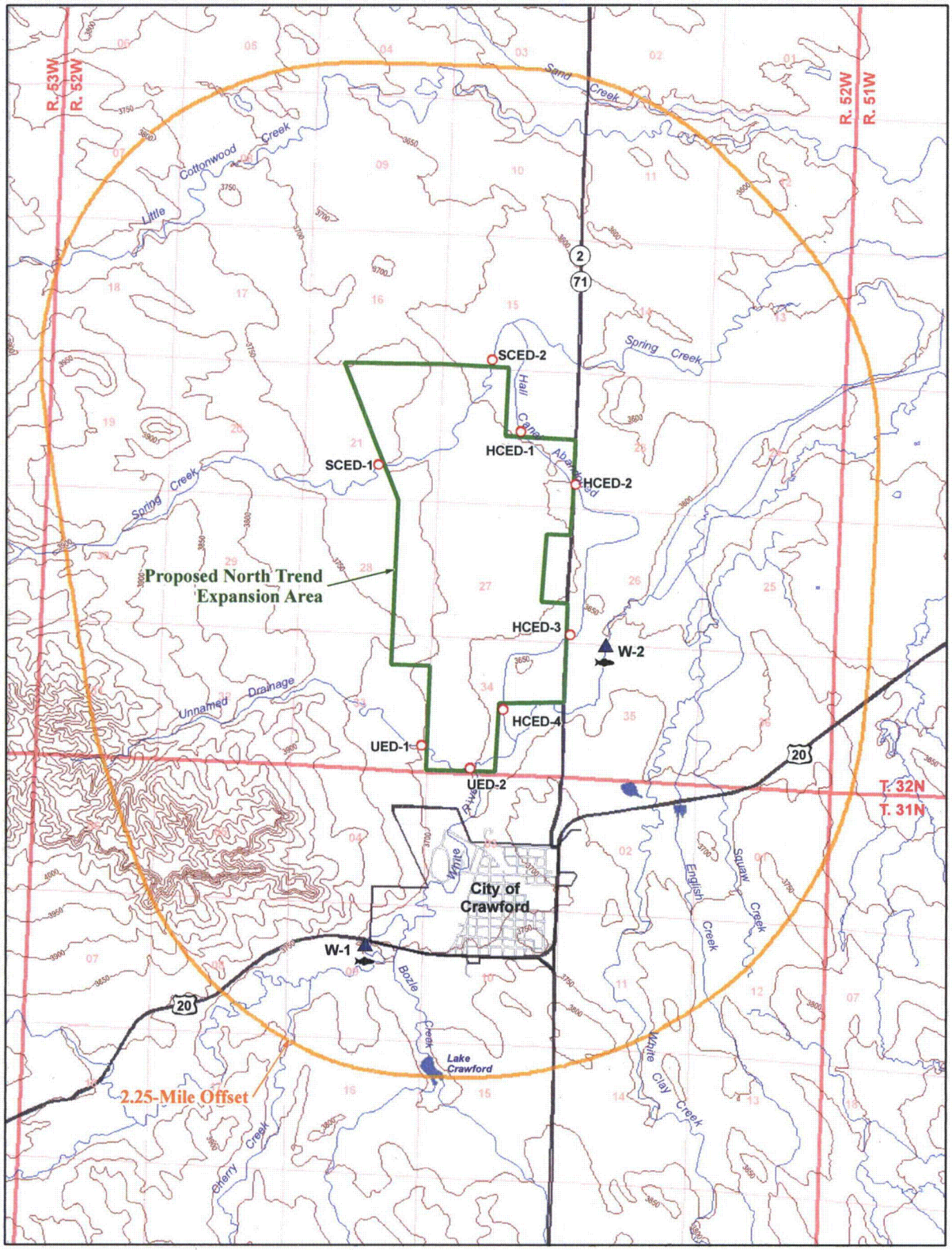

LEGEND

- Ephemeral Streams Sampling Location
- White River Sampling Location
- Fish Sampling Location
- Proposed North Trend Expansion Area
- 2.25-Mile Area of Review (AOR)
- Lake
- Stream
- Highway
- Elevation Contour (50-Feet Interval)

SCED: Spring Creek Ephemeral Drainage
HCED: Hall Canal Ephemeral Drainage
UED: Unnamed Ephemeral Drainage
W-1: White River Upstream
W-2: White River Downstream

0 2,000 4,000
Scale in Feet

Projection:
NAD_1927_State_Plane_
Nebraska_North_FIPS_2601

N
W E

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FIGURE 2.9-5
ADDITIONAL NORTH TREND SURFACE WATER, SEDIMENT AND FISH SAMPLING LOCATIONS

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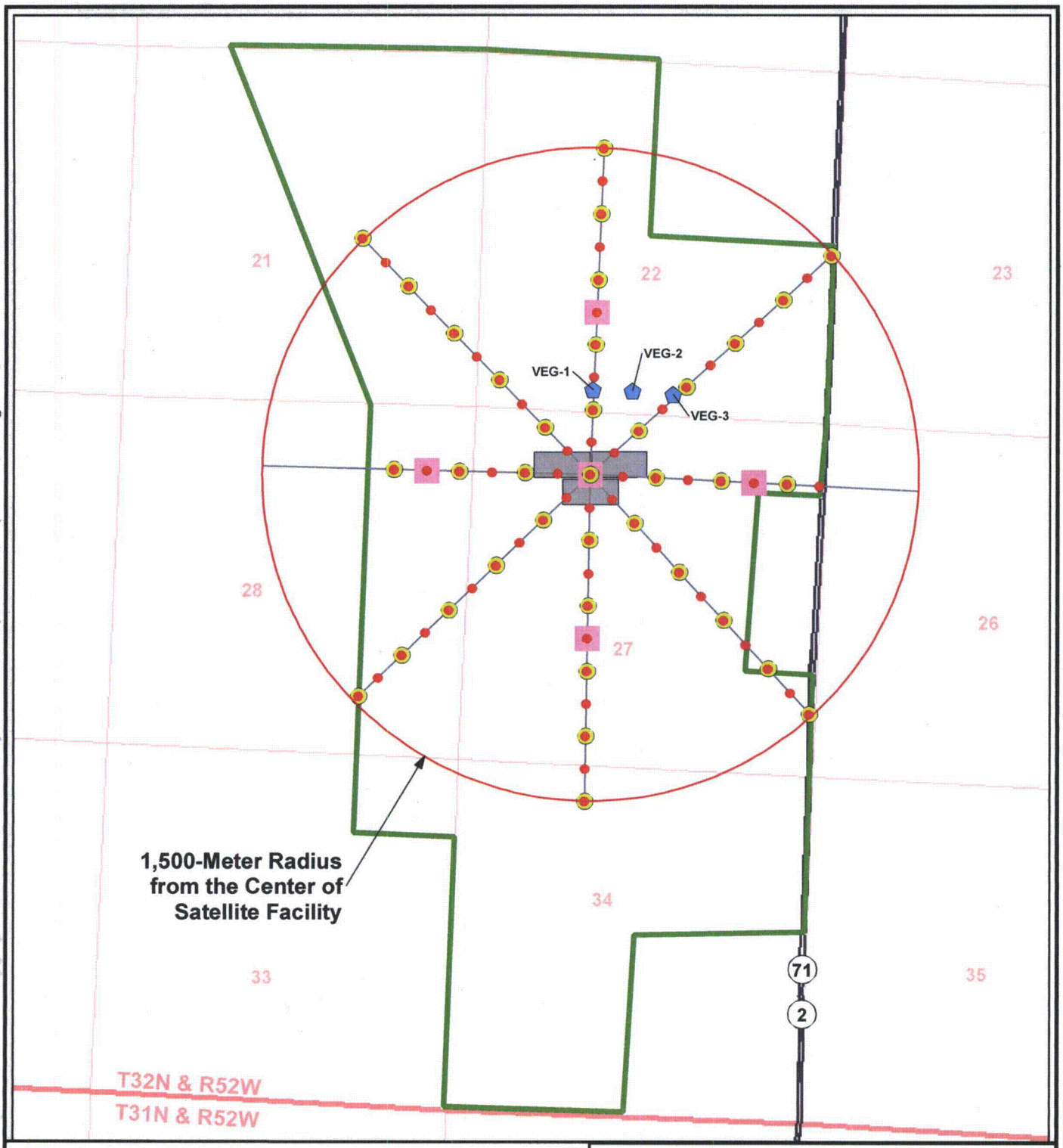

LEGEND

- Gamma Survey Location
- Surface Soil Sampling Location
- Vegetation Sampling Location
- Subsurface Soil Sampling Location
- Satellite Facility
- Proposed North Trend Expansion Area (NTEA)

0 1,000 2,000
Scale in Feet

PROJECTION: NAD_1927_STATEPLANE_ NEBRASKA_NORTH_FIPS_2601

CROW BUTTE RESOURCES, INC.

FIGURE 2.9-6
ADDITIONAL PREOPERATIONAL SAMPLING LOCATIONS FOR SOILS, VEGETATION AND GAMMA SURVEYS

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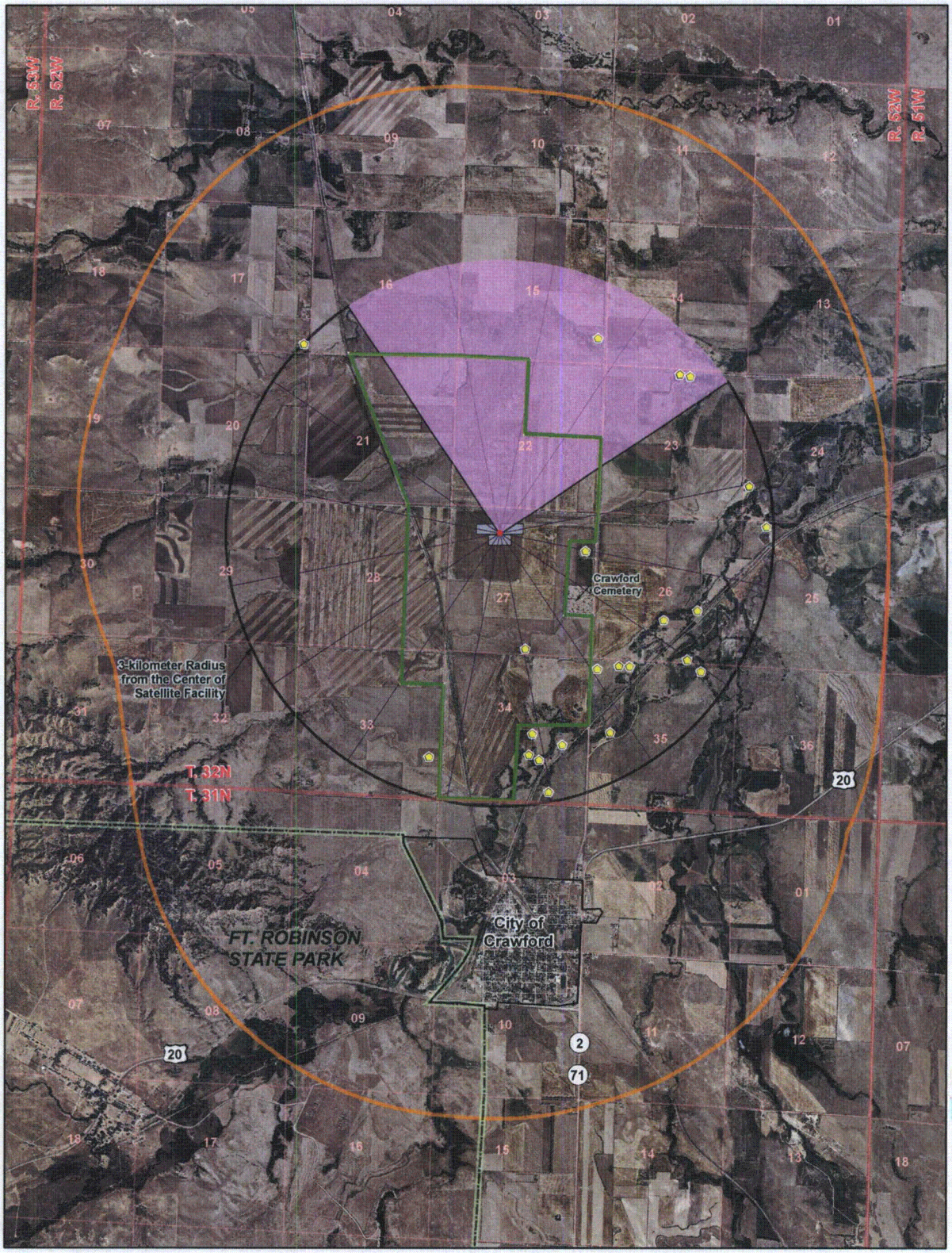

LEGEND

- Rural Residence
- Proposed North Trend Expansion Area (NTEA)
- Primary Sampling Area for Crops and Livestock
- Secondary Sampling Area for Crops and Livestock
- Boundary of Sampling Quadrants
- Center of NTEA Satellite Facility
- NTEA Satellite Facility
- Boundary of Fort Robinson
- 2.25-Mile Buffer of Proposed NTEA Boundary

Aerial Source: NAIP 2006, Dawes County, NE

N
W — E

0 2,000 4,000
Scale in Feet

Projection:
NAD_1927_State_Plane_
Nebraska_North_FIPS_2601

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FIGURE 2.9-7
ADDITIONAL NORTH TREND PREOPERATIONAL SAMPLING AREAS FOR CROPS AND LIVESTOCK

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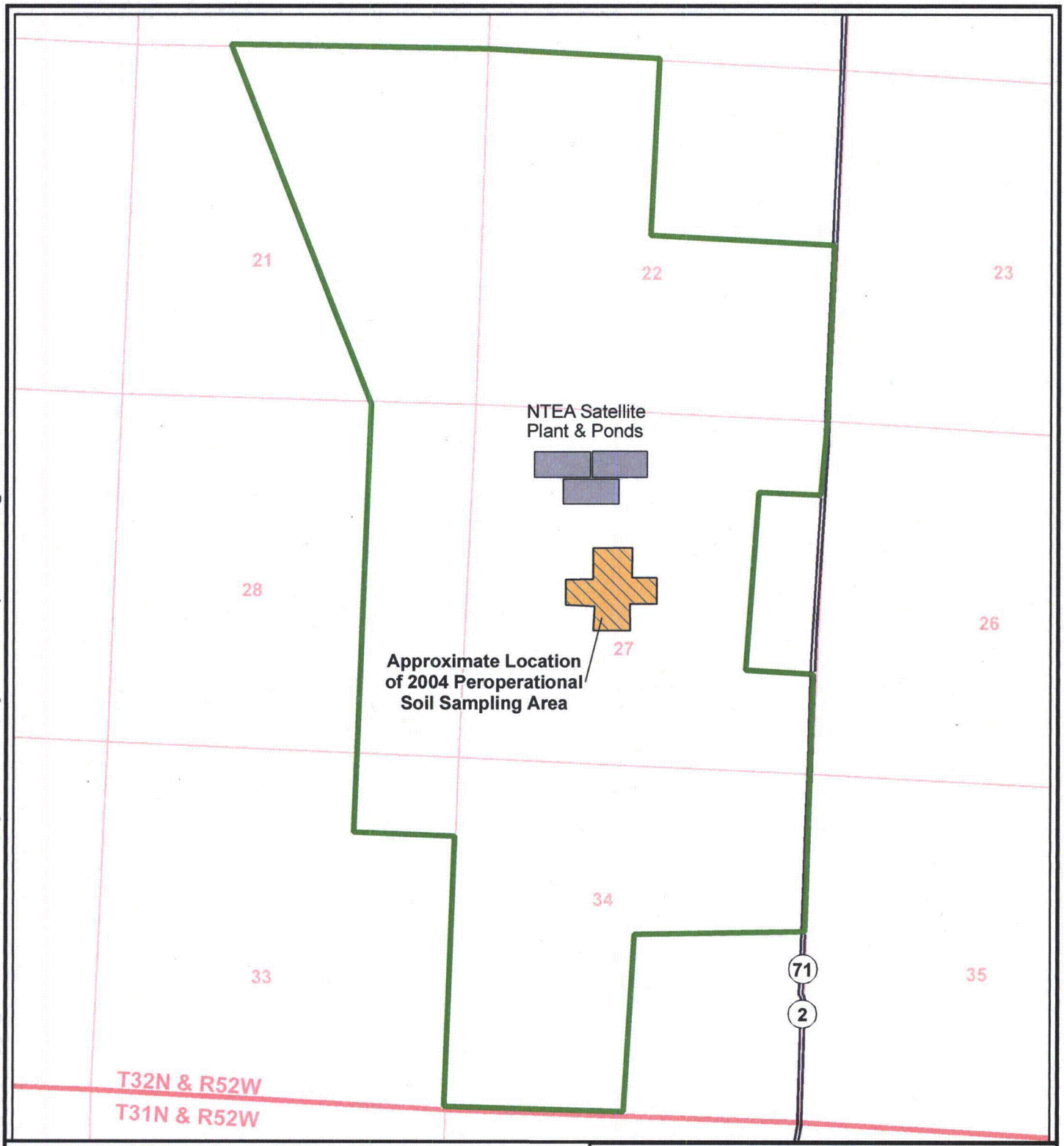


LEGEND

- 2004 Operational Soil Sampling Area (Approximate)
- Satellite Plant & Ponds
- Proposed North Trend Expansion Area (NTEA)

0 1,000 2,000

Scale in Feet

PROJECTION:
*NAD_1927_STATEPLANE_*
NEBRASKA_NORTH_FIPS_2601

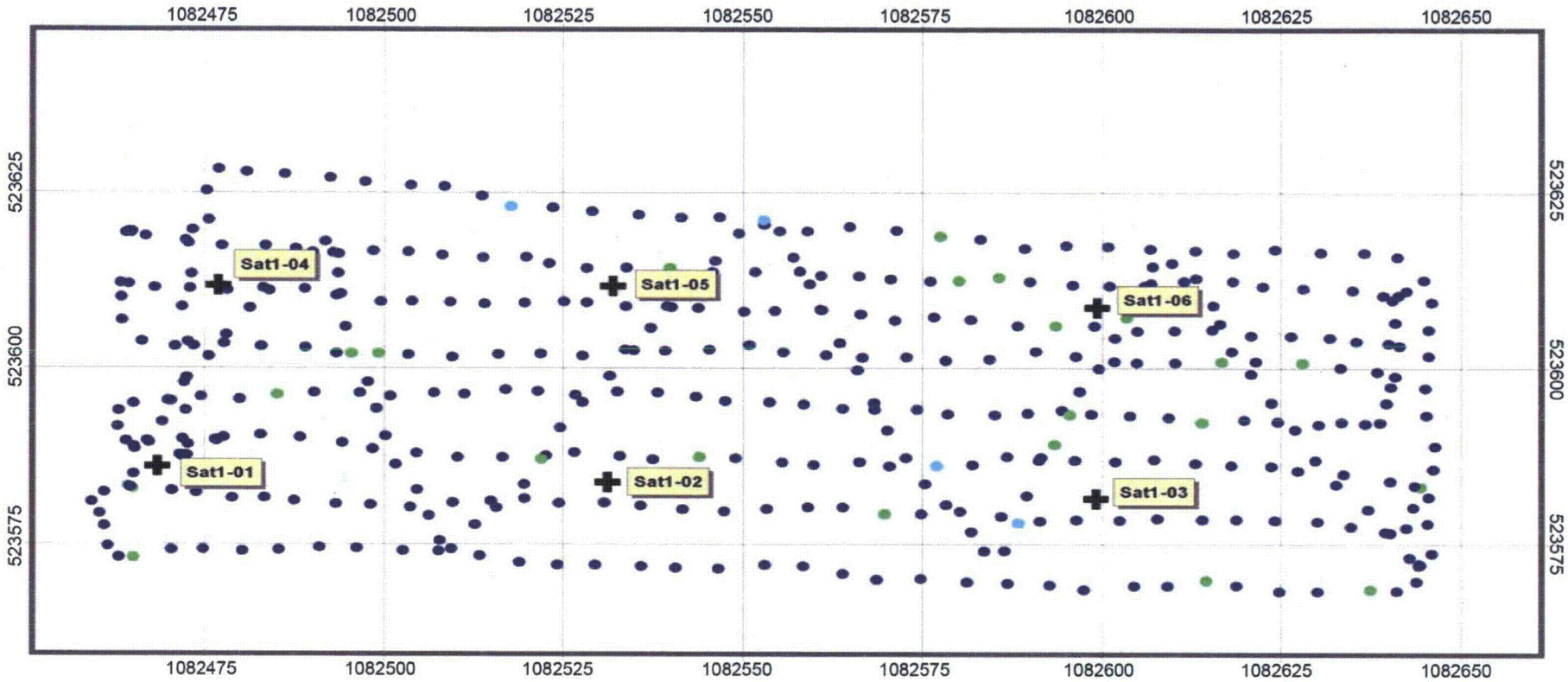
CROW BUTTE RESOURCES, INC.

FIGURE 2.9-8
2004 NORTH TREND
PREOPERATIONAL SOIL SAMPLING AREA

PROJECT: CO001396.00001 MAPPED BY: JC CHECKED BY: JEC

ARCADIS
630 Plaza Drive, Ste. 100
Highlands Ranch, CO 80129
P: 720-344-3500 F: 720-344-3535
www.arcadis-us.com

K:\CBR_Projects\CO001322_NTEA\2_GIS\ArcMaps\0001_TR\TechRpt_2_9-6_2010to2011 NT Preoperational Sampling Locations for Soils, Veg and Gamma Surveys.mxd - 6/16/2010 @ 12:00:51 AM



Gamma Count Rate (cpm) At 18" Above Ground

- < 13,000
- 13,000 - 16,000
- 16,000 - 19,000
- 19,000 - 22,000
- >22,000

Soil Sample Locations

Crow Butte Process Plant Approximately 6 Miles SE

25 0 25 Feet

N
W E

Source: CBR

CROW BUTTE RESOURCES, INC.

FIGURE 2.9-9
2004 NORTH TREND PREOPERATIONAL GAMMA SURVEY RESULTS FOR SOIL SAMPLING LOCATIONS

PROJECT: CO001396.00001 MAPPED BY: JC CHECKED BY: JEC

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Highlands Ranch, CO 80129
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www.arcadis-us.com

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Replacement Pages for Section 3.0
Description of Proposed Facility

Replace pages:

3.1-9/3.1-10

3.1-11/3 .1-12

3.1-13/3.1-14

3.2-33/3.2-34

3.3-37/3.3-38

3.3-39/3.3-40

Note: Red-line version located behind blue cover page after replacement pages

3.1.2.3 Well Development

Following well construction (and before baseline water quality samples are taken for restoration and monitoring wells), the wells must be developed to restore the natural hydraulic conductivity and geochemical equilibrium of the aquifer. All wells are initially developed immediately after construction using airlifting or other accepted development techniques. This process is necessary to allow representative samples of groundwater to be collected. Well development removes water and drilling fluids from the casing and borehole walls along the screened interval. The primary goal for well development is to allow formation water to enter the well screen.

The well is developed until the water produced is clear. This can be determined visually or with a turbidimeter. During the final stages of initial development, water samples will be collected in a transparent or translucent container and visually examined for turbidity (i.e., cloudiness and visual suspended solids). Development is continued until clear, sediment-free formation water is produced.

When the water begins to become clear, the development will be temporarily stopped and/or the flow rate will be varied. Sampling and examination for turbidity will be continued. When varying the development rate no longer causes the sample to become turbid, the initial development will be deemed complete.

Before obtaining baseline samples from monitor or restoration wells, the well must be further developed to ensure that representative formation water is available for sampling. Final development is performed by pumping the well or swabbing for an adequate period to ensure that stable formation water is present. Monitoring for pH and conductivity is performed during this process to ensure that development activities have been effective. The field parameters must be stable at representative formation values before baseline sampling will begin.

Section 3.1.5 (Wellfield and Process Waste) has additional discussions as to process wastewaters generated by the wellfield and Satellite Facility.

3.1.2.4 Well Integrity Testing

Field-testing of all (i.e., injection, production, and monitor) wells is performed to demonstrate the mechanical integrity of the well casing. This mechanical integrity test (MIT) is performed using pressure-packer tests. Every well will be tested after well construction is completed before it can be placed in service, after any workover with a drill rig or servicing with equipment or procedures that could damage the well casing, at

least once every five years, and whenever there is any question of casing integrity. To assure the accuracy of the integrity tests, periodic comparisons are made between the field pressure gauges and a calibrated test gauge. The MIT procedures have been approved by the NDEQ and are currently contained in SHEQ MS Program Volume III, *Operating Manual*. These same procedures will be used at the North Trend Expansion Area.

The following general MIT procedure is used:

- The test consists of placement of one or two packers within the casing. The bottom packer is set just above the well screen and the upper packer is set at the wellhead. The packers are inflated with nitrogen and the casing is pressurized with water to 125 percent of the maximum operating pressure (i.e., 125 psi).

- The well is then "closed in" and the pressure is monitored for a minimum of twenty minutes.

- If more than ten percent of the pressure is lost during this time period, the well has failed the integrity test. When possible, a well that fails the integrity testing will be repaired and the testing repeated. If the casing leakage cannot be repaired or corrected, the well is plugged and reclaimed as described in Section 6.0.

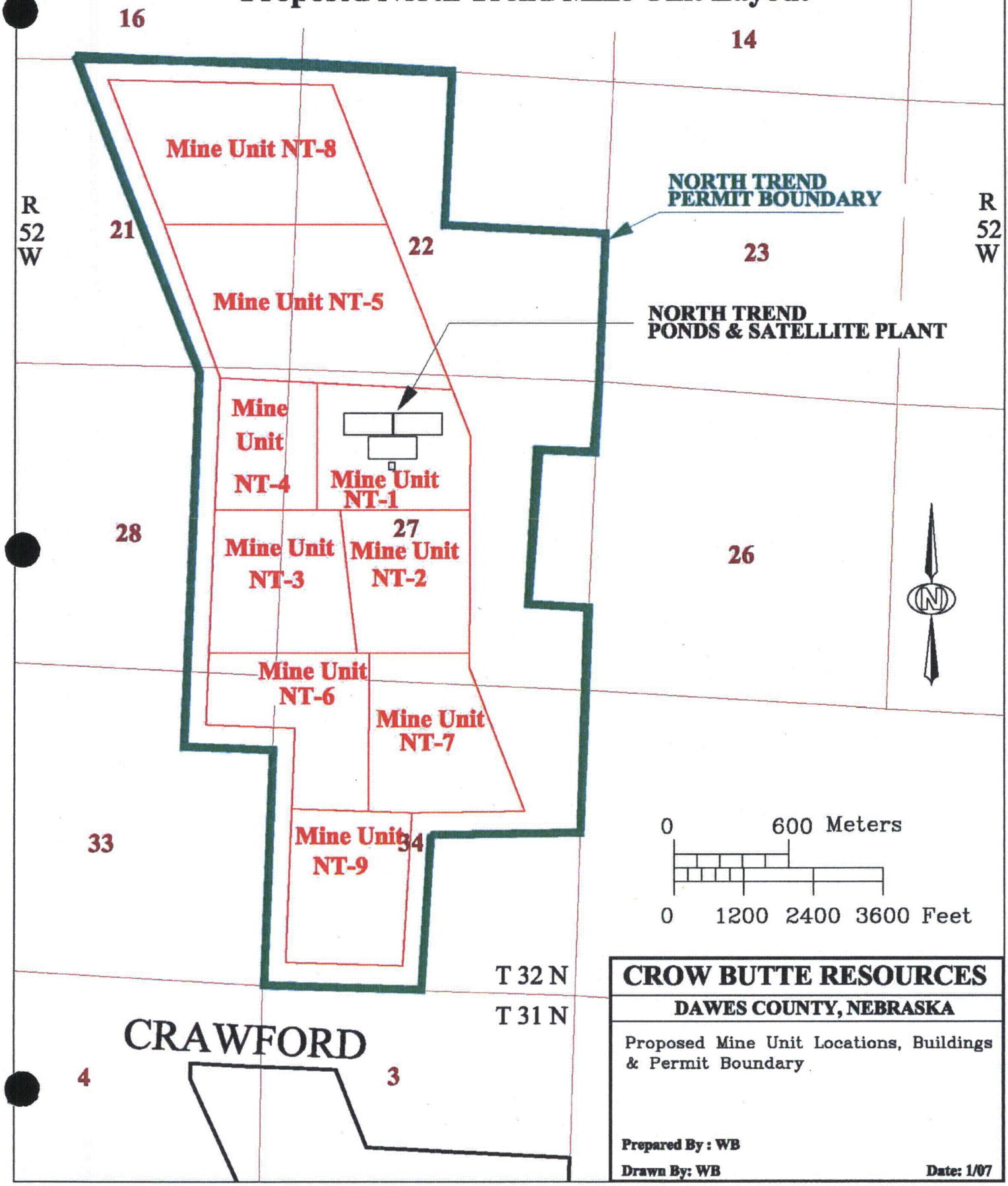
CBR submits all integrity testing records to the NDEQ for review after the initial construction of a mine unit or wellfield. Test results are also maintained on site for regulatory review.

3.1.3 Wellfield Design and Operation

The proposed North Trend Mine Unit map and mine schedule are shown in Figure 3.1-4 and Figure 3.1-5. The preliminary map and mine schedule are based on CBR's current knowledge of the area. As the North Trend Expansion Area is developed, the mine schedule and a mine unit map will be developed further. The North Trend Expansion Area will be subdivided into an appropriate number of mine units. Each mine unit will contain a number of wellhouses where injection and recovery solutions from the satellite plant building are distributed to the individual wells. The injection and production manifold piping from the satellite process facility to the wellfield houses will be either polyvinyl chloride (PVC) or high-density polyethylene (HDPE) with butt welded joints or an equivalent. In the wellfield house, injection pressure will be monitored on the injection trunk lines. Oxidizer will be added to the injection stream and all injection lines off of the injection manifold will be equipped with totalizing flow meters, which will be

FIGURE 3.1-4

Proposed North Trend Mine Unit Layout



CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

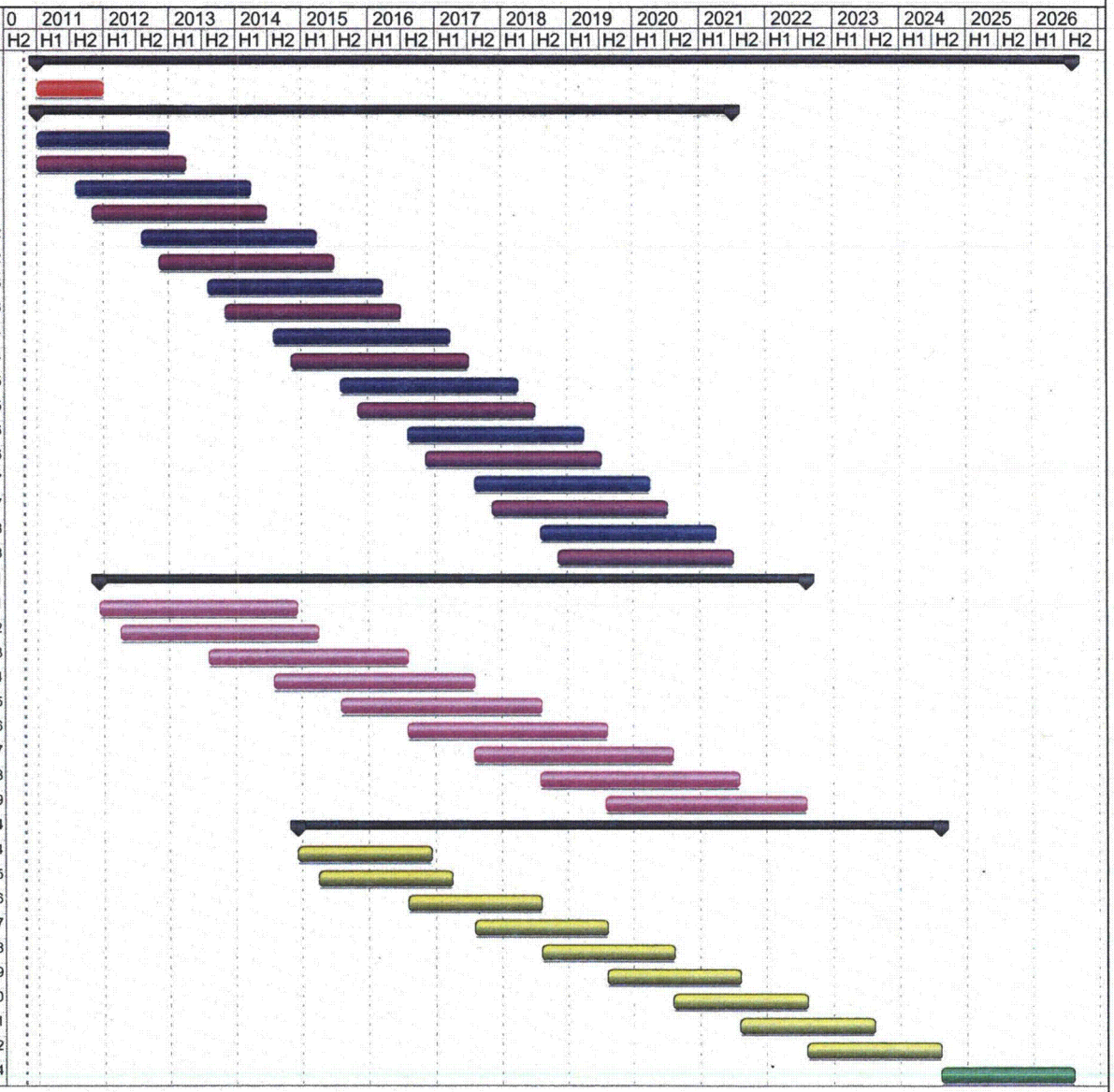
Proposed Mine Unit Locations, Buildings & Permit Boundary

Prepared By : WB

Drawn By: WB **Date: 1/07**

Figure 3.1-5 North Trend Mine Unit Schedule

ID	Task Name	Start
1	**North Trend Mine Unit Schedule**	**Thu 1/6/11**
2	**North Trend Facility Construction**	Thu 1/6/11
3	**North Trend Wellfield Construction**	**Thu 1/6/11**
4	Mine Unit NT-1 Well Development Drilling and Casing	Thu 1/6/11
5	Mine Unit NT-1 Surface Construction	Thu 1/6/11
6	Mine Unit NT-2 Well Development Drilling and Casing	Fri 8/5/11
7	Mine Unit NT-2 Surface Construction	Wed 11/2/11
8	Mine Unit NT-3 Well Development Drilling and Casing	Fri 8/3/12
9	Mine Unit NT-3 Surface Construction	Thu 11/8/12
10	Mine Unit NT-4 Well Development Drilling and Casing	Mon 8/5/13
11	Mine Unit NT-4 Surface Construction	Fri 11/8/13
12	Mine Unit NT-5 Well Development Drilling and Casing	Sun 8/3/14
13	Mine Unit NT-5 Surface Construction	Sat 11/8/14
14	Mine Unit NT-6 Well Development Drilling and Casing	Wed 8/5/15
15	Mine Unit NT-6 Surface Construction	Mon 11/9/15
16	Mine Unit NT-7 Well Development Drilling and Casing	Fri 8/5/16
17	Mine Unit NT-7 Surface Construction	Thu 11/10/16
18	Mine Unit NT-8 Well Development Drilling and Casing	Mon 8/7/17
19	Mine Unit NT-8 Surface Construction	Fri 11/10/17
20	Mine Unit NT-9 Well Development Drilling and Casing	Mon 8/6/18
21	Mine Unit NT-9 Surface Construction	Mon 11/12/18
22	**North Trend Production**	**Wed 12/7/11**
23	Mine Unit NT-1	Wed 12/7/11
24	Mine Unit NT-2	Mon 4/2/12
25	Mine Unit NT-3	Fri 8/2/13
26	Mine Unit NT-4	Fri 8/1/14
27	Mine Unit NT-5	Mon 8/3/15
28	Mine Unit NT-6	Mon 8/1/16
29	Mine Unit NT-7	Tue 8/1/17
30	Mine Unit NT-8	Wed 8/1/18
31	Mine Unit NT-9	Thu 8/1/19
32	**Groundwater Restoration**	**Mon 12/8/14**
33	Mine Unit NT-1	Mon 12/8/14
34	Mine Unit NT-2	Mon 3/30/15
35	Mine Unit NT-3	Tue 8/2/16
36	Mine Unit NT-4	Thu 8/3/17
37	Mine Unit NT-5	Thu 8/9/18
38	Mine Unit NT-6	Thu 8/8/19
39	Mine Unit NT-7	Fri 8/7/20
40	Mine Unit NT-8	Mon 8/9/21
41	Mine Unit NT-9	Tue 8/9/22
42	**Final Site Reclamation**	Tue 8/13/24



monitored in the satellite Control Room. The North Trend Expansion Area wellfields will be designed in a manner consistent with the existing CBR wellfields.

For now, CBR has recognized the two year limit enumerated in 10 CFR §40.42(h)(1). In reality, the duration of restoration will vary and in large part will be depend on the pore volume of the particular mine unit. CBR will discuss administrative options in the context of a 10 CFR §40.42(h)(2)(i) alternate schedule. Specifically, administrative processes are in place for the NDEQ to track restoration progress. These processes could satisfy NRC oversight needs and operate in lieu of an artificial cycle of proposed schedules and extensions that do not reflect the reality of ISR restoration.

There is a minimum potential for flooding throughout the North Trend Expansion Area. As shown in Tables 2.7-1 and 2.7-2, the average monthly stream flow of the White River at the Crawford gauge station is about 20 cfs. The highest discharge and gauge height on record between 1920 and 2004 occurred on May 10, 1991. On that date, severe thunderstorms resulted in significant rainfall, the gauge height was 16.32 feet and the stream flow exceeded 13,300 cfs. Several city facilities were damaged by floodwaters and hail, including the local golf course and fishery, and the event was considered a "100 year" flood. However, it is noted that, while there are certainly historical extremes, the average gauge height on the While River at Crawford is less than 5 feet, with an average annual stream flow of 20.2 cfs.

An assessment of the potential for flooding or erosion that could impact the in-situ mining processing facilities and surface impoundments has been performed based on data from the Federal Emergency Management Agency (FEMA; http://msc.fema.gov). FEMA has not mapped unincorporated Dawes County north of Crawford, Nebraska. However, FEMA maps are available for the City of Crawford (Figure 2.7-1A), and an analogy can be drawn between the flooding potential in Crawford and that immediately north of Crawford adjacent to the proposed North Trend Permit Area. For example, FEMA has classified the portion of Crawford between the former Chicago and Northwestern Railroad tracks (immediately west of First Street) as Zone A (i.e., an area that could be impacted by a 100-year flood) (*Managing Floodplain Development in Approximate Zone A Areas; FEMA, April 1995*). The elevation of the White River in the Zone A classification ranges from 3,669 to 3,659 feet AMSL. The surface elevation of the railroad tracks ranges from 3,678 to 3,671 feet AMSL. These data suggest that significant flooding potential exists with a rise in the White River Elevation of 9 to 12 feet above base flow conditions. This is consistent with the data from the 1991 100-year flood event, where the river elevation was approximately 11.3 feet above base gauge height (approximately 5 feet).

The proposed North Trend surface facilities are to be located in the north-central portion of Section 27, approximately one mile northwest of White River, and approximately 70 feet topographically above the common river elevation. Proposed wellfields are planned for portions of Sections 21, 22, 27, 28, 33 and 34 T32N, R52W. With the exception of

Section 34, the wellfields are projected to be at least 50 feet above the White River elevation.

The portion of the proposed North Trend Expansion Area where the greatest flooding potential related to the White River exists is the southeast part of Section 34 (Figure 2.7-1). The White River elevation in that area varies from 3,645 feet AMSL on the western portion of the southern permit boundary, to 3,622 feet AMSL to the northeast. Because of lower elevation and proximity to the White River, final wellfield layout in Section 34 may necessitate consideration of potential flood impacts (e.g., below a surface elevation of 3,657 feet on the west, and 3,634 feet to the northeast).

Based on these data, the North Trend surface facilities occur outside of the 100 year-flood plain, and are not considered to be in a "flood prone" area. Therefore, consistent with NUREG-1623, erosion modeling was not considered necessary or performed.

The wellfield injection/production pattern employed is based on a hexagonal seven spot pattern, which is modified as needed to fit the characteristics of the ore body. The standard production cell for the seven spot pattern contains six injection wells surrounding a centrally located recovery well.

The cell dimensions vary depending on the formation and the characteristics of the ore body. The injection wells in a normal pattern are expected to be between 65 feet and 150 feet apart. A typical wellfield layout is shown in Figure 3.1-6. The wellfield is a repeated seven spot design, with the spacing between production wells ranging from 65 to 150 feet.

Other wellfield designs include alternating single line drives.

All wells are completed so they can be used as either injection or recovery wells, so that wellfield flow patterns can be changed as needed to improve uranium recovery and restore the groundwater in the most efficient manner. During operations, leaching solution enters the formations through the injection wells and flows to the recovery wells. Within each mine unit, more water is produced than injected to create an overall hydraulic cone of depression in the production zone. Under this pressure gradient the natural groundwater movement from the surrounding area is toward the wellfield providing additional control of the leaching solution movement. The difference between

cleaned using recommended methods in CGA G-4.1[2]. The design and installation of oxygen distribution systems is based on CGA-4.4[3].

The design location of the carbon dioxide and oxygen storage tanks are shown on Figure 3.2-1.

- Sodium Sulfide

Hazardous materials typically used during groundwater restoration activities include the addition of a chemical reductant (i.e., sodium sulfide or hydrogen sulfide gas). To minimize potential impacts to radiological safety, these materials are stored outside of process areas. Sodium sulfide is currently used as the chemical reductant during groundwater restoration at the current license area. The material consists of a dry flaked product and is typically purchased on pallets of 55-pound bags or super sacks of 1,000 pounds. The bulk inventory is stored outside of process areas in a cool, dry, clean environment to prevent contact with any acid, oxidizer, or other material that may react with the product. Hydrogen sulfide gas has never been used at the Crow Butte Uranium Project. In the event that CBR determines that use of hydrogen sulfide as a chemical reductant is necessary, proper safety precautions will be taken to minimize potential impacts to radiological and chemical safety.

As part of the SHEQ MS Program, a risk assessment was completed to recognize potential hazards and risks associated with chemical storage facilities (and other processes) and to mitigate those risks to acceptable levels. The risk assessment process identified hydrochloric acid as the most hazardous chemical with the greatest potential for impacts to chemical and radiological safety. The hydrochloric acid storage and distribution system at the existing Central Processing Plant (see Figure 3.2-3) has a maximum capacity of approximately 6,000 gals. Strict unloading procedures are utilized to ensure that safety controls are in place during the transfer of hydrochloric acid. Process safety controls are also in place at the Central Processing Plant where hydrochloric acid is added to the precipitation circuit. Since precipitation will not be performed at the satellite facility, the use and storage of concentrated hydrochloric acid will not be necessary in this area.

None of the hazardous chemicals used at the Crow Butte Uranium Project are covered under the EPA's Risk Management Program (RMP) regulations. The RMP regulations require certain actions by covered facilities to prevent accidental releases of hazardous chemicals and minimize potential impacts to the public and environment. These actions include measures such as accidental release modeling, documentation of safety information, hazard reviews, operating procedures, safety training, and emergency response preparedness.

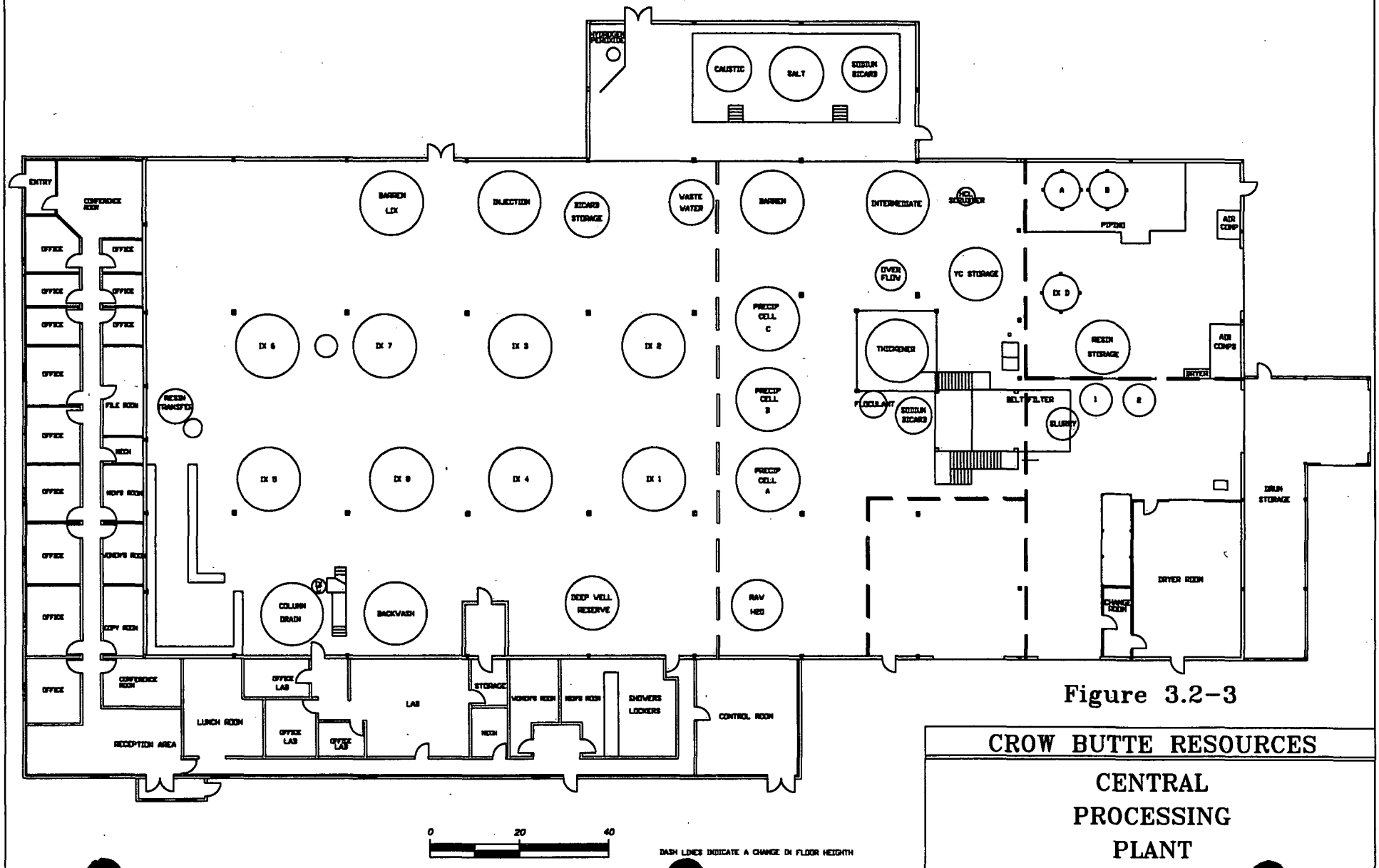


Figure 3.2-3

CROW BUTTE RESOURCES

CENTRAL PROCESSING PLANT

External Radiation Equipment

- Ludlum Model 19 Gamma Meter (μR/hr) or equivalent
- Ludlum Model 3 Gamma Meter with Ludlum Model 44-38 G-M detector (mR/hr) or equivalent
- Ludlum Model 2221 Ratemeter/Scaler with a Ludlum Model 44-10 NaI detector (cpm) or equivalent
- Calibrated annually or after repair-manufacturer or qualified accredited vendor

Surface Contamination Equipment

- Ludlum Model 2241 scaler or a Ludlum Model 12 Ratemeter with a Model 43-65 or Model 43-5 alpha scintillation probe or equivalent (Total Alpha)
- Ludlum Model 177 Ratemeter with a Ludlum Model 43-5 alpha scintillation probe or equivalent (Personnel Contamination)
- Ludlum Model 2000 Scaler or Model 2200 Scaler with an Eberline SAC-R5 or Ludlum Model 43-10 alpha scintillation sample counter or equivalent (Removable Alpha, Radon Daughters, Airborne Radioactivity)

Instruments will be calibrated annually or at a frequency recommended by the manufacturer, whichever is more frequent. Repairs will be by the manufacturer by or by a qualified accredited vendor, and the instrument will be calibrated following such repair. The calibration vendor shall provide the as-found calibration condition of each instrument. If greater than 10% of the instruments are out of calibration when received by the calibration vendor, consideration would be given to increasing the calibration frequency.

New radiation survey instruments will be acquired for use at the NTEA. The number of instruments purchased will be sufficient so that backup instruments are available in the event of failure of one, or if one instrument has been sent to the vendor for calibration or repair.

The manufacturer or a qualified accredited vendor shall calibrate portable survey instruments, counter/scalers, mass flow meters and/or dry cell calibrators, and calibration sources. Calibration will be performed as recommended in ANSI N323 and ANSI N323A. The ANSI standard requires that radiation detection instruments be performance tested on an annual basis to verify that they continue to meet operational and design requirements. Instruments must be tested for range, sensitivity, linearity, detection limit, and response to overload. The specific calibration requirements for various types of instruments are discussed in CBR's SHEQ MS *Volume IV Health Physics Manual.* Regulatory Guide 8.30 specifies requirements for routine maintenance and calibration of radiological survey instruments. Regulatory Guide 8.30 references the standards

contained in ANSI N323-1978, *Radiation Protection Instrumentation Test and Calibration.* ANSI is in the process of a major revision of this Standard that will result in three separate Standards that apply to radiological instrumentation. The first revision, ANSI-N323A-1997, *Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments*, was incorporated in this Chapter. When conflicts arise between NRC Regulatory Guide 8.30 and the ANSI Standard, the Regulatory Guide recommendations will be followed.

Calibration vendors will provide a certificate of calibration for all instruments. These calibration certificates will be maintained by the RSO on file for that instrument. Records of repair completed by the calibration vendor will also be maintained in the instrument file.

Documentation of calibration of air samplers performed on site will be maintained. This documentation will be maintained by the RSO in the sampler file.

Record of instrument checks including the daily checks and initial checks will be maintained in a format determined by the RSO. These records will be readily available and in a format that will allow the RSO to review the records for the types of potential problems (e.g., background drift in a continuous direction, battery check that does not respond, ratemeter that does not zero and alpha background rates greater than 0.5 cpm).

All records of instrument calibration and checks will be retained until NRC License termination. The RSO will be responsible for record retention.

Details as to calibration, functional tests, procedures and recordkeeping/retention are discussed in CBR's SHEQ MS *Volume IV Health Physics Manual.*

Red-line Version of Replacement Pages

3.1.2.3 Well Development

Following well construction (and before baseline water quality samples are taken for restoration and monitoring wells), the wells must be developed to restore the natural hydraulic conductivity and geochemical equilibrium of the aquifer. All wells are initially developed immediately after construction using airlifting or other accepted development techniques. This process is necessary to allow representative samples of groundwater to be collected. Well development removes water and drilling fluids from the casing and borehole walls along the screened interval. The primary goal for well development is to allow formation water to enter the well screen.

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The following general MIT procedure is used:

- The test consists of placement of one or two packers within the casing. The bottom packer is set just above the well screen and the upper packer is set at the wellhead. The packers are inflated with nitrogen and the casing is pressurized with water to 125 percent of the maximum operating pressure (i.e., 125 psi).

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monitored in the satellite Control Room. The North Trend Expansion Area wellfields will be designed in a manner consistent with the existing CBR wellfields.

~~CBR is proposing a 3 year restoration schedule for the NTEA individual mine units (Figure 3.1-5). Based on decommissioning timeline regulations specified in 10 CFR 40.42 (g) (2), CBR's schedule of 3 years, as opposed to the NRC's requirement of 2 years for completion of decommissioning, will be considered an alternate restoration schedule. The NRC must approve such an alternate schedule, as per 10 CFR 40.42 (g) (2). By this application, CBR is requestingwill request a formal alternate restoration schedule in the NTEA license application, with timeline deviations requiring a license amendment. CBR is of the opinion, based on recent restoration experience, that full restoration of a mine unit will take approximately 3 years.~~ For now, CBR has recognized the two year limit enumerated in 10 CFR §40.42(h)(1). In reality, the duration of restoration will vary and in large part will be depend on the pore volume of the particular mine unit. CBR will discuss administrative options in the context of a 10 CFR §40.42(h)(2)(i) alternate schedule. Specifically, administrative processes are in place for the NDEQ to track restoration progress. These processes could satisfy NRC oversight needs and operate in lieu of an artificial cycle of proposed schedules and extensions that do not reflect the reality of ISR restoration.

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Zone A classification ranges from 3,669 to 3,659 feet AMSL. The surface elevation of the railroad tracks ranges from 3,678 to 3,671 feet AMSL. These data suggest that significant flooding potential exists with a rise in the White River Elevation of 9 to 12 feet above base flow conditions. This is consistent with the data from the 1991 100-year flood event, where the river elevation was approximately 11.3 feet above base gauge height (approximately 5 feet).

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Other wellfield designs include alternating single line drives.

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with an option of installing polishing filters downstream. The lixiviant injection pumps are centrifugal type.

A discussion of the areas in the proposed satellite facility where fumes or gases could be generated can be found in Section 7.3. The potential sources are minimal in the satellite facility since the mining solutions contained in the process equipment are maintained under a positive pressure. Building ventilation in the process equipment area will be accomplished by the use of an exhaust system that draws in fresh air and sweeps the plant air out to the atmosphere.

3.2.2 Chemical Storage Facilities

Chemical storage facilities at the North Trend Satellite Plant will include both hazardous and non-hazardous material storage areas. Bulk hazardous materials, which have the potential to impact radiological safety, will be stored outside and segregated from areas where licensed materials are processed and stored (Figure 3.2-1). Other non-hazardous bulk process chemicals (e.g., sodium carbonate) that do not have the potential to impact radiological safety may be stored within the satellite facilities.

3.2.2.1 Process Related Chemicals

Process-related chemicals stored in bulk at the North Trend Satellite Plant will include carbon dioxide, oxygen, and or hydrogen peroxide. Sodium sulfide may also be stored for use as a reductant during groundwater restoration.

- Carbon Dioxide

Carbon dioxide is stored adjacent to the satellite plant where it will be added to the lixiviant prior to leaving the satellite plant.

- Oxygen

Oxygen is also typically stored at the satellite plant, or within wellfield areas, where it is centrally located for addition to the injection stream in each wellhouse. Since oxygen readily supports combustion, fire and explosion are the principal hazards that must be controlled. The oxygen storage facility will be located a safe distance from the satellite plant and other chemical storage areas for isolation. The storage facility will be designed to meet industry standards in NFPA-50[1].

Oxygen service pipelines and components must be clean of oil and grease since gaseous oxygen will cause these substances to burn with explosive violence if ignited. All components intended for use with the oxygen distribution system will be properly

cleaned using recommended methods in CGA G-4.1[2]. The design and installation of oxygen distribution systems is based on CGA-4.4[3].

The design location of the carbon dioxide and oxygen storage tanks are shown on Figure 3.2-1.

- Sodium Sulfide

Hazardous materials typically used during groundwater restoration activities include the addition of a chemical reductant (i.e., sodium sulfide or hydrogen sulfide gas). To minimize potential impacts to radiological safety, these materials are stored outside of process areas. Sodium sulfide is currently used as the chemical reductant during groundwater restoration at the current license area. The material consists of a dry flaked product and is typically purchased on pallets of 55-pound bags or super sacks of 1,000 pounds. The bulk inventory is stored outside of process areas in a cool, dry, clean environment to prevent contact with any acid, oxidizer, or other material that may react with the product. Hydrogen sulfide gas has never been used at the Crow Butte Uranium Project. In the event that CBR determines that use of hydrogen sulfide as a chemical reductant is necessary, proper safety precautions will be taken to minimize potential impacts to radiological and chemical safety.

As part of the ~~EHSMS~~SHEQ MS Program, a risk assessment was completed to recognize potential hazards and risks associated with chemical storage facilities (and other processes) and to mitigate those risks to acceptable levels. The risk assessment process identified hydrochloric acid as the most hazardous chemical with the greatest potential for impacts to chemical and radiological safety. The hydrochloric acid storage and distribution system at the existing Central Processing Plant (see Figure 3.2-3) has a maximum capacity of approximately 6,000 gals. Strict unloading procedures are utilized to ensure that safety controls are in place during the transfer of hydrochloric acid. Process safety controls are also in place at the Central Processing Plant where hydrochloric acid is added to the precipitation circuit. Since precipitation will not be performed at the satellite facility, the use and storage of concentrated hydrochloric acid will not be necessary in this area.

None of the hazardous chemicals used at the Crow Butte Uranium Project are covered under the EPA's Risk Management Program (RMP) regulations. The RMP regulations require certain actions by covered facilities to prevent accidental releases of hazardous chemicals and minimize potential impacts to the public and environment. These actions include measures such as accidental release modeling, documentation of safety information, hazard reviews, operating procedures, safety training, and emergency response preparedness.

processor, which will allow it to operate independent of the main computer. Pressure switches will be fitted to each injection manifold in the Header House to alert the plant and wellfield operators of increasing manifold pressures. All critical equipment will be equipped with uninterruptible power supply (UPS) systems in the event of a power failure.

Through this system, not only will the plant operators be able to monitor and control every aspect of the operation on a real-time basis, but management will be able to review historical data to develop trend analysis for production operations. This will not only ensure an efficient operation, but will allow Crow Butte personnel to anticipate problem areas and to remain in compliance with appropriate regulatory requirements.

In the process areas, tank levels are measured in chemical storage tanks as well as process tanks.

Detailed information on the instrumentation and controls will be developed as part of the final design activities prior to construction. This information will be made available to the NRC for review prior to any construction activities.

Handheld radiation detection instruments and portable samplers will be used to monitor radiological conditions at the satellite plant. Specifications for this equipment are included in the ~~EHSMS~~SHEQ MS Program Volume IV, *Health Physics Manual,* and are discussed in further detail in Section 5. The location of monitoring points, monitoring procedures, and monitoring frequencies for in-plant radiation safety is also discussed in Section 5.

The types of health physics instrumentation that would be used at the proposed NTEA include the following:

Air Sampling Equipment

- Eberline RAS-1 or Aircon 2 samplers (0-100 lpm) or equivalent

  Calibrated semiannually or after repair-on site with a primary standard instrument or a properly calibrated secondary standard instrument

- BDX II or SKC lapel samplers (0-5 lpm) or equivalent

  Calibrated daily before each use-on site with a primary standard instrument or a properly calibrated secondary standard instrument

External Radiation Equipment

- Ludlum Model 19 Gamma Meter (μR/hr) or equivalent
- Ludlum Model 3 Gamma Meter with Ludlum Model 44-38 G-M detector (mR/hr) or equivalent
- Ludlum Model 2221 Ratemeter/Scaler with a Ludlum Model 44-10 NaI detector (cpm) or equivalent

Calibrated annually or after repair-manufacturer or qualified accredited vendor

Surface Contamination Equipment

- Ludlum Model 2241 scaler or a Ludlum Model 12 Ratemeter with a Model 43-65 or Model 43-5 alpha scintillation probe or equivalent (Total Alpha)
- Ludlum Model 177 Ratemeter with a Ludlum Model 43-5 alpha scintillation probe or equivalent (Personnel Contamination)
- Ludlum Model 2000 Scaler or Model 2200 Scaler with an Eberline SAC-R5 or Ludlum Model 43-10 alpha scintillation sample counter or equivalent (Removable Alpha, Radon Daughters, Airborne Radioactivity)

Instruments will be calibrated annually or at a frequency recommended by the manufacturer, whichever is more frequent. Repairs will be by the manufacturer by or by a qualified accredited vendor, and the instrument will be calibrated following such repair. The calibration vendor shall provide the as-found calibration condition of each instrument. If greater than 10% of the instruments are out of calibration when received by the calibration vendor, consideration would be given to increasing the calibration frequency.

New radiation survey instruments will be acquired for use at the NTEA. The number of instruments purchased will be sufficient so that backup instruments are available in the event of failure of one, or if one instrument has been sent to the vendor for calibration or repair.

The manufacturer or a qualified accredited vendor shall calibrate portable survey instruments, counter/scalers, mass flow meters and/or dry cell calibrators, and calibration sources. Calibration will be performed as recommended in ANSI N323 and ANSI N323A. The ANSI standard requires that radiation detection instruments be performance tested on an annual basis to verify that they continue to meet operational and design requirements. Instruments must be tested for range, sensitivity, linearity, detection limit, and response to overload. The specific calibration requirements for various types of instruments are discussed in CBR's SHEQ MS *Volume IV Health Physics Manual*~~, *Environmental, Health, and Safety Management System*~~.

Regulatory Guide 8.30 specifies requirements for routine maintenance and calibration of radiological survey instruments. Regulatory Guide 8.30 references the standards contained in ANSI N323-1978, *Radiation Protection Instrumentation Test and Calibration.* ANSI is in the process of a major revision of this Standard that will result in three separate Standards that apply to radiological instrumentation. The first revision, ANSI-N323A-1997, *Radiation Protection Instrumentation Test and Calibration, Portable Survey Instruments*, was incorporated in this Chapter. When conflicts arise between NRC Regulatory Guide 8.30 and the ANSI Standard, the Regulatory Guide recommendations will be followed.

Calibration vendors will provide a certificate of calibration for all instruments. These calibration certificates will be maintained by the RSO on file for that instrument. Records of repair completed by the calibration vendor will also be maintained in the instrument file.

Documentation of calibration of air samplers performed on site will be maintained. This documentation will be maintained by the RSO in the sampler file.

Record of instrument checks including the daily checks and initial checks will be maintained in a format determined by the RSO. These records will be readily available and in a format that will allow the RSO to review the records for the types of potential problems (e.g., background drift in a continuous direction, battery check that does not respond, ratemeter that does not zero and alpha background rates greater than 0.5 cpm).

All records of instrument calibration and checks will be retained until NRC License termination. The RSO will be responsible for record retention.

Details as to calibration, functional tests, procedures and recordkeeping/retention are discussed in CBR's SHEQ MS *Volume IV Health Physics Manual*~~,~~. ~~*Environmental, Health, and Safety Management System.*~~

3.4 REFERENCES

[1] National Fire Protection Association, NFPA-50, *Standard for Bulk Oxygen Systems at Consumer Sites*, (NFPA, 1996).

[2] Compressed Gas Association, CGA G-4.1, *Cleaning Equipment for Oxygen Service*, (CGA, 2000).

[3] Compressed Gas Association, CGA G-4.4, *Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems*, (CGA, 1993).

Replacement Pages for Section 4
Effluent Control Systems

Replace Pages:

4-3/4-4

4-11/4-12

4/13/4-14

4/17-4/18

Note: Red-line version located behind blue cover page after replacement pages

4.1.1 Tank and Process Vessel Ventilation Systems

A separate ventilation system will be installed for all indoor non-sealed process tanks and vessels where radon-222 or process fumes would be expected. The system will consist of an air duct or piping system connected to the top of each of the process tanks having the potential to produce radon (i.e., up-flow IX columns, resin transfer tank, and wastewater tanks]. Redundant exhaust fans will direct collected gases to discharge piping that will exhaust fumes to the outside atmosphere by forced air ventilation. The design of the fans will be such that the system will be capable of limiting employee exposures with the failure of any single fan. Discharge stacks will be located away from building ventilation intakes to prevent introducing exhausted radon into the facility as recommended in Regulatory Guide 8.31[2]. Airflow through any openings in the vessels will be from the process area into the vessel and into the ventilation system, controlling any releases that occur inside the vessel. Separate ventilation systems may be used as needed for the functional areas within the satellite plant.

A tank ventilation system of this type is utilized in the Central Processing Plant. Operational radiological in-plant monitoring for radon concentrations has proven this system to be an effective method for minimizing employee exposure.

4.1.2 Work Area Ventilation System

The work area ventilation system would be designed to force air to circulate within the satellite plant process areas.

4.1.2.1 Ventilation System at Current CBR Operating Facility

The ventilation system at the current CBR operating facility has been shown to adequately ventilate areas where radon and daughter products could accumulate. The ventilation system maintains a negative pressure on the process building to prevent gases such as radon from accumulating in the work areas. The current ventilation system consists of 3 wall fans that exhaust air out of the building while drawing across the plant floor. Each fan has a capacity of 11,000 cubic feet per minute (cfm). The total plant air volume is approximately 988,949 cubic feet (ft^3). Based on the fan capacities and the total air volume of the facilities, the turnover of the complete plant air volume is approximately 29.97 minutes. Tanks in the process area having the potential for radon emissions have vent fans that discharge emissions outside of the building. For example the west IX column tanks (6,000 cfm) and east IX column tanks (6,000 cfm) have separate vent vans that discharge to a common vent system. There are also vent fans for the backwash tank (800 cfm), waste tank (1,500 cfm), eluant tank (1,500 cfm), precipitation tank (1,500 cfm), east resin screen (1,200 cfm) and west resin screen (1,200 cfm). These later fans vent emissions to the outside of the building.

Before any plant startup, after a power bump or outage and after any vent system has been shut down for any reason, the ventilation system is inspected and assessed as per multiple criteria identified in CBR's SHEQ MS. The ventilation system for the upflow IX columns and the precipitation tank have alarms that will sound in the event they cease to work properly.

During favorable weather conditions, open doorways and convection vents in the roof assist in providing satisfactory work area ventilation. The design of the ventilation system is adequate to ensure that radon daughter concentrations in the facility are maintained below 25% of the derived air concentration (DAC) from 10 CFR Part 20.

Radon daughter monitoring results for the current processing facility for the year 2008 are show in **Table 4.1-1**. Monitoring is conducted monthly unless the results exceed an action limit of 25% of the DAC. If this action level is triggered, then weekly monitoring is required until four consecutive weeks of radon daughter concentrations are below the 25% level. The DAC is 0.333 Working Levels (WL) and 25% DAC is 0.08 WL. As can be seen in **Table 4.1-1**, the 25% action level and DAC were not exceeded in 2008. The method used to sample radon daughters is based on a simulated worst case scenario. All of the building doors are closed and time is allowed for the radon concentration to build up, if present. This is a very conservative estimate, because unless it is extremely cold, the doors are almost never completely closed. This enhances the building ventilation.

Airborne uranium monitoring results for the current processing facility for the year 2008 are shown in **Table 4.1-2**. Monitoring is conducted monthly. The DAC for soluble (D classification) natural uranium of 5×10^{-10} uCi/ml from Appendix B to 10 CFR 20.2401 is used. An action level of 25% of the DAC for soluble natural uranium is established at the current operations site. If an airborne uranium sample exceeds 25 % of the DAC during monthly monitoring, an investigation will be performed. As can be seen in Table 4.1-2, the measured concentrations are well below the action level and DAC. Concentrations at the North Trend Facility would be expected to be lower since there will be no yellowcake production or packing.

4.1.2.2 North Trend Ventilation System

The ventilation system at the proposed North Trend Facilities would be similar to the ventilation system used at the current CBR operating facility. Exhaust fans would exhaust air within the building outside of the building, drawing fresh air in. These exhaust fans would be located at floor level to ensure areas where radon could accumulate are ventilated sufficiently to prevent radon accumulation. Storage tanks with the potential for radon emissions would also be vented to the outside of the building. Separate and independent local ventilation systems may be used temporarily as needed for non-routine activities such as maintenance. As discussed above for the current processing facility, radon daughter monitoring at the proposed North Trend satellite facility would be used to

- Daily Inspections

  Daily inspections consist of checking the pond depth and visually inspecting the pond embankments for slumping, movement, or seepage. The pond depth measurements will be checked against the freeboard requirements.

- Weekly Inspections

  Weekly inspections consist of checking the perimeter game-proof fence and restricted area signs, checking the pond inlet piping, making underdrain measurements, checking the pond enhanced evaporation system (if installed), visually inspecting the liner, and measuring the vertical depth of fluid in the pond underdrain standpipes. During periods of seismic activity, flooding, severe rainfall, or other event that could cause the pond to leak, underdrain measurements will be taken daily and recorded.

- Monthly Inspections

  During monthly inspections, the waste piping from the plant building to the ponds will be visually inspected for signs of seepage indicating a possible pipeline break. Diversion channels surrounding the ponds will be examined for channel bank erosion, obstruction to flow, undesirable vegetation, or any other unusual conditions.

- Quarterly Inspections

  Quarterly inspections will check for embankment settlement and for irregularities in alignment and variances from originally constructed slopes (i.e., sloughing, toe movement, surface cracking or erosion). Embankments will be inspected for any evidence of seepage, erosion, and any changes to the upstream watershed areas that could affect runoff to the ponds. Emergency lines will be inspected to ensure that the rope has not deteriorated and the ropes reach to the pond water level.

- Annual Inspection

  A technical evaluation of the pond system will be done annually which addresses the hydraulic and hydrologic capacities of the ponds and ditches and the structural stability of the embankments. A survey of the pond embankments will be done on an annual basis and the survey results documented and incorporated into the annual inspection report. The survey will be reviewed for evidence of embankment settlement, irregularities in embankment alignment, and any changes in the originally constructed slopes. The technical evaluation will be the result of an annual inspection and a review of the weekly, monthly, and quarterly

inspection reports by a professional engineer registered in the State of Nebraska. Examination of the pond monitor well sampling data will also be reviewed for signs of seepage in the embankments. The inspection report will present the results of the technical evaluation and the inspection data collected since the last report. The report will be kept on file at the site for review by regulatory agencies. A copy will also be submitted to the NRC.

- Pond Leak Corrective Actions

  If six inches or more of fluid is present in the standpipes, the contents will be analyzed for specific conductance. If the water quality in the standpipe is degraded beyond the action level, the water will be further sampled for chloride, alkalinity, sodium, and sulfate. The action level is defined as a specific conductivity of the fluid of the standpipe that is 50 % of the specific conductivity of the pond contents.

  If there is an abrupt increase in both the vertical fluid depth of a standpipe and the specific conductance of the fluid of the standpipe, the liner will be immediately inspected for liner damage. Abnormal increases of these two indicators confirm a potential liner leak and agency reporting (i.e., NRC and NDEQ) will be required.

  Upon verification of a liner leak, the fluid level will be lowered by transferring the cell's contents to the other cell. Water quality in the affected standpipes will be analyzed for the five parameters listed above once every seven days during the leak period, and once every seven days for at least two weeks following repairs.

4.2.1.2 Potential Pollution Events Involving Liquid Waste

Although there are a number of potential sources of pollution present at the Crow Butte facility, existing regulatory requirements from the NRC and NDEQ and provisions of the CBR SHEQ MS have established a framework that significantly reduces the possibility of an occurrence. Extensive training of all personnel is standard policy at the existing Crow Butte facility and will be implemented at the North Trend Satellite Facility. Frequent inspections of waste management facilities and systems will be conducted. Detailed procedures are included in the CBR SHEQ MS Program, which will be adapted for use at the North Trend Satellite Facility.

Potential sources of pollution include the following:

4.2.1.2.1 Solar Evaporation Pond

The solar evaporation pond could contribute to a pollution problem in several ways. First, a pond could fail, either in a catastrophic fashion or as a result of a slow leak. In addition, a pond could overflow due to excess production or restoration flow, as well as due to the addition of rainwater.

With respect to a pond failure, all ponds will be built to NRC standards, and will be equipped with leak detection systems. Standard operating procedures will require a periodic inspection of all ponds, liners, and berms. The inspection program will be similar to the program currently implemented by CBR for the commercial ponds at the Central Plant. In the event of a leak, the contents of the pond cell can be transferred to the other pond cell while repairs are made.

With respect to pond overflow, operating procedures will be such that no individual pond cell is allowed to fill to a point where overflow is considered a realistic possibility. Since the primary disposal method will be deep disposal, the flow rate of liquids to the pond cells is expected to be minimal and there will be ample time to reroute the flow to another pond. Regarding the addition of rainwater, the freeboards of ponds considered "full" will be sufficient to contain the addition of significant quantities of rainwater before an overflow occurs. The inclusion of the freeboard allowance also precludes over-washing of the walls during high winds.

4.2.1.2.2 Wellfield Buildings and Piping

Wellfield buildings are not considered to be a potential source of pollutants during normal operations, as there will be no process chemicals or effluents stored within them. The only instance in which a wellfield building could contribute to pollution would be in the event of a release of injection or recovery solutions due to pipe failure. The possibility of such an occurrence is considered to be minimal as the piping will be leak checked before it is initially placed into service. Piping from the wellfields will generally be buried, minimizing the possibility of an accident. In addition, the flows through the wellfield piping will be monitored and will be at a relatively low pressure. Flow monitoring will provide alarms in the event of a significant piping failure which will allow flow to be stopped, preventing any significant migration of process fluids. Wellfield buildings will also be equipped with wet alarms for early detection of leaks.

4.2.1.2.3 Satellite Facility

The satellite facility will serve as a central hub for the mining operations in the North Trend Expansion Area. Therefore, the satellite facility has the greatest potential for spills or accidents resulting in the release of potential pollutants. Spills could result from a release of solutions due to a piping failure or a process storage tank failure.

The design of the satellite facility building will be such that any release of liquid waste would be contained within the structure. A concrete curb will be built around the entire process building. This pad will be designed to contain the contents of the largest tank within the building in the event of a rupture. In the event of a piping failure, the pump system will immediately shut down, limiting any release. Liquid inside the building, both from a spill or from washdown water, will be drained through a sump and sent to the liquid waste disposal system.

4.2.1.2.4 Deep Well Pumphouse and Wellhead

The design of the deep well pumphouse and wellhead will be such that any release of liquids will be contained within the building or in a bermed containment area surrounding the facilities. Liquid inside the building will be contained and managed as appropriate.

4.2.1.2.5 Transportation Vehicles

The release of pollutants to the environment could occur due to accidents involving transportation vehicles. This could involve either vehicles transporting ion exchange resin to and from the satellite facility to the Central Plant or transporting radioactive contaminated waste from the satellite facility to an approved disposal site.

All chemicals and products delivered to or transported from the satellite facility will be carried in DOT-approved packaging. In the event of an accident, procedures are currently in place in SHEQ MS Program Volume VIII, *Emergency Manual,* to insure a rapid response to the situation.

The uranium-loaded resin will be transported from the North Trend Satellite Plant to the Central Plant in a specially designed, low profile, 4,000-gallon capacity tanker trailer. The transport route is approximately 8.25 miles in length with the majority of the route following lightly traveled secondary roads. In the event of an accident, each resin transport vehicle will be equipped with an emergency contingency package whereby the

levels lower than those specified in NRC guidance[7]. An area will be maintained inside the restricted area boundary for storage of contaminated materials prior to their disposal.

4.2.2.3 Septic System Solid Waste

Domestic liquid wastes from the restrooms and lunchrooms will be disposed of in an approved septic system that meets the requirements of the State of Nebraska. Disposal of solid materials collected in septic systems must be performed by companies or individuals licensed by the State of Nebraska. NDEQ regulations for control of these systems are contained in Title 124[8].

4.2.2.4 Hazardous Waste

The potential exists for any industrial facility to generate hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). In the State of Nebraska, hazardous waste is governed by the regulations contained in Title 128[9]. Based on waste determinations conducted by CBR as required in Title 128, CBR is a Conditionally Exempt Small Quantity Generator (CESQG). To date CBR only generates universal hazardous wastes such as used waste oil and batteries. CBR recently estimated that the current operation generates approximately 1,325 liters of waste oil per year. CBR estimates that the proposed North Trend Satellite Facility would produce approximately 800 liters of waste oil per year. Waste oil is disposed of by a licensed waste oil recycler. CBR has management procedures in place in SHEQ MS Program Volume VI, *Environmental Manual,* to control and manage these types of wastes.

4.3 REFERENCES

[1] U.S. Nuclear Regulatory Commission, Regulatory Guide/CR-6733, *A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees* (September 2001).

[2] U. S. Nuclear Regulatory Commission, Regulatory Guide 8.31, *Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Reasonably Achievable* (Revision 1, May 2002).

[3] Nebraska Department of Environmental Quality, Title 119, *Rules and Regulations Pertaining to the Issuance of Permits under the National Pollutant Discharge Elimination System,* (May 2005).

[4] Nebraska Department of Environmental Quality, Title 122, *Rules and Regulations for Underground Injection and Mineral Production Wells* (April 2002).

[5] U. S. Nuclear Regulatory Commission, Regulatory Guide 3.11, *Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities* (Revision 3, November 2008).

[6] U. S. Nuclear Regulatory Commission, Regulatory Guide 3.11.1, *Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mill Tailings* (Revision 1, October 1980).

[7] U. S. Nuclear Regulatory Commission, *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for By-Product, Source or Special Nuclear Material* (May 1987).

[8] Nebraska Department of Environmental Quality, Title 124, *Rules and Regulations for the Design, Operation, and Maintenance of On-site Wastewater Treatment Systems,* (May 2005).

[9] Nebraska Department of Environmental Quality, Title 128, *Nebraska Hazardous Waste Regulations,* (January 2007).

Red-line Version of Replacement Pages

4.1.1 Tank and Process Vessel Ventilation Systems

A separate ventilation system will be installed for all indoor non-sealed process tanks and vessels where radon-222 or process fumes would be expected. The system will consist of an air duct or piping system connected to the top of each of the process tanks having the potential to produce radon (i.e., up-flow IX columns, resin transfer tank, and wastewater tanks]. Redundant exhaust fans will direct collected gases to discharge piping that will exhaust fumes to the outside atmosphere by forced air ventilation. The design of the fans will be such that the system will be capable of limiting employee exposures with the failure of any single fan. Discharge stacks will be located away from building ventilation intakes to prevent introducing exhausted radon into the facility as recommended in Regulatory Guide 8.31[2]. Airflow through any openings in the vessels will be from the process area into the vessel and into the ventilation system, controlling any releases that occur inside the vessel. Separate ventilation systems may be used as needed for the functional areas within the satellite plant.

A tank ventilation system of this type is utilized in the Central Processing Plant. Operational radiological in-plant monitoring for radon concentrations has proven this system to be an effective method for minimizing employee exposure.

4.1.2 Work Area Ventilation System

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4.1.2.1 Ventilation System at Current CBR Operating Facility

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During favorable weather conditions, open doorways and convection vents in the roof assist in providing satisfactory work area ventilation. The design of the ventilation system is adequate to ensure that radon daughter concentrations in the facility are maintained below 25% of the derived air concentration (DAC) from 10 CFR Part 20.

Radon daughter monitoring results for the current processing facility for the year 2008 are show in **Table 4.1-1**. Monitoring is conducted monthly unless the results exceed an action limit of 25% of the DAC. If this action level is triggered, then weekly monitoring is required until four consecutive weeks of radon daughter concentrations are below the 25% level. The DAC is 0.333 Working Levels (WL) and 25% DAC is 0.08 WL. As can be seen in **Table 4.1-1**, the 25% action level and DAC were not exceeded in 2008. The method used to sample radon daughters is based on a simulated worst case scenario. All of the building doors are closed and time is allowed for the radon concentration to build up, if present. This is a very conservative estimate, because unless it is extremely cold, the doors are almost never completely closed. This enhances the building ventilation.

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4.1.2.2 North Trend Ventilation System

The ventilation system at the proposed North Trend Facilities would be similar to the ventilation system used at the current CBR operating facility. Exhaust fans would exhaust air within the building outside of the building, drawing fresh air in. These exhaust fans would be located at floor level to ensure areas where radon could accumulate are ventilated sufficiently to prevent radon accumulation. Storage tanks with the potential for radon emissions would also be vented to the outside of the building. Separate and independent local ventilation systems may be used temporarily as needed for non-routine activities such as maintenance. As discussed above for the current processing facility, radon daughter monitoring at the proposed North Trend satellite facility would be used to

- Daily Inspections

  Daily inspections consist of checking the pond depth and visually inspecting the pond embankments for slumping, movement, or seepage. The pond depth measurements will be checked against the freeboard requirements.

- Weekly Inspections

  Weekly inspections consist of checking the perimeter game-proof fence and restricted area signs, checking the pond inlet piping, making underdrain measurements, checking the pond enhanced evaporation system (if installed), visually inspecting the liner, and measuring the vertical depth of fluid in the pond underdrain standpipes. During periods of seismic activity, flooding, severe rainfall, or other event that could cause the pond to leak, underdrain measurements will be taken daily and recorded.

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  During monthly inspections, the waste piping from the plant building to the ponds will be visually inspected for signs of seepage indicating a possible pipeline break. Diversion channels surrounding the ponds will be examined for channel bank erosion, obstruction to flow, undesirable vegetation, or any other unusual conditions.

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  Quarterly inspections will check for embankment settlement and for irregularities in alignment and variances from originally constructed slopes (i.e., sloughing, toe movement, surface cracking or erosion). Embankments will be inspected for any evidence of seepage, erosion, and any changes to the upstream watershed areas that could affect runoff to the ponds. Emergency lines will be inspected to ensure that the rope has not deteriorated and the ropes reach to the pond water level.

- Annual Inspection

  A technical evaluation of the pond system will be done annually which addresses the hydraulic and hydrologic capacities of the ponds and ditches and the structural stability of the embankments. A survey of the pond embankments will be done on an annual basis and the survey results documented and incorporated into the annual inspection report. The survey will be reviewed for evidence of embankment settlement, irregularities in embankment alignment, and any changes in the originally constructed slopes. The technical evaluation will be the result of an annual inspection and a review of the weekly, monthly, and quarterly

inspection reports by a professional engineer registered in the State of Nebraska. Examination of the pond monitor well sampling data will also be reviewed for signs of seepage in the embankments. The inspection report will present the results of the technical evaluation and the inspection data collected since the last report. The report will be kept on file at the site for review by regulatory agencies. A copy will also be submitted to the NRC.

- Pond Leak Corrective Actions

  If six inches or more of fluid is present in the standpipes, the contents will be analyzed for specific conductance. If the water quality in the standpipe is degraded beyond the action level, the water will be further sampled for chloride, alkalinity, sodium, and sulfate. The action level is defined as a specific conductivity of the fluid of the standpipe that is 50 % of the specific conductivity of the pond contents.

  If there is an abrupt increase in both the vertical fluid depth of a standpipe and the specific conductance of the fluid of the standpipe, the liner will be immediately inspected for liner damage. Abnormal increases of these two indicators confirm a potential liner leak and agency reporting (i.e., NRC and NDEQ) will be required.

  Upon verification of a liner leak, the fluid level will be lowered by transferring the cell's contents to the other cell. Water quality in the affected standpipes will be analyzed for the five parameters listed above once every seven days during the leak period, and once every seven days for at least two weeks following repairs.

4.2.1.2 Potential Pollution Events Involving Liquid Waste

Although there are a number of potential sources of pollution present at the Crow Butte facility, existing regulatory requirements from the NRC and NDEQ and provisions of the CBR ~~Environmental, Health, and Safety Management System (EHSMS)~~ SHEQ MS have established a framework that significantly reduces the possibility of an occurrence. Extensive training of all personnel is standard policy at the existing Crow Butte facility and will be implemented at the North Trend Satellite Facility. Frequent inspections of waste management facilities and systems will be conducted. Detailed procedures are included in the CBR ~~EHSMS~~SHEQ MS Program, which will be adapted for use at the North Trend Satellite Facility.

Potential sources of pollution include the following:

4.2.1.2.1 Solar Evaporation Pond

The solar evaporation pond could contribute to a pollution problem in several ways. First, a pond could fail, either in a catastrophic fashion or as a result of a slow leak. In addition, a pond could overflow due to excess production or restoration flow, as well as due to the addition of rainwater.

With respect to a pond failure, all ponds will be built to NRC standards, and will be equipped with leak detection systems. Standard operating procedures will require a periodic inspection of all ponds, liners, and berms. The inspection program will be similar to the program currently implemented by CBR for the commercial ponds at the Central Plant. In the event of a leak, the contents of the pond cell can be transferred to the other pond cell while repairs are made.

With respect to pond overflow, operating procedures will be such that no individual pond cell is allowed to fill to a point where overflow is considered a realistic possibility. Since the primary disposal method will be deep disposal, the flow rate of liquids to the pond cells is expected to be minimal and there will be ample time to reroute the flow to another pond. Regarding the addition of rainwater, the freeboards of ponds considered "full" will be sufficient to contain the addition of significant quantities of rainwater before an overflow occurs. The inclusion of the freeboard allowance also precludes over-washing of the walls during high winds.

4.2.1.2.2 Wellfield Buildings and Piping

Wellfield buildings are not considered to be a potential source of pollutants during normal operations, as there will be no process chemicals or effluents stored within them. The only instance in which a wellfield building could contribute to pollution would be in the event of a release of injection or recovery solutions due to pipe failure. The possibility of such an occurrence is considered to be minimal as the piping will be leak checked before it is initially placed into service. Piping from the wellfields will generally be buried, minimizing the possibility of an accident. In addition, the flows through the wellfield piping will be monitored and will be at a relatively low pressure. Flow monitoring will provide alarms in the event of a significant piping failure which will allow flow to be stopped, preventing any significant migration of process fluids. Wellfield buildings will also be equipped with wet alarms for early detection of leaks.

4.2.1.2.3 Satellite Facility

The satellite facility will serve as a central hub for the mining operations in the North Trend Expansion Area. Therefore, the satellite facility has the greatest potential for spills or accidents resulting in the release of potential pollutants. Spills could result from a release of solutions due to a piping failure or a process storage tank failure.

The design of the satellite facility building will be such that any release of liquid waste would be contained within the structure. A concrete curb will be built around the entire process building. This pad will be designed to contain the contents of the largest tank within the building in the event of a rupture. In the event of a piping failure, the pump system will immediately shut down, limiting any release. Liquid inside the building, both from a spill or from washdown water, will be drained through a sump and sent to the liquid waste disposal system.

4.2.1.2.4 Deep Well Pumphouse and Wellhead

The design of the deep well pumphouse and wellhead will be such that any release of liquids will be contained within the building or in a bermed containment area surrounding the facilities. Liquid inside the building will be contained and managed as appropriate.

4.2.1.2.5 Transportation Vehicles

The release of pollutants to the environment could occur due to accidents involving transportation vehicles. This could involve either vehicles transporting ion exchange resin to and from the satellite facility to the Central Plant or transporting radioactive contaminated waste from the satellite facility to an approved disposal site.

All chemicals and products delivered to or transported from the satellite facility will be carried in DOT-approved packaging. In the event of an accident, procedures are currently in place in ~~EHSMS~~SHEQ MS Program Volume VIII, *Emergency Manual,* to insure a rapid response to the situation.

The uranium-loaded resin will be transported from the North Trend Satellite Plant to the Central Plant in a specially designed, low profile, 4,000-gallon capacity tanker trailer. The transport route is approximately 8.25 miles in length with the majority of the route following lightly traveled secondary roads. In the event of an accident, each resin transport vehicle will be equipped with an emergency contingency package whereby the

levels lower than those specified in NRC guidance[7]. An area will be maintained inside the restricted area boundary for storage of contaminated materials prior to their disposal.

4.2.2.3 Septic System Solid Waste

Domestic liquid wastes from the restrooms and lunchrooms will be disposed of in an approved septic system that meets the requirements of the State of Nebraska. Disposal of solid materials collected in septic systems must be performed by companies or individuals licensed by the State of Nebraska. NDEQ regulations for control of these systems are contained in Title 124[8].

4.2.2.4 Hazardous Waste

The potential exists for any industrial facility to generate hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). In the State of Nebraska, hazardous waste is governed by the regulations contained in Title 128[9]. Based on waste determinations conducted by CBR as required in Title 128, CBR is a Conditionally Exempt Small Quantity Generator (CESQG). To date CBR only generates universal hazardous wastes such as used waste oil and batteries. CBR recently estimated that the current operation generates approximately 1,325 liters of waste oil per year. CBR estimates that the proposed North Trend Satellite Facility would produce approximately 800 liters of waste oil per year. Waste oil is disposed of by a licensed waste oil recycler. CBR has management procedures in place in ~~EHSMS~~SHEQ MS Program Volume VI, *Environmental Manual,* to control and manage these types of wastes.

4.3 REFERENCES

[1] U.S. Nuclear Regulatory Commission, Regulatory Guide/CR-6733, *A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licensees* (September 2001).

[2] U. S. Nuclear Regulatory Commission, Regulatory Guide 8.31, *Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Reasonably Achievable* (Revision 1, May 2002).

[3] Nebraska Department of Environmental Quality, Title 119, *Rules and Regulations Pertaining to the Issuance of Permits under the National Pollutant Discharge Elimination System,* (May 2005).

[4] Nebraska Department of Environmental Quality, Title 122, *Rules and Regulations for Underground Injection and Mineral Production Wells* (April 2002).

[5] U. S. Nuclear Regulatory Commission, Regulatory Guide 3.11, *Design, Construction, and Inspection of Embankment Retention Systems at Uranium Recovery Facilities* (Revision 3, November 2008).

[6] U. S. Nuclear Regulatory Commission, Regulatory Guide 3.11.1, *Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mill Tailings* (Revision 1, October 1980).

[7] U. S. Nuclear Regulatory Commission, *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for By-Product, Source or Special Nuclear Material* (May 1987).

[8] Nebraska Department of Environmental Quality, Title 124, *Rules and Regulations for the Design, Operation, and Maintenance of On-site Wastewater Treatment Systems,* (May 2005).

[9] Nebraska Department of Environmental Quality, Title 128, *Nebraska Hazardous Waste Regulations,* (January 2007).

Replacement Pages for Section 5
Operations

Replace All of Section 5, pages 5-1 through 5-60

Note: Red-line version located behind blue cover page after replacement pages

5 OPERATIONS

Crow Butte Resources, Inc. (CBR) operates a commercial scale in-situ leach uranium mine (the Crow Butte Uranium Project) near Crawford, Nebraska. Required NRC licenses and amendments, as well as surety agreements, are issued in the name of Crow Butte Resources, Inc. All CBR operations, including the Crow Butte Uranium Project operations, are conducted in conformance with applicable laws, regulations and requirements of the various regulatory agencies. The responsibilities described below have been designed to ensure compliance and further implement the CBR policy for providing a safe working environment with cost effective incorporation of the philosophy of maintaining radiation exposures as low as is reasonably achievable (ALARA).

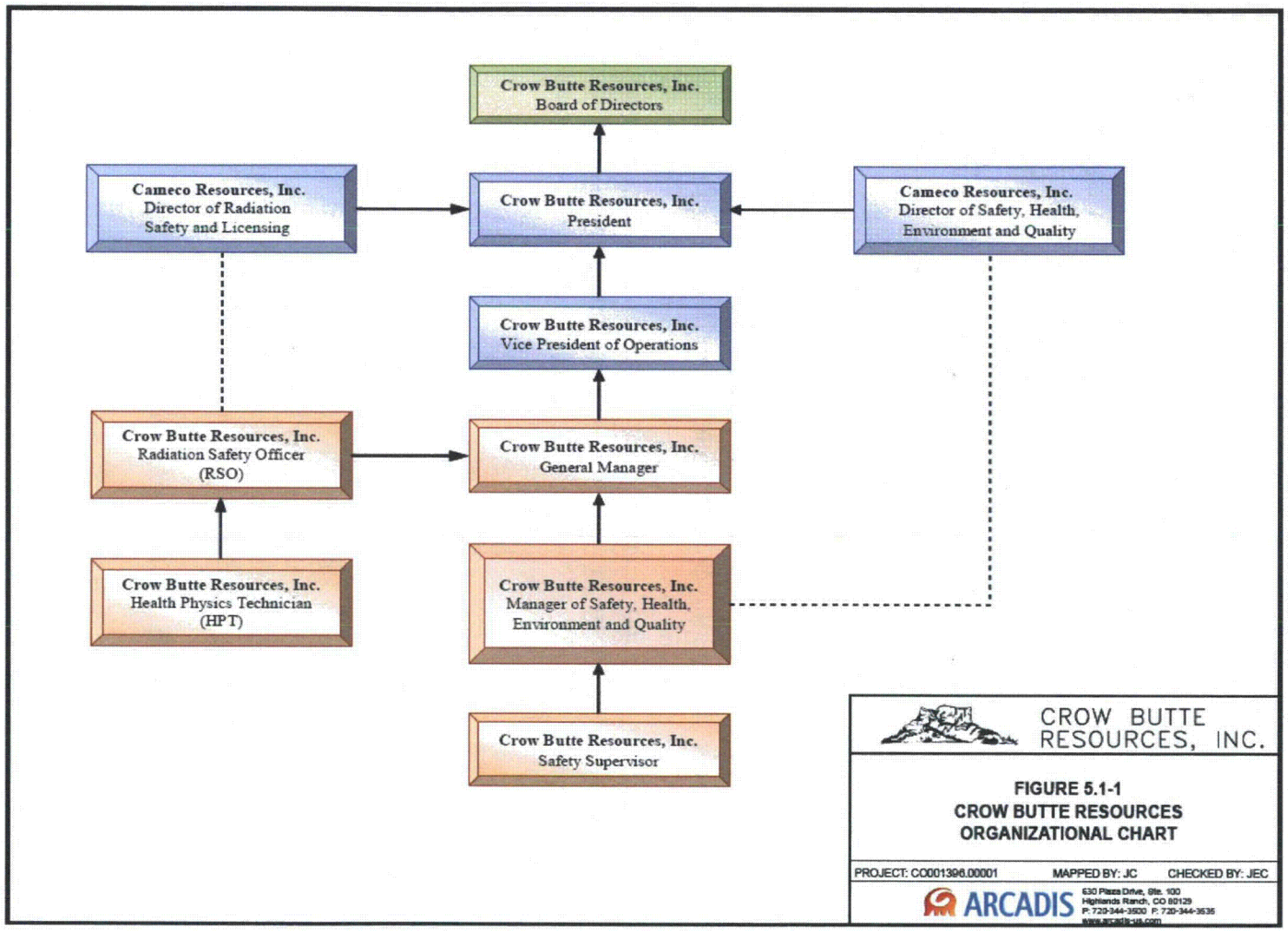
5.1 CORPORATE ORGANIZATION AND ADMINISTRATIVE PROCEDURES

CBR will maintain a performance-based approach to the management of the environment and employee health and safety, including radiation safety. The SHEQ MS Program encompasses licensing, compliance, environmental monitoring, industrial hygiene, and health physics programs under one umbrella, and it includes involvement for all employees from the individual worker to senior management. This SHEQ MS. will allow CBR to operate efficiently and maintain an effective environment, health and safety program.

Figure 5.1-1 is a partial organization chart for CBR with respect to the operation of the Crow Butte Uranium Project and associated operations and represents the management levels that play a key part in the SHEQ MS. The personnel identified are responsible for the development, review, approval, implementation, and adherence to operating procedures, radiation safety programs, environmental and groundwater monitoring programs as well as routine and non-routine maintenance activities. These individuals may also serve a functional part of the Safety and Environmental Review Panel (SERP) described under Section 5.2.3.

Specific responsibilities in the organization are provided below:

Figure 5.1-1: Crow Butte Resources Organizational Chart



5.1.1 Board of Directors

The Board of Directors for Crow Butte Resources, Inc. has the ultimate responsibility and authority for radiation safety and environmental compliance for CBR. The Board of Directors sets corporate policy and provides procedural guidance in these areas. The Board of Directors provides operational direction to the President of CBR.

5.1.2 President

The President of Crow Butte Resources, Inc. is responsible for interpreting and acting upon the Board of Directors policy and procedural decisions. The President directly supervises the Vice-President of Operations, the Director of Safety, Health, Environment and Quality (SHEQ) and the Director of Radiation Safety and Licensing. The President is empowered by the Board of Directors to have the responsibility and authority for the radiation safety and environmental compliance programs at the Crow Butte facility. The President is responsible for ensuring that CBR operations staff comply with all applicable regulations and permit/license conditions through direct supervision of the Vice President of Operations, the SHEQ Director and the Director of Radiation Safety and Licensing. The President has overall responsibility for approving the North Trend facility design including radiological controls (e.g., ventilation systems), and the manner in which the RSO is integrated into this process.

5.1.3 Vice President of Operations

The Vice President of Operations reports to the President and is directly responsible for ensuring that CBR personnel comply with industrial safety, radiation safety, and environmental protection programs as established in the SHEQ MS. The Vice President of Operations is also responsible for company compliance with all regulatory license conditions/stipulations, regulations and reporting requirements. The Vice President of Operations has the responsibility and authority to terminate immediately any activity that is determined to be a threat to employees or public health, the environment, or potentially a violation of state or federal regulations. The Vice President of Operations directly supervises the General Manager of Operations.

5.1.4 General Manager

The General Manager is responsible for all uranium production activity at the project site. The General Manager is also responsible for implementing any industrial and radiation safety and environmental protection programs associated with operations. The General Manager is authorized to immediately implement any action to correct or prevent hazards. The General Manager has the responsibility and the authority to suspend, postpone or modify, immediately if

necessary, any activity that is determined to be a threat to employees, public health, the environment, or potentially a violation of state or federal regulations. The General Manager cannot unilaterally override a decision for suspension, postponement or modification if that decision is made by the Vice President of Operations, the SHEQ Director, the SHEQ Manager, or the RSO. The General Manager reports directly to the Vice President of Operations.

5.1.5 Director Safety, Health, Environment and Quality

The SHEQ Director reports directly to the President and is responsible for ensuring the corporate personnel comply with industrial safety, radiation safety, and environmental protection programs as stated in the SHEQ MS. The SHEQ Director is also responsible for company compliance with all regulatory license conditions/stipulations, regulations and reporting requirements. The SHEQ Director has the responsibility and authority to terminate immediately any activity that is determined to be a threat to employees or public health, the environment, or potentially a violation of state or federal regulations as indicated in reports from the SHEQ Manager or the RSO.

5.1.5a Director of Radiation Safety and Licensing

The Director of Radiation Safety and Licensing reports directly to the President, is responsible for submitting quality permit and license applications to appropriate regulatory agencies and will manage the approval process. The position will also act as a resource to site SHEQ managers and ensure that permit conditions, agency responses, revisions, and, other Cameco SHEQ requirements are met. Additionally, this position will act as the corporate RSO and assists in the development and review of radiologic sampling and analysis and programs.

5.1.6 Safety, Health, Environment and Quality Manager

The SHEQ Manager is responsible for all radiation protection, health and safety, and environmental programs as stated in the SHEQ MS and for ensuring that CBR complies with all applicable regulatory requirements. This manger is responsible for the drafting, approving and updating SHEQ MS procedures on an annual basis. The SHEQ Manager reports directly to the General Manager to ensure that the radiation safety and environmental monitoring and protection programs are conducted in a manner consistent with regulatory requirements and the SHEQ MS. This position assists in the development and review of radiological and environmental sampling and analysis procedures and is responsible for routine auditing of the programs. The SHEQ Manager also has the responsibility and authority to suspend, postpone, or modify any activity that is determined to be a threat to employees, public health, the environment or potentially a violation of state or federal regulations. As such the SHEQ Manager has a secondary reporting requirement to the SHEQ Director. The SHEQ Manager has no production-related responsibilities.

5.1.7 Radiation Safety Officer

The RSO is responsible for the development, administration, and enforcement of all radiation safety programs, having sufficient authority for the development and administration of the radiation protection and ALARA program. The RSO is directly responsible for supervising the Health Physics Technician, for overseeing the day-to-day operation of the health physics program, and for ensuring records required by the NRC are maintained. The RSO has responsibility to review and approve plans for new equipment, process changes, or changes in operating procedures to ensure that the plans do not adversely affect the protection program against uranium and its daughters. The RSO is authorized to conduct inspections and to immediately order any change necessary to preclude or eliminate radiation safety hazards and/or maintain regulatory compliance. The RSO is responsible for the implementation of all on-site environmental programs, including emergency procedures. The RSO inspects facilities to verify compliance with all applicable requirements in the areas of radiological health and safety. The RSO works closely with all supervisory personnel to ensure that established programs are maintained. The RSO is also responsible for the collection and interpretation of employee exposure related monitoring, including data from radiological safety. The RSO makes recommendations to improve any and all radiological safety related controls. The RSO reports directly to the General Manager. The RSO, as a direct report to the General Manager, and through reporting lines shown in Figure 5.1.1, has both the responsibility and the authority to suspend, postpone, or modify any observed or planned work activity that is unsafe or potentially a violation of the NRC's regulations or license conditions, including the ALARA program. The RSO has no production-related responsibilities, maintaining independence from operations personnel. The RSO also has a secondary reporting requirement to the Director of Radiation Safety and Licensing.

Consistent with Regulatory Guide 8.31, the RSO may delegate radiation survey requirements to properly trained, experienced, plant personnel. Such personnel would be familiar with operations and received the necessary radiation safety training, including hands-on training (e.g., use of survey instruments for monitoring items removed from the restricted area) (see Section 5.8.6 for additional discussions).

5.1.8 Health Physics Technician

The Health Physics Technician (HPT) assists the RSO with the implementation of the radiological and industrial safety programs. The HPT is responsible for the orderly collection and interpretation of all monitoring data, to include data from radiological safety and environmental programs. The HPT reports directly to the RSO.

5.1.9 Safety Supervisor

The Safety Supervisor is responsible for the non-radiation related health and safety programs. The Safety Supervisor is authorized to conduct inspections and to immediately order any

change necessary to preclude or eliminate safety hazards and/or maintain regulatory compliance. Responsibilities include the development and implementation of health and safety programs in compliance with Occupational Safety and Health Administration (OSHA) regulations. Responsibilities of the Safety Supervisor include development of industrial safety and health programs and procedures, coordination with the RSO where industrial and radiological safety concerns are interrelated, safety and health training of new and existing employees, and the maintenance of appropriate records to document compliance with regulations. The Safety Supervisor may also be a qualified HPT and may function in that capacity when needed. The Safety Supervisor reports directly to the SHEQ Manager.

5.1.10 ALARA Program Responsibilities

The purpose of the ALARA program is to keep exposures to all radioactive materials and other hazardous material as low as possible and to as few personnel as possible, taking into account the state of technology and the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to the utilization of atomic energy in the public interest.

In order for an ALARA program to correctly function, all individuals including management, supervisors, health physics staff, and workers, must take part in and share responsibility for keeping all exposures as low as reasonably achievable. This policy addresses this need and describes the responsibilities of each level in the organization.

5.1.11 Management Responsibilities

Consistent with Regulatory Guide 8.31[1], CBR senior management is responsible for the development, implementation, and enforcement of applicable rules, policies, and procedures as directed by regulatory agencies and company policies. These responsibilities include the following:

1. The development of a strong commitment to and continuing support of the implementation and operations of the ALARA program;
2. An Annual Audit Program which reviews radiation monitoring results, procedural, and operational methods;
3. A continuing evaluation of the Health Physics Program including adequate staffing and support; and
4. Proper training and discussions that address the ALARA program and its function to all facility employees and, when appropriate, to contractors and visitors.

5.1.11.1 Radiation Safety Officer ALARA Responsibility

The RSO is responsible for ensuring the technical adequacy of the radiation protection program, implementation of proper radiation protection measures, and the overall surveillance and maintenance of the ALARA program. The RSO is assigned the following:

1. The responsibility for the development and administration of the ALARA program;
2. Enforcement of regulations and administrative policies that affect any radiological aspect of the SHEQ MS;
3. Assist with the review and approval of new equipment, process changes or operating procedures to ensure that the plans do not adversely affect the radiological aspects of the SHEQ MS;
4. Maintain equipment and surveillance programs to assure continued implementation of the ALARA program;
5. Assist with conducting an Annual ALARA Audit as discussed in Section 5.3.3, to determine the effectiveness of the program and make any appropriate recommendations or changes as may be dictated by the ALARA philosophy;
6. Review annually all existing operating procedures involving or potentially involving any handling, processing, or storing of radioactive materials to ensure the procedures are ALARA and do not violate any newly established or instituted radiation protection practices; and
7. Conduct (or designate a qualified individual to conduct) daily inspections of pertinent facility areas to observe that general radiation control practices, hygiene, and housekeeping practices are in line with the ALARA principle.

5.1.11.2 Supervisor Responsibility

Supervisors shall be the front line for implementing the ALARA program. Each supervisor shall be trained and instructed in the general radiation safety practices and procedures. Their responsibilities include:

1. Adequate training to implement the general philosophy behind the ALARA program;
2. Provide direction and guidance to subordinates in ways to adhere to the ALARA program;
3. Enforcement of rules and policies as directed by the SHEQ MS, which implement the requirements of regulatory agencies and company management; and
4. Seek additional help from management and the RSO should radiological problems be deemed by the supervisor to be outside their sphere of training.

5.1.11.3 Worker Responsibility

Because success of both the radiation protection and ALARA programs are contingent upon the cooperation and adherence to those policies by the workers themselves, the facility employees

must be responsible for certain aspects of the program in order for the program to accomplish its goal of keeping exposures as low as possible. Worker responsibilities include:

1. Adherence to all rules, notices, and operating procedures as established by management and the RSO through the SHEQ MS.;
2. Making valid suggestions which might improve the radiation protection and ALARA programs;
3. Reporting promptly, to immediate supervisor, any malfunction of equipment or violation of procedures which could result in an unacceptable increased radiological hazard;
4. Proper use of protective equipment; and
5. Proper performance of required contamination surveys.

5.2 MANAGEMENT CONTROL PROGRAM

5.2.1 Environment, Health and Safety Management System

CBR's SHEQ MS Program formalizes the Company's approach to environmental, health, and safety management to ensure a consistency across its operations. The SHEQ MS is a key element in assuring that all employees demonstrate "due diligence" in addressing environmental, health, and safety issues and describes how the operations of the facility will comply with the requirements of the CBR Safety, Health, Environment and Quality (SHEQ) Policy and regulatory requirements. The SHEQ Manager, with assistance from the RSO and Safety Supervisor, is responsible for drafting, approving, and updating (as needed) the SHEQ MS procedures on an annual basis. More frequent updates may be made if site activities and/or conditions warrant such actions.

The CBR SHEQ MS:

- Assures that sound management practices and processes are in place to ensure that strong EHS performance is sustainable;
- Clearly sets out and formalizes the expectations of management;
- Provides a systematic approach to the identification of issues and ensures that a system of risk identification and management is in place;
- Provides a framework for personal, site and corporate responsibility and leadership;
- Provides a systematic approach for the attainment of CBR's objectives; and
- Ensures continued improvement of programs and performance.

The SHEQ MS has the following characteristics:

- The system is certified to meet the ISO 14001 Environmental Management System Standard;

- The system is straightforward in design and is intended as an effective management tool for all types of activities and operations, and is capable of implementation at all levels of the organization;
- The system is supported by standards that clearly spell out CBR's expectations, while leaving the means by which these are attained as a responsibility of line management;
- The system is readily auditable; and
- The system is designed to provide a practical tool to assist the operations in identifying and achieving their EHS objectives while satisfying CBR's governance requirements.

The SHEQ MS uses a series of standards that align with specific management processes and sets out the minimum expectations for performance. The standards consist of management processes that require assessment, planning, implementation (including training, corrective actions, safe work programs, and emergency response), checking (including auditing, incident investigation, compliance management, and reporting), and management review. These standards meet the recommendations contained in USNRC Regulatory Guide 8.2[2]

5.2.1.1 Operating Procedures

CBR has developed procedures consistent with the corporate policies and standards and regulatory requirements to implement these management controls. The SHEQ MS consists of the following standards and operating procedures contained in eight volumes:

Volume 1 – *Standards*
Volume 2 – *Management Procedures*
Volume 3 – *Operating Manual* (SOPs)
Volume 4 – *Health Physics Manual*
Volume 5 – *Industrial Safety Manual*
Volume 6 – *Environmental Manual*
Volume 7 – *Training Manual*
Volume 8 – *Emergency Manual*

Written operating procedures have been developed for all process activities including those activities involving radioactive materials for the Crow Butte Uranium Project. Where radioactive material handling is involved, pertinent radiation safety practices are incorporated into the operating procedure. Additionally, written operating procedures have been developed for non-process activities including environmental monitoring, health physics procedures, emergency procedures, and general safety.

The procedures enumerate pertinent radiation safety procedures to be followed. A copy of the written procedure will be kept in the area where it is used. All procedures involving radiation safety will be reviewed and approved in writing by the RSO or another individual with similar

qualifications prior to being implemented. The RSO will also perform a documented review of the operating procedures annually.

5.2.1.2 Radiation Work Permits

In the case that employees are required to conduct activities of a nonroutine nature where there is the potential for significant exposure to radioactive materials and for which no operating procedure exists, a Radiation Work Permit (RWP) will be required. The RWP will describe the scope of the work, precautions necessary to maintain radiation exposures to ALARA, and any supplemental radiological monitoring and sampling to be conducted during the work. The RWP shall be reviewed and approved in writing by the RSO (or qualified designee in the absence of the RSO) prior to initiation of the work.

The RSO may also issue Standing Radiation Work Permits (SRWP's) for periodic tasks that require similar radiological protection measures (e.g., maintenance work on a specified plant system). The SRWP will describe the scope of the work, precautions necessary to maintain radiation exposures to ALARA, and any supplemental radiological monitoring and sampling to be conducted during the work. The SRWP shall be reviewed and approved in writing by the RSO (or qualified designee in the absence of the RSO) prior to initiation of the work.

5.2.1.3 Record Keeping and Retention

The SHEQ MS Volume II, *Management Procedures,* provides specific instructions for the proper maintenance, control, and retention of records associated with implementation of the program. The program is consistent with the requirements of 10 CFR 20 Subpart L and 10 CFR §40.61 (d) and (e). Records of surveys, calibrations, personnel monitoring, bioassays, transfers or disposal of source or byproduct material, and transportation accidents will be maintained on site until license termination. Records containing information pertinent to decommissioning and reclamation such as descriptions of spills, excursions, contamination events, etc., as well as information related to site and aquifer characterization and background radiation levels will be maintained on site until license termination. Duplicates of all significant records will be maintained in the corporate office or other offsite locations.

5.2.2 Performance Based License Condition

This license application is the basis of the Performance Based License (PBL) originally issued in 1998. Under that license CBR may, without prior NRC approval or the need to obtain a License Amendment:

1. Make changes to the facility or process, as presented in the license application (as updated);
2. Make changes in the procedures presented in the license application (as updated); and
3. Conduct tests or experiments not presented in the license application (as updated).

A License Amendment and/or NRC approval will be necessary prior to implementing a proposed change, test or experiment if the change, test or experiment would:

1. Result in any appreciable increase in the frequency of occurrence of an accident previously evaluated in the license application (as updated);
2. Result in any appreciable increase in the likelihood of occurrence of a malfunction of a structure, system, or component (SSC) important to safety previously evaluated in the license application (as updated);
3. Result in any appreciable increase in the consequences of an accident previously evaluated in the license application (as updated);
4. Result in any appreciable increase in the consequences of a malfunction of an SSC previously evaluated in the license application (as updated);
5. Create a possibility for an accident of a different type than any previously evaluated in the license application (as updated);
6. Create a possibility for a malfunction of an SSC with a different result than previously evaluated in the license application (as updated);
7. Result in a departure from the method of evaluation described in the license application (as updated) used in establishing the final safety evaluation report (FSER) or the environmental assessment (EA) or technical evaluation reports (TERs) or other analysis and evaluations for license amendments.
8. For purposes of this paragraph as applied to this license, SSC means any SSC that has been referenced in a staff SER, TER, EA, or environmental impact statement (EIS) and supplements and amendments thereof.

Additionally CBR must obtain a license amendment unless the change, test, or experiment is consistent with the NRC conclusions, or the basis of, or analysis leading to, the conclusions of actions, designs, or design configurations analyzed and selected in the site or facility SER, TERs, and EIS or EA. This would include all supplements and amendments, and TERs, EAs, and EISs issued with amendments to this license.

5.2.3 Safety and Environmental Review Panel

A Safety and Environmental Review Panel (SERP) will make the determination of compliance concerning the conditions discussed in Section 5.2.2. The SERP will consist of a minimum of three individuals. One member of the SERP will have expertise in management and will be responsible for managerial and financial approval for changes; one member will have expertise in operations and/or construction and will have expertise in implementation of any changes; and one member will be the RSO, or equivalent. Other members of the SERP may be utilized as appropriate, to address technical aspects of the change, experiment or test, in several areas, such as health physics, groundwater hydrology, surface water hydrology, specific earth sciences, and others. Temporary members, or permanent members other than the three identified above, may be consultants.

The SERP is responsible for monitoring any proposed change in the facility or process, making changes in procedures, and conducting tests or experiments not contained in the current NRC license. As such, they are responsible for insuring that any such change results in no degradation in the essential safety or environmental commitments of CBR.

5.2.3.1 Safety and Environmental Review Panel Review Procedures

The CBR SERP will implement the following review procedures for the evaluation of all appropriate changes to the facility operations as outlined in SHEQ MS. Volume II, *Management Procedures*. The SERP may delegate any portion of these responsibilities to a committee of two or more members of the SERP. Any committees so constituted will report their findings to the full SERP for a determination of compliance with Section 5.2.2 of this chapter. In their documented review of whether a potential change, test, or experiment (hereinafter called the change) is allowed under the PBL (or Performance Based License Condition (PBLC)) without a license amendment, the SERP shall consider the following:

- Current NRC License Requirements

The SERP will conduct a review of the most current NRC license conditions to assess which, if any, conditions will have an impact on or be impacted by the potential SERP action. If the SERP action will conflict with a specific license requirement, then a license amendment is necessary before initiating the change. This review includes information included in the approved license application.

- Ability to Meet NRC Regulations

The SERP will determine if the change, test, or experiment conflicts with applicable NRC regulations (example: 10 CFR Parts 20 and 40 requirements). If the SERP action conflicts with NRC regulations, a license amendment is necessary.

- Licensing Basis

The SERP will review whether the change, test, or experiment is consistent with NRC's conclusions regarding actions analyzed and selected in the licensing basis. Documents that the SERP must review in conducting this evaluation include the SER and EA prepared in support of the license renewal application (February 1998) and any SERs, TERs, EAs, or EISs prepared to support amendments to the license. The RSO will maintain a current copy of all pertinent documents for review by the SERP during these evaluations.

- Financial Surety

The SERP will review the proposed action to determine if any adjustment to financial surety arrangement or approved amount is required. If the proposed action will require an increase to the existing surety amount, the financial surety instrument must be increased accordingly before the change can be approved. The surety estimate must be updated either through a license amendment or through the course of the annual surety update to the NRC. The NRC incorporates the annual surety update by license amendment.

- Essential Safety and Environmental Commitments

The SERP will assure that there is no degradation in the essential safety or environmental commitment in the license application, or as provided by the approved reclamation plan.

5.2.3.2 Documentation of SERP Review Process

After the SERP conducts the review process for a proposed action, it will document its findings, recommendations, and conclusions in a written report format. All members of the SERP shall sign concurrence on the final report. If the report concludes that the action meets the appropriate PBL or PBLC requirements and does not require a license amendment, the proposed action may then be implemented. If the report concludes that a license amendment is necessary before implementing the action, the report will document the reasons why, and what course CBR plans to pursue. The SERP report shall include the following:

- A description of the proposed change, test, or experiment (proposed action);
- A listing of all SERP members conducting the review and their qualifications (if a consultant or other member not previously qualified);
- The technical evaluation of the proposed action, including all aspects of the SERP review procedures listed above;
- Conclusions and recommendations;
- Signatory approvals of the SERP members; and
- Any attachments such as all applicable technical, environmental, or safety evaluations, reports, or other relevant information including consultant reports.

All SERP reports and associated records of any changes made pursuant to the PBL or PBLC shall be maintained through termination of the NRC license.

On an annual basis, CBR will submit a report to the NRC that describes all changes, tests, or experiments made pursuant to the PBL or PBLC. The report will include a summary of the

SERP evaluation of each change. In addition, CBR will annually submit any pages of the license renewal application to reflect changes to the License Renewal Application or supplementary information. Each replacement page shall include both a change indicator for the area of change (e.g., bold marking vertically in the margin adjacent to the portion actually changed), and a page change identification (date of change or change number, or both).

5.3 MANAGEMENT AUDIT AND INSPECTION PROGRAM

The following internal inspections, audits and reports are performed for the Crow Butte Uranium Project operations. Similar activities will be performed for the North Trend Expansion Area.

5.3.1 Radiation Safety Inspections

5.3.1.1 Daily Inspections

The RSO, HPT or Lead Operator conducts a daily walkthrough inspection of the plant. In addition to the Lead Operator having been trained and having experience with the operating facilities, this position also has been trained and instructed in the general radiation safety practices and procedures described in Section 5.2.3. Daily inspections consist of a daily walk-through (visual) inspection of all work and storage areas of the facility to ensure proper implementation of good radiation safety procedures, including good housekeeping and cleanup practices that would minimize unnecessary contamination. The inspection entails a visual examination of compliance or other problems, which are reviewed with the Operations Manager.

5.3.1.2 Weekly RSO Inspections

On a weekly basis, the RSO and Operations Manager (or designee in their absence, such as the HPT, General Manager or Lead Operator) will conduct an inspection of all facility areas to observe general radiation control practices and review required changes in procedures and equipment. The results of the daily inspections are reviewed, and as needed, schedules are developed for addressing any identified corrective actions. Daily work-orders and shift logs are reviewed in order to determine that all jobs and operations with a potential for exposing personnel to uranium, especially those RWP jobs that would require a radiation survey and monitoring, were approved in writing by the RSO, the RSO's staff or the RSO's designee (e.g., HPT) prior to initiation of work.

5.3.1.3 Monthly RSO Reports

The RSO provides a written summary of the month's radiological activities at the Crow Butte Uranium Project facilities. The report includes a review of all monitoring and exposure data for the month, a summary of worker protection activities, a summary of all pertinent radiation survey records, a discussion of any trends in the ALARA program, and a review of adequacy of the implementation of NRC license conditions. Recommendations are made for any corrective actions or improvements in the process or safety programs.

5.3.2 Evaporation Pond Inspections

The inspection program developed by CBR for use on the ponds in the current production area are contained in SHEQ MS Volume VI, *Environmental Manual,* and is based on the guidance in USNRC Regulatory Guide 3.11.1[3]. The existing pond inspection program will be used as applicable as the basis for inspections on the NTEA evaporation pond. The inspection program is summarized below.

5.3.2.1 Daily Inspections

- Pond Depth - The depth of water in each pond is measured and recorded.
- Pond Embankments - The pond embankments are visually inspected for signs of cracking, slumping, movement or a concentration of seepage.

5.3.2.2 Weekly Inspections

- Perimeter Fence - The game-proof perimeter fence is inspected for holes that would allow animals to enter the pond area.
- Inlet Pipes – The pond inlet piping is inspected to verify that it is not clogged with ice, dirt, etc.
- Underdrain Measurements - The underdrains are measured and the vertical depth of fluid in the standpipe is recorded.
- Pond Sprays - When in use, the enhanced evaporation systems should be checked at regular intervals.
- Pond Liner - The liner is visually inspected weekly for holes or other signs of distress.
- Leak Detection System - The leak detection pipes for all ponds are measured for fluid in the standpipes and the vertical depth of the fluid shall be recorded on the Pond Inspection Forms.

5.3.2.3 Quarterly Inspections

- Embankment Settlement - The top of the embankments and downstream toe area are examined for settlement or depressions.
- Embankment Slopes - Embankment slopes are examined for irregularities in alignment and variances from originally constructed slopes (i.e., sloughing, toe movement, surface cracking or erosion).
- Seepage - Evidence of seepage in any areas surrounding the ponds (especially the downstream toes) is investigated and documented.
- Slope Protection - Vegetation on the out slopes of the pond is examined. Any evidence of rills or gullies forming is noted.
- Post-Construction Changes - Any changes to the upstream watershed areas that could affect runoff to the ponds is noted.
- Emergency lines are inspected to ensure that the rope has not deteriorated and the ropes reach to the pond water level.

5.3.2.4 Annual Inspection

A technical evaluation of the pond system will be done annually which addresses the hydraulic and hydrologic capacities of the ponds and ditches and the structural stability of the embankments. A survey of the pond embankments will be done on an annual basis and the survey results documented and incorporated into the annual inspection report. The survey is reviewed for evidence of embankment settlement, irregularities in embankment alignment, and any changes in the originally constructed slopes.

The technical evaluation will be the result of an annual inspection and a review of the weekly, monthly, and quarterly inspection reports by a professional engineer registered in Nebraska. Examination of the pond monitor well sampling data will also be reviewed for signs of seepage in the embankments.

The inspection report will present the results of the technical evaluation and the inspection data collected since the last report. The report will be kept on file at the site for review by regulatory agencies. A copy is also submitted to the NRC within one month of the annual inspection.

5.3.3 Annual ALARA Audits

CBR will conduct annual audits of the radiation safety and ALARA programs. The SHEQ Manager may conduct these audits. Alternatively, CBR may use qualified personnel from other uranium recovery facilities or an outside radiation protection auditing service to conduct these audits. The purpose of the audits is to provide assurance that all radiation health protection procedures and license condition requirements are being conducted properly at the Crow Butte Uranium Project facility. Any outside personnel used for this purpose will be qualified in

radiation safety procedures as well as environmental aspects of solution mining operations. Whether conducted internally or through the use of an audit service, the auditor will meet the minimum qualifications for education and experience as for the RSO as described in Section 5.4.

The audit of the radiation protection and ALARA program is conducted in accordance with the recommendations contained in Regulatory Guide 8.31. A written report of the results is submitted to corporate management. The RSO may accompany the auditor but

may not participate in the conclusions.

The annual ALARA audit report summarizes the following data:

1. Employee exposure records;
2. Bioassay results;
3. Inspection log entries and summary reports of mine and process inspections;
4. Documented training program activities;
5. Applicable safety meeting reports;
6. Radiological survey and sampling data;
7. Reports on any overexposure of workers; and
8. Operating procedures that were reviewed during this time period

The ALARA audit report specifically discusses the following:

1. Trends in personnel exposures;
2. Proper use, maintenance and inspection of equipment used for exposure control; and
3. Recommendations on ways to further reduce personnel exposures from uranium and its daughters.

The ALARA audit report is submitted to and reviewed by the President and General Manager. Implementations of the recommendations to further reduce employee exposures, or improvements to the ALARA program, are discussed with the ALARA auditor.

An audit of the Quality Assurance/Quality Control (QA/QC) program is also conducted on an annual basis. An individual qualified in analytical and monitoring techniques who does not have direct responsibilities in the areas being audited performs the audit. The results of the QA/QC audit are documented with the ALARA Audit. The RSO has the primary responsibility for the implementation of the radiological QA/QC programs at the Crow Butte Uranium Project facilities.

The RSO has the ultimate responsibility for ensuring that the NRC's radiological standards are being met at the North Trend site. The Lead Operator at the Satellite Facility or Wellfield operations would have the responsibility for responding to any spill requiring cleanup. Plant operators and wellfield operators, who have received spill response training, would conduct the cleanup operations.

The proposed management audit and inspection programs for the North Trend operations would be sufficient for the type of operations and number and type of employees. CBR has projected that the staffing level for the North Trend operations would be twelve full-time CBR staff members in order to staff 3 employees per 12-hour shifts (One lead Operator and two plant operators). These new employees will be needed for the satellite plant, wellfield operations and maintenance positions. Other staff members working out of the current CBR processing facility that would occasionally visit the North Trend Satellite Facility and associated wellfields would include the RSO, HPT, Safety Supervisor, SHEQ Manager, as well as various technical and managerial staff members.

5.4 HEALTH PHYSICS STAFF QUALIFICATIONS

CBR project staff is highly experienced in the management of uranium development, mining and operations. The following minimum personnel specifications and qualifications are strictly adhered to.

5.4.1 Radiation Safety Officer Qualifications

The minimum qualifications for the Radiation Safety Officer (RSO) are as follows:

- Education - A Bachelor's Degree in the physical sciences, industrial hygiene, environmental technology or engineering from an accredited college or university or an equivalent combination of training and relevant experience in uranium mill/solution mining radiation protection. As per Regulatory Guide 8.31, two years of relevant experience are generally considered equivalent to 1 year of academic study.
- Health Physics Experience - A minimum of 1 year of work experience relevant to uranium mill/solution mining operations in applied health physics, radiation protection, industrial hygiene or similar work.

- Specialized Training - A formalized, specialized course(s) in health physics specifically applicable to uranium milling/solution mining operations, of at least 4 weeks duration. The RSO attends refresher training on uranium mill health physics every two years.
- Specialized Knowledge - The RSO, through classroom training and on-the-job experience, possesses a thorough knowledge of the proper application and use of all health physics equipment used in the operation, the procedures used for radiological sampling and monitoring, methods used to calculate personnel exposures to uranium and its daughters, and a thorough understanding of the solution mining process and equipment used and how hazards are generated and controlled during the process.

5.4.2 Health Physics Technician Qualifications

The Health Physics Technician (HPT) will have one of the following combinations of education, training and experience:

1. Education (Option #1) – An associate degree or 2 years or more of study in the physical sciences, engineering or a health-related field,

   Training - At least a total of 4 weeks of generalized training (up to 2 weeks may be on-the-job training) in radiation health protection applicable to uranium mills/solution mining operations.

   Experience - One year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene, or industrial safety measures to be applied in a uranium mill/solution mining operation; or

2. Education (Option #2) - A high school diploma.

   Training - A total of at least 3 months of specialized training (up to 1 month may be on-the-job training) in radiation health protection relevant to uranium mills.

   Experience - Two years of relevant work experience in applied radiation protection.

5.5 RADIATION SAFETY TRAINING

All site employees and contractor personnel at the Crow Butte Uranium Project are administered a training program based upon the SHEQ MS covering radiation safety, radioactive material handling, and radiological emergency procedures. The CBR Training Program in SHEQ MS Volume VII, *Training Manual,* provides requirements for radiation safety training. The training program is administered in keeping with standard radiological

protection guidelines and the guidance provided in USNRC Regulatory Guide 8.29[4], USNRC Regulatory Guide 8.31, and USNRC Regulatory Guide 8.13[5]. The technical content of the training program is under the direction of the RSO. The RSO or a qualified designee conducts all radiation safety training. CBR will implement this training program for activities at the North Trend Expansion Area.

5.5.1 Training Program Content

5.5.1.1 Visitors

Visitors to the Crow Butte Uranium Project facilities who have not received training are escorted by on site personnel properly trained and knowledgeable about the hazards of the facility. At a minimum, visitors are instructed specifically on what they should do to avoid possible hazards in the area of the facilities that they are visiting.

5.5.1.2 Contractors

Any contractors having work assignments at the facilities are given appropriate radiological safety training. Contract workers who will be performing work on heavily contaminated equipment receive the same training normally required of Crow Butte workers as discussed in Section 5.5.1.3.

5.5.1.3 Crow Butte Resources Employees

All CBR employees (and some contractors as noted in Section 5.5.1.2) receive training as radiation workers. The program incorporates the following topics recommended in USNRC Regulatory Guide 8.31:

<u>Fundamentals of health protection</u>

- Using respirators when appropriate.
- Eating, drinking and smoking only in designated areas.
- Using proper methods for decontamination.

Facility-provided protection

- Cleanliness of working space.
- Safety designed features for process equipment.
- Ventilation systems and effluent controls.
- Standard operating procedures.
- Security and access control to designated areas.

Health protection measurements

- Measurements of airborne radioactive material.
- Bioassay to detect uranium (urinalysis and in vivo counting).
- Surveys to detect contamination of personnel and equipment.
- Personnel dosimetry.

Radiation protection regulations

- Regulatory authority of NRC, OSHA and state.
- Employee rights in 10 CFR Part 19.
- Radiation protection requirements in 10 CFR Part 20.

Emergency procedures

All new workers, including supervisors, are given specialized instruction on the health and safety aspects of the specific jobs they will perform. This instruction is done in the form of individualized on-the-job training. Retraining is performed annually and documented.

5.5.2 Testing Requirements

A written test with questions directly relevant to the principals of radiation safety and health protection in the facility covered in the training course is given to each worker. The instructor reviews the test results with each worker and discusses incorrect answers to the questions with

the worker until worker understanding is achieved. Workers who fail the exam are retested and test results remain on file.

5.5.3 On-The-Job Training

5.5.3.1 Health Physics Technician

On-the-job training is provided to HPT's in radiation exposure monitoring and exposure determination programs, instrument calibration, plant inspections, posting requirements, respirator programs and Health Physics Procedures contained in SHEQ MS Volume IV, *Health Physics Manual.*

5.5.4 Refresher Training

Following initial radiation safety training, all permanent employees and long-term contractors receive ongoing radiation safety training as part of the annual refresher training and, if determined necessary by the RSO, during monthly safety meetings. This ongoing training is used to discuss problems and questions that have arisen, any relevant information or regulations that have changed, exposure trends and other pertinent topics.

5.5.5 Training Records

Records of training are kept until license termination for all employees trained as radiation workers (i.e., occupationally-exposed employees).

5.6 SECURITY

CBR security measures for the current operation are specified in the Security Plan and Security Threat chapter in Volume VIII, *Emergency Manual.* Crow Butte Resources, Inc. CBR is committed to:

- Providing employees with a safe, healthful, and secure working environment;
- Maintaining control and security of NRC licensed material;
- Ensuring the safe and secure handling and transporting of hazardous materials; and
- Managing records and documents that may contain sensitive and confidential information.

The NRC requires licensees to maintain control over licensed material (i.e., natural uranium ("source material") and byproduct material defined in 10 CFR §40.4). 10 CFR 20, Subpart I, *Storage and Control of Licensed Material*, requires the following:

§20.1801 Security of Stored Material
The licensee shall secure from unauthorized removal or access licensed materials that are stored in controlled or unrestricted areas.

§20.1802 Control of Material Not in Storage

The licensee shall control and maintain constant surveillance of licensed material that is in a controlled or unrestricted area and that is not in storage.

Stored licensed material at the Crow Butte Central Processing Plant would include uranium packaged for shipment from the facility or byproduct materials awaiting disposal. Examples of material not in storage would include yellowcake slurry or loaded ion exchange resin removed from the restricted area for transfer to other areas.

At the North Trend Expansion Area, licensed stored material would typically include loaded ion exchange resin and byproduct waste awaiting disposal. Lixiviant would be found in production piping in the well field and well field house, production trunkline to the Satellite Facility, and within piping located in the satellite building. Loaded ion exchange resin would be placed in a transport truck and temporarily stored in the vehicle until the truck is filled and ready for delivery to the Crow Butte Central Processing Plant.

5.6.1 License Area and Plant Facility Security

5.6.1.1 Current Central Processing Facility Area

The active mining areas are controlled with fences and appropriate signs. All central processing facility areas where source or byproduct material is handled are fenced. The main access road is equipped with a locking gate. Strategically placed surveillance cameras monitor the access road and areas around the central processing facility. A 24-hour per day 7-day per week staff is on duty in the central processing facility.
Central plant operators perform an inspection to ensure the proper storage and security of licensed material at the beginning of each shift. The inspection determines whether all licensed material is properly stored in a restricted area Figure 2.1-2) or, if in controlled or unrestricted areas, is properly secured. In particular, operators ensure that loaded ion exchange resin, slurry, drummed yellowcake, and byproduct material is properly secured. If licensed material is found outside a restricted area, the operator will ensure that it is secured, locked, moved to a restricted area, or kept under constant surveillance by direct observation by site personnel or surveillance cameras. The results of this inspection will be properly documented.

5.6.1.2 Office Building

There is a reception area located at the main entrance into the office building. All other entrances are locked during off-shift hours. There are a limited number of traceable keys to the office and they are given out to select employees. The main door and the door to the central plant facility entrance are also equipped with an access keypad.

Visitors entering the office are greeted by the receptionist and announced to the receiving person. All visitors are required to sign the access log and indicate the purpose of their visit and the employee to be visited. The person being visited is responsible to supervise the visitors at all times when they are on site. Visitors are only allowed at the facility during regular working hours unless prior approval is obtained from the Mine Manager or the SHEQ Manager.

5.6.2 North Trend Security

The entrance to the North Trend Expansion Area site will be from a gravel road to the south of the facility. The entrance to the site will be posted indicating that permission is required prior to entry. A gate on the access route will be capable of being locked. The satellite plant site within the license area will be properly posted in accordance with 10 CFR § 20.1902 (e). Evaporation ponds will be fenced and posted.

The security fence surrounding the North Trend Satellite Facility serves as a control for industrial/property protection purposes, with the restricted areas as required by 10 CFR 20 noted in red in Figures 2.3-1 and 3.2-1. The area within the security fencing surrounding the evaporation ponds will be a designated restricted area as per 10 CFR 20 (Figure 3.2-1). Access to wellfields will have area fencing that will serve as a control for industrial/property protection purposes. Appropriate signage will be placed on all fencing advising of access restrictions.

Restricted area at the North Trend Satellite Facility refers to *"...an area where access to is limited by the licensee for the purpose of protecting individuals against undue risks from exposure to radiation and radioactive materials"* (10 CFR 20.1003). Proposed restricted areas for the North Trend Satellite Facility are shown in Figures 2.1-3 and 3.2-1. Each radiation area will be posted with a conspicuous sign or signs bearing the radiation symbol and the words "CAUTION, RADIATION AREA" (10 CFR 20.1902). Radiological warnings are posted based upon actual or likely conditions. Actual conditions are determined through area monitoring. Likely conditions are identified based on professional judgment or experience regarding the probability that a radiological condition will exist. When evaluating the likelihood of specific conditions, normal situations as well as unique situations that can reasonably be expected to occur will be considered.

All visitors, contractors, inspectors, and new employees entering the North Trend Expansion Area site will be required to register at the plant office and will not be permitted inside the plant or wellfield areas without proper authorization. All visitors needing safety equipment, such as hardhat and safety glasses, will be issued the items by company personnel. Inexperienced visitors will be escorted within the controlled area of the facility unless they are frequent visitors who have been instructed regarding the potential hazards in various site areas. All appropriate and necessary safety or radiological training will be provided and documented by the Radiation Safety Officer or designee. Training requirements associated with visitors and contractors are discussed in Section 5.5.

The satellite plant will routinely operate 24 hours per day and 7 days per week, so CBR employees will normally be on-site except for occasional shutdowns. The Satellite Plant structure will be equipped with locks to prevent unauthorized access. All plant personnel are instructed to immediately report any unauthorized persons to their supervisors. The supervisor will contact the reported unauthorized person and make sure that they have been authorized for entry. If the person is unauthorized, and has no business on the property, they will be escorted to the main entrance for departure.

Access by unauthorized personnel to the stored and non-stored licensed materials (pregnant lixiviant solution, loaded ion exchange resin and By-product material awaiting disposal) would be controlled by perimeter access gates with locks and site personnel. This would include piping, process vessels, tankage, and any truck vehicle containing loaded ion exchange resin and parked within or near the Satellite Facility building.

Wellfield houses where pregnant lixiviant solutions would be present in the production piping would be kept locked. Only authorized personnel would have keys to the wellfield houses. The production trunk line conveying pregnant lixivant from the wellfield houses to the satellite building would be located within an area within perimeter fencing that only authorized personnel would be allowed to enter. Gates associated with perimeter fencing enclosing any well field that is in operation would be kept locked when operators and workers are not present (e.g., remote from the satellite facility). Security may further be increased by installing continuous video surveillance of outside areas.

CBR maintains and enforces requirements of the SHEQ MS Volume *IV, Health Physics Manual*, that specifies access controls and security issues applicable to visitors, contractors and employees, radiological posting, and radiological survey and monitoring requirements associated with activities at the site.

Even without consideration of reduced exposures due to the security measures discussed above, the highest estimated total effective dose equivalent (TEDE), as determined using methods described in Section 7.3.3, for a downwind receptor near the North Trend Expansion Area is 5.8 mrem/year. This is based on an occupancy factor of 100% or 8760 hours per year. If the frequent visitor were onsite for 2000 hours per year (a full work year) and exposed to the same

sources of radiation as the highest downwind receptor, the visitor would receive an annual dose of 1.2 mrem per year. It is unlikely that even frequent visitors to the North Trend Expansion area could receive annual doses near the 100 mrem public dose limit.

5.6.3 Transportation Security

CBR routinely receives, stores, uses, and ships hazardous materials as defined by the U.S. Department of Transportation (DOT). In addition to the packaging and shipping requirements contained in the DOT Hazardous Materials Regulations (HMR), 49 CFR 172, Subpart I, *Security Plans*, requires that persons that offer for transportation or transport certain hazardous materials develop a Security Plan. Shipments may qualify for this DOT requirement under the following categories:

> §172.800(b)(4) A shipment of a quantity of hazardous materials in a bulk package having a capacity equal to or greater than 13,248 L (3,500 gallons) for liquids or gases or more than 13.24 cubic meters (468 cubic feet) for solids;
>
> §172.800(b)(5) A shipment in other than a bulk packaging of 2,268 kg (5,000 pounds) gross weight or more of one class of hazardous material for which placarding of a vehicle, rail car, or freight container is required for that class under the provisions of subpart F of this part;
>
> §172.800(b)(7) A quantity of hazardous material that requires placarding under the provisions of subpart F of this part.

DOT requires that Security Plans assess the possible transportation security risks and evaluate appropriate measures to address those risks. All hazardous materials shippers and transporters subject to these standards must take measures to provide personnel security by screening applicable job applicants, prevent unauthorized access to the hazardous materials or vehicles being prepared for shipment, and provide for en route security. Companies must also train appropriate personnel in the elements of the Security Plan.

Transport of licensed/hazardous material by CBR employees will generally be restricted to moving ion exchange resin from a satellite facility to the central processing facility or transferring contaminated equipment between company facilities. This transport generally occurs over short distances through remote areas. Therefore, the potential for a security threat during transport by CBR vehicle is minimal. The goal of the driver, cargo, and equipment security measures is to ensure the safety of the driver and the security and integrity of the cargo from the point of origin to the final destination by:

- Clearly communicating general point-to-point security procedures and guidelines to all drivers and non-driving personnel;

- Providing the means and methods of protecting the drivers, vehicles, and customer's cargo while on the road; and
- Establishing consistent security guidelines and procedures that shall be observed by all personnel.

For the security of all tractors and trailers, the following will be adhered to:

- If material is stored in the vehicle, access must be secured at all openings with locks and/or tamper indicators;
- Off site tractors will always be secured when left unattended with windows closed, doors locked, the engine shut off, and no keys or spare keys in or on the vehicle;
- The unit is to be kept visible by an employee at all times when left unattended outside a restricted area.

The security guidelines and procedures apply to all transport assignments. All drivers and non-driving personnel are expected to be knowledgeable of, and adhere to, these guidelines and procedures when performing any load-related activity.

5.7 RADIATION SAFETY CONTROLS AND MONITORING

CBR has a strong corporate commitment to and support for the implementation of the radiological control program at the Crow Butte Uranium Project facilities. This corporate commitment to maintaining personnel exposures as low as reasonably achievable (ALARA) has been incorporated into the radiation safety controls and monitoring programs described in the following sections.

5.7.1 Effluent Control Techniques

5.7.1.1 Gaseous and Airborne Particulate Effluents

Under routine operations, the only radioactive effluent at the North Trend satellite plant facility will be the release of radon-222 gas from the production solutions. Elution and processing of uranium product will be performed at the central plant, where a vacuum dryer is used for drying the yellowcake product. Therefore, there will be no airborne particulate effluent from the North Trend Satellite Plant.

The radon-222 is found in the pregnant lixiviant that comes from the wellfield into the North Trend Satellite Plant. The production flow will be directed to the satellite plant process building for separation of the uranium. The uranium will be separated by passing the recovery solution through pressurized downflow ion exchange units. The vents from the individual vessels will be

connected to a manifold that will be exhausted outside the plant building through the plant stack.

Venting to the atmosphere outside of the plant building minimizes personnel exposure. Small amounts of radon-222 may be released in the satellite plant building during solution spills, filter changes, ion exchange resin transfer operations and maintenance activities. The satellite plant building will be equipped with exhaust fans to remove any radon that may be released in the building. No significant personnel exposure to radon gas is expected based on operating experience from similar facilities. Ventilation and effluent control equipment will be inspected for proper operation as recommended in USNRC Regulatory Guide 3.56[6]. Ventilation and effluent control equipment inspections will be conducted during radiation safety inspections as discussed in Section 5.3.1.

5.7.1.2 Liquid Effluents

The liquid effluents from the North Trend Satellite Plant can be classified as follows:

- Water generated during well development - This water is recovered groundwater and has not been exposed to any mining process or chemicals. The water will be discharged directly to a solar evaporation pond and silt, fines and other natural suspended matter collected during well development will settle out.

- Liquid process waste - The operation of the satellite facility results in one primary source of liquid waste, a production bleed stream. The production bleed will be disposed of in the solar evaporation pond or in a deep disposal well permitted under the Nebraska Department of Environmental Quality (NDEQ) Class I Underground Injection Control (UIC) Program.

- Aquifer restoration - Following mining operations, restoration of the affected aquifer commences which results in the production of wastewater. The current groundwater restoration plan consists of four activities: 1) Groundwater Transfer; 2) Groundwater Sweep; 3) Groundwater Treatment; and, 4) Wellfield Recirculation. Only the groundwater sweep and groundwater treatment activities will generate wastewater.

  During groundwater sweep, water would be extracted from the mining zone without injection causing an influx of baseline quality water to sweep the affected mining area. The extracted water must be sent to the wastewater disposal system during this activity, such as deep well disposal and/or onsite evaporation ponds. Historically Crow Butte has not used groundwater sweep, but this option could be used in the future if warranted. As has been the case with past operations at Crow Butte, it is anticipated that during restoration groundwater at the NTEA will be treated using ion exchange (IX) and reverse osmosis (RO). Using this method, there would be no water consumption

activities and only the bleed has to be dealt with for disposal, with the rest of the treated water being reinjected.

Groundwater treatment activities involve the use of process equipment to lower the ion concentration of the groundwater in the affected mining area. A reverse osmosis (RO) unit is typically used to reduce the total dissolved solids of the groundwater. The RO unit produces clean water (permeate) and brine. The permeate is normally injected into the formation but, under certain circumstances, may be disposed of in the wastewater disposal system. The brine is sent to the wastewater disposal system. There are no plans for land application as an alternate groundwater disposal option.

The existing NRC Source Materials License allows CBR to dispose of wastewater from the central plant by three methods:

- Evaporation from the evaporation ponds;
- Deep well injection; and
- Land application.

CBR proposes to handle liquid effluents from the North Trend Expansion Area using evaporation from evaporation ponds and deep well injection.

The design, installation and operation criteria for solar evaporation ponds are those found to be applicable in USNRC Regulatory Guide 3.11[7]. The pond will be membrane-lined with a leak detection system under the membrane. The pond will have the capability of being pumped for deep disposal well injection. The pond may also be pumped for water treatment prior to discharge under an NPDES land application permit. A variety of treatment options exist depending upon the specific chemical contaminants identified in the wastewater. In general, a combination of chemical precipitation and reverse osmosis is adequate to restore the water to a quality that falls within the NPDES parameters.

5.7.1.3 Spill Contingency Plans

The RSO is charged with the responsibility to develop and implement appropriate procedures to handle potential spills of radioactive materials. Personnel representing the engineering and operations functions of the Crow Butte Uranium Project facility will assist the RSO in this effort. Basic responsibilities include:

- Assignment of resources and manpower.
- Responsibility for materials inventory.

- Responsibility for identifying potential spill sources.
- Establishment of spill reporting procedures and visual inspection programs.
- Review of past incidents of spills.
- Coordination of all departments in carrying out goals of containing potential spills.
- Establishment of employee emergency response training programs.
- Responsibility for program implementation and subsequent review and updating.
- Review of new construction and process changes relative to spill prevention and control.

Spills can take two forms within an in-situ uranium mining facility: 1) surface spills such as tank failures, piping ruptures, transportation accidents, etc.; and 2) subsurface releases such as a well excursion, in which process chemicals migrate beyond the wellfield, or a pond liner leak resulting in a subsurface release of waste solutions.

Engineering and administrative controls are currently in place to prevent both surface and subsurface releases to the environment and to mitigate the effects should a release occur. Where appropriate, similar controls will be instituted for the North Trend Satellite Plant.

Supervisory personnel, as well as satellite facility and wellfield operators, receive spill response training for release of radiological and non-radiological materials. In the event of a spill, a designated supervisor (dependent upon location of spill) would take the lead, providing guidance and direction to the facility operators responding to the spill. Supervisory personnel take guidance and direction from the RSO, Safety Supervisor and SHEQ Manager, as applicable.

- <u>Surface Releases</u>

  Failure of process tanks - Potential failures of process tanks will be contained within the satellite building. The entire building will drain to a sump that will allow transfer of the spilled solutions to appropriate tankage or the evaporation pond.

  Surface Releases - The most common form of surface releases from in-situ mining operations occurs from breaks, leaks, or separations within the piping system that transfers mining fluids between the central plant and the wellfield. These are generally small releases due to engineering controls that detect pressure changes in the piping systems and alert the plant operators through system alarms.

In general, piping from the satellite plant to and within the wellfield will be constructed of PVC or high-density polyethylene (HDPE) pipe with butt welded joints or an equivalent. All pipelines will be pressure tested at operating pressures prior to operation. It is unlikely that a break would occur in a buried section of line because no additional stress is placed on the pipes. In addition, underground pipelines will be protected from vehicles driving over the lines, which could cause breaks. The only exposed pipes will be at the satellite process plant, the wellheads and in the wellhouses. Trunkline flows and wellhead pressures will be monitored for process control. Spill response is specifically addressed in the Radiological Emergencies and Emergency Reporting chapters of SHEQ MS. Volume VIII, *Emergency Manual.*

CBR's spill control programs have been very effective at limiting surface releases from mining operations. CBR has never had a spill that was reportable under 10 CFR 20 reporting requirements. All spills are analyzed for root causes and contributing factors. Periodically, the CBR SERP meets to analyze recent spill events and to determine whether engineering or administrative improvements are indicated to reduce the frequency and magnitude of spills.

- Releases Associated With Transportation

The Transportation Emergencies chapter of SHEQ MS. Volume VIII, *Emergency Manual,* provides the CBR emergency action plan for responding to a transportation accident involving a radioactive materials shipment. The chapter provides instructions for proper packaging, documentation, driver emergency and accident response procedures and cleanup and recovery actions. This chapter currently includes instructions that specifically address the CBR emergency action plan for responding to a transportation accident involving a shipment of eluent or ion exchange resin enroute to or from the Central Plant. Tanker trailers used for transportation of ion exchange resin between the North Trend satellite plant and the central plant will meet or exceed DOT and NRC requirements.

The worst-case transportation accident would involve a failure of the tanker, spilling the entire contents of uranium-loaded resin enroute to the central plant. The wet resin with the chemically bonded uranium would be confined to the immediate vicinity of the accident and would not become an airborne hazard. The close proximity of any accident to the central plant would ensure the rapid response of cleanup crews to contain and retrieve any spilled material.

- Sub-surface releases

Well Excursions - Mining fluids are normally maintained in the production aquifer within the immediate vicinity of the wellfield. The function of the encircling monitor well ring is to detect any mining solutions that may migrate away from the production

area due to fluid pressure imbalance. This system has been proven to function satisfactorily over many years of operating experience with in-situ mining.

At the North Trend Expansion Area site, an undetected excursion will be highly unlikely. A ring of perimeter monitor wells located no further than 300 feet from the wellfield and screened in the ore-bearing Chadron Aquifer will surround all wellfields. Additionally, shallow monitor wells will be placed in the first overlying aquifer above each wellfield segment. Sampling of these wells will be done on a biweekly basis. Past experience at the Crow Butte central plant and other in-situ leach mining facilities has shown that this monitoring system is effective in detecting lixiviant migration. The total effect of the close proximity of the monitor wells, the low flow rate from the well patterns, and over-production of leach fluids (production bleed) makes the likelihood of an undetected excursion extremely remote.

Migration of fluids to overlying aquifers has also been considered. Several controls are in place to prevent this. CBR will plug all exploration holes to prevent commingling of the Brule and Chadron aquifers and to isolate the mineralized zone. In addition, prior to placing a well in service, a well mechanical integrity test (MIT) will be performed. This requirement of the NDEQ UIC Program ensures that all wells are constructed properly and capable of maintaining pressure without leakage. Finally, monitor wells completed in the overlying aquifer will be sampled on a regular basis for the presence of leach solution.

Pond Liner Leak - Seepage of solutions from the evaporation ponds into ground or surface water is a potential release source. This has not been a problem at the Crow Butte central plant and should not be a problem at the North Trend Expansion Area ponds. Construction and operational safeguards will be implemented to insure maximum competency of the synthetic liner and earthen embankments. An underdrain leak detection system will allow sampling that would detect a leak. The pond soil foundation will have low ambient moisture due to its elevation, soil type and preparation. In the unlikely event of pond fluids seeping into the compacted subsoil, the liquid would be quickly absorbed and would not migrate. Pond monitor wells will be located downgradient in the uppermost aquifer to detect leaks.

In addition to the spills described above, the accumulation of sediment or erosion of existing soils can lead to potential releases of pollutants. The likelihood of significant sediment or erosion problems is greatest during construction activities. If rain, producing runoff, occurs during construction a small amount of the fill may be carried away from the construction area. Significant precipitation during pond and plant facility construction may also produce the same effect. Plant cover for erosion control will be established as soon as possible on exposed areas. Little additional suspendable material should be produced during mining operations and restoration activities. Site reclamation in the future with backfilling of ponds, grading the plant site, and replacing the topsoil will also expose unsecured soil for suspension in runoff waters.

The sediment load as a result of precipitation during future construction or reclamation activities should not significantly affect the quality of any watercourses since the projected satellite plant location is not crossed by any streams.

Runoff from precipitation events should be controlled to minimize any exposure to pollutants on the site. At the North Trend Expansion Area, runoff should not be a major issue, given the engineering design of the facilities, as well as engineering and administrative controls. Rainwater entering a pond leading to a pond overflow would be the greatest item of concern. The design and operation of the ponds will preclude a runoff-induced overflow as a realistic possibility. Should there be high runoff concurrent with a pipeline failure, some contamination could be spread depending upon the relative saturation of the soils beneath the leaking area. In any event, only minimal releases of solutions would occur in the event of a pipeline failure, and migration of pollutants due to runoff would be minimal.
As an adjunct to this approach, CBR will survey, remove and dispose field spill soils at levels greater than the 10 CFR Part 40, Appendix A, Criterion 6(6), with the unity rule applied where appropriate. This approach will reduce CBR decommissioning obligations and further mitigate the already limited contribution from field spills to offsite soil, vegetation and surface water contamination.

5.7.2 EXTERNAL RADIATION EXPOSURE MONITORING PROGRAM

5.7.2.1. Gamma Surveys

External gamma radiation surveys have been performed routinely at the Crow Butte Uranium Project and will be performed at the North Trend Satellite Plant. The required frequency is quarterly in designated Radiation Areas and semiannually in all other areas of the plant. Surveys will be performed at worker-occupied stations and areas of potential gamma sources such as tanks and filters. CBR establishes a Radiation Area if the gamma survey exceeds the action level of 5.0 mRem in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates. An investigation is performed to determine the probable source and survey frequency for areas exceeding 5.0 mRem per hour is increased to quarterly. Records are maintained of each investigation and the corrective action taken. If the results of a gamma survey identified areas where gamma radiation is in excess of levels that delineate a "Radiation Area", access to the area is restricted and the area is posted as required in 10 CFR §20.1902 (a). Designated Radiation Areas will be as defined in 10 CFR 20.1003: *Radiation area* means an area, accessible to individuals, in which radiation levels could result in an individual receiving a dose equivalent in excess of 0.005 rem (0.05 mSv) in 1 hour at 30 centimeters from the radiation source or from any surface that the radiation penetrates.

External gamma surveys are performed with survey equipment that meets the following minimum specifications:

1. Range - Lowest range not to exceed 100 microRoentgens per hour (μR/hr) full-scale with the highest range to read at least 5 milliRoentgens per hour (mR per hour) full scale; and

2. Battery operated and portable.

Examples of satisfactory instrumentation that meets these requirements are the Ludlum Model 3 survey meter with a Ludlum 44-38 probe or equivalent. Gamma survey instruments are calibrated at the manufacturer's suggested interval or at least annually and are operated in accordance with the manufacturer's recommendations. Instrument checks are performed each day that an instrument is used.

Gamma exposure rate surveys will be performed in accordance with the instructions currently contained in SHEQ MS. Volume IV, *Health Physics Manual.* Proposed survey locations for the North Trend Satellite Plant are shown on Figure 5.7-2. Gamma survey instruments will be checked each day of use in accordance with the manufacturer's instructions. Surveys are performed in accordance with the guidance contained in USNRC Regulatory Guide 8.30[8].

Beta surveys of specific operations that involve direct handling of large quantities of aged yellowcake are recommended in USNRC Regulatory Guide 8.30, Section 1.4 and are performed in accordance with the instructions currently contained in SHEQ MS. Volume IV, *Health Physics Manual.* Beta evaluations may be substituted for surveys using radiation survey instruments. Since elution, precipitation, and drying operations will be performed in the existing central plant, beta surveys should not be necessary at the North Trend Satellite Plant.

5.7.2.2 Personnel Dosimetry

10 CFR §20.1502 (a)(1) requires exposure monitoring for "Adults likely to receive, in 1 year from sources external to the body, a dose in excess of 10 percent of the limits in §20.1201 (a)". Ten percent of the dose limit would correspond to a Deep Dose Equivalent (DDE) of 0.500 Rem. Maximum individual annual exposures at the Crow Butte Uranium Project facilities since 1987 have been well below the limit, with a maximum individual external exposure of 495 mRem in 1995.

CBR determines monitoring requirements in accordance with the guidance contained in USNRC Regulatory Guide 8.34[9]. CBR believes that it is not likely that any employee working at the North Trend satellite plant will exceed 10 percent of the regulatory limit (i.e., 500 mrem/yr). Although monitoring of external exposure may not be required in accordance with §20.1201(a), CBR currently issues dosimetry to all process employees and exchanges them on a

quarterly basis. The North Trend process plant and wellfield operators would be included in this program.
Dosimeters are provided by a vendor that is accredited by National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology as required in 10 CFR § 20.1501. The dosimeters have a range of 1 mR to 1000 R. Dosimeters are exchanged and read on a quarterly basis.

Results from personnel dosimetry will be used to determine individual Deep Dose Equivalent (DDE) for use in determining Total Effective Dose Equivalent (TEDE) in accordance with the instructions currently contained in SHEQ MS. Volume IV, *Health Physics Manual.*

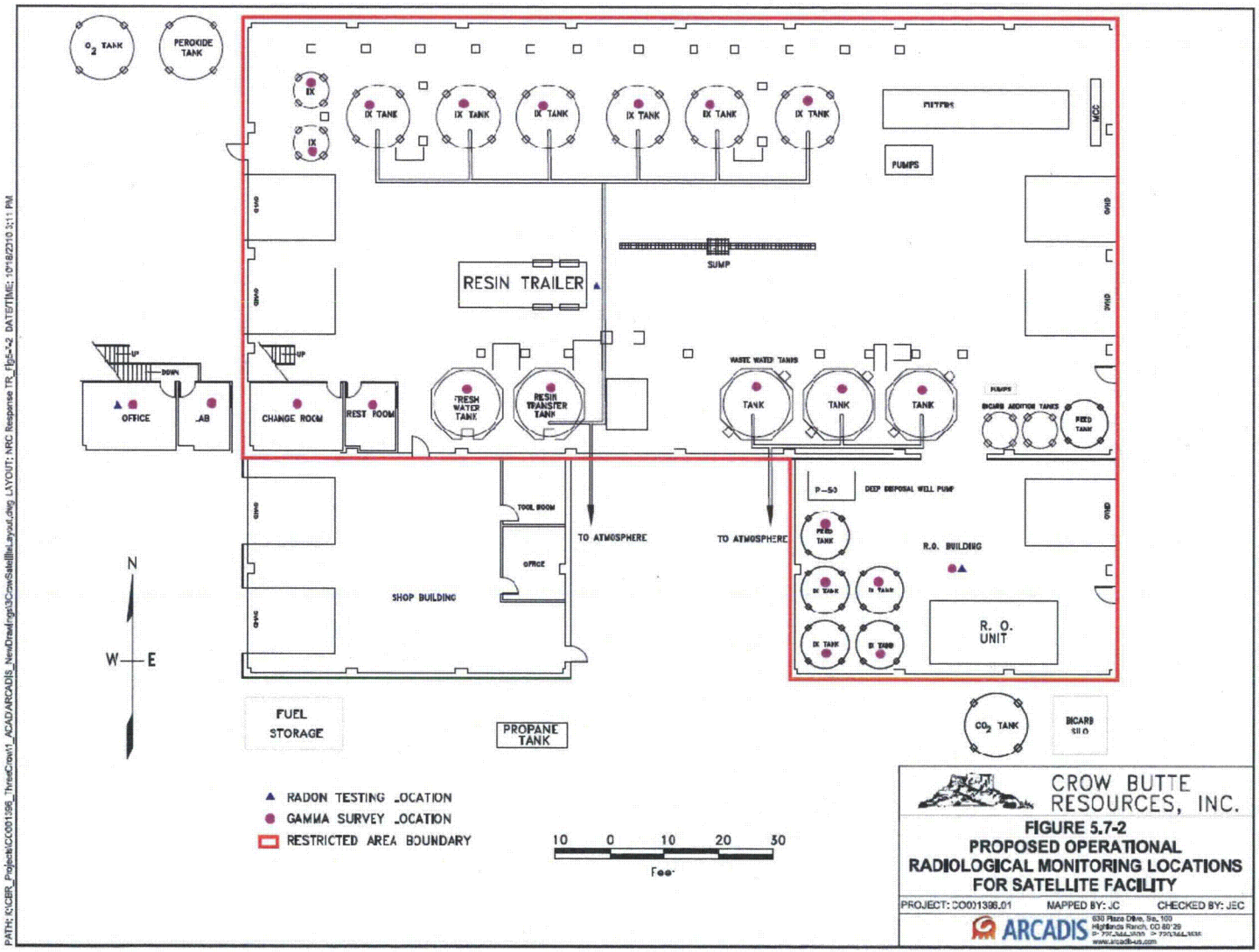
CBR has data for other external dose parameters such as Shallow Dose Equivalent (SDE) and Lens Dose Equivalent (LDE) for the existing site. As with the Deep Dose Equivalent (DDE) it can be shown that the external doses are all less than 10% of the applicable limits. Extremity monitoring is required when the dose to the extremity is higher than the dose to rest of the body. This would be applicable to beta doses associated with aged yellowcake sources as discussed in 5.7.2.1. The North Trend Expansion area will not have aged sources of yellowcake since it is frequently transferring the ion exchange resin to the central plant facility for further processing. There may be cases such as wellfield piping where Radium-226 has built up in pipe scale but in these cases the whole body DDE should be similar to the extremity dose.

Cumulative Exposures

Based on the proposed type of operations at the North Trend site (i.e., wet process) and historical exposures at the current operations, no significant increase in risks associated with exposure levels are expected for employees that work at the North Trend site and the current main operating plant. The North Trend operations would have a full-time staff that would be dedicated to working at that site. However, there may be some employees that would work at both locations for specified periods of time. Regardless of work locations, all CBR employees would be monitored for occupational external exposure if the exposure is likely to exceed 10% of the occupational dose limit appropriate for the individual (e.g., adult or declared pregnant woman), as specified in 10 CFR 20 1201 (a). As stated above, all wellfield and plant personnel at the North Trend operations would be included in the dosimetry program. The RSO would be responsible for determining the radiological monitoring requirements for all employees based on the facility radiation levels, worker job locations and tasks, and specific licensing requirements. The RSO would be responsible for reviewing the dosimetry results and comparing them with past data and regulatory exposure limits.

5.7.3 IN-PLANT AIRBORNE RADIATION MONITORING PROGRAM

The proposed airborne sampling location for the North Trend satellite facility is shown on Figure 5.7-2.. The location of the sampling points for radon, airborne uranium and gamma surveys are based on experience with similar equipment and operations at the current CBR operations. Factors that would be considered are the stage of the process (some areas more prone to exposure than others), potential known release points associated with the equipment and operations, and airflow patterns (based on current CBR operations). The sites selected are expected to have the highest potential for Figure 5.7-2 Proposed Operational Radiological Monitoring Locations for Satellite Facility releases of radiological contaminants (specific release points in the process and resin storage areas) and in areas where sampling would identify any elevated exposure levels due to inadvertent contamination (i.e., office, laboratory, change room and restroom). Sampling points of the process area are similar to other proposed satellite facilities. During the first year of operation, CBR will carry out a sampling program to assess the initial sampling locations and determine whether these locations provide measurements of the concentration representative of the concentration to which workers would be exposed.


O_2 TANK
PEROXIDE TANK
IX TANK
FILTERS
PUMPS
MCC
SUMP
RESIN TRAILER
WASTE WATER TANKS
TANK
FRESH WATER TANK
RESIN TRANSFER TANK
BICARB ADDITION TANKS
FEED TANK
OFFICE
LAB
CHANGE ROOM
REST ROOM
UP
DOWN
TOOL ROOM
OFFICE
SHOP BUILDING
TO ATMOSPHERE
P-53
DEEP DISPOSAL WELL PUMP
R.O. BUILDING
R. O. UNIT
N
W
E
FUEL STORAGE
PROPANE TANK
CO_2 TANK
BICARB SILO
RADON TESTING LOCATION
GAMMA SURVEY LOCATION
RESTRICTED AREA BOUNDARY
10 0 10 20 30
Feet
CROW BUTTE RESOURCES, INC.
FIGURE 5.7-2
PROPOSED OPERATIONAL
RADIOLOGICAL MONITORING LOCATIONS
FOR SATELLITE FACILITY
PROJECT: CO001396.01
MAPPED BY: JC
CHECKED BY: JEC
ARCADIS

The NTEA would be subject to requirements of CBR's SHEQ MS Volume III, Operating Manual, which has a section on the operation of the ventilation system.

Locations of sample points are based, in part, on a determination of airflow patterns in areas where monitoring is needed. Once the ventilation system is installed and operational, and prior to process operations, a portable anemometer would be used to assess the ventilation patterns (i.e., direction and velocity) in the work areas. Specific attention would be given to areas perceived as having a higher risk for releases. Assessments would be made of any different configurations that may be used for the ventilation system. The RSO would work with those designing the ventilation system in order to offer any suggestions to minimize worker exposure and to locate monitors at the most optimum locations, using experience from the current CBR operating facilities.

Once the final design has been completed, an assessment would be made by the RSO and operations staff as to the most optimum locations of radiological sampling points. Once the facility is constructed and operational, another assessment would be made of the sampling points and results, and a determination made as to the need for any changes to the monitoring points and frequency.

Monitoring locations and planned surveys would be consistent with USNRC Regulatory Guide 8.30. The airborne radiation monitoring program would allow for the determination of concentrations of airborne radioactive materials (including radon) during routine and non-routine operations, maintenance and cleanup. The controls and monitoring program will be sufficient to limit airborne radiation exposures and airborne radioactive releases to as low as reasonably achievable and is in conformance with regulatory requirement identified in 10 CFR Part 20.

5.7.3.1 Airborne Uranium Particulate Monitoring

Airborne particulate levels at solution mines that ship loaded ion exchange resin are normally very low since the product is wet. No precipitation, drying, or packaging of source material will be performed at the North Trend satellite facility. Yellowcake drying and packaging operations will be performed at the central facility. Therefore, the airborne uranium concentrations should be at or near local background levels. One location near the resin transfer station will be sampled monthly for airborne uranium particulates.
Area samples will be taken in accordance with the instructions currently contained in SHEQ MS. Volume IV, *Health Physics Manual.* The Air Monitoring Chapter implements the guidance contained in USNRC Regulatory Guide 8.25[10]. Samples will be taken with a glass fiber filter and a regulated air sampler such as an Eberline RAS-1 or equivalent. Sample volume will be adequate to achieve the lower limits of detection (LLD) for uranium in air. The LLD value for uranium in air would be $5e^{-11}$ uCi/ml, which is 10% of the DAC. Samplers will be calibrated at the manufacturer's suggested interval or semiannually with a digital mass flowmeter or other

primary calibration standard. Sampler calibration will be performed in accordance with the instructions currently contained in SHEQ MS. Volume IV, *Health Physics Manual.*

Breathing zone sampling is performed to determine individual exposure to airborne uranium during certain operations involving potential airborne exposure. Individual breathing zone monitoring may be required infrequently occur at times when engineering controls are impracticable or inoperable (non-routine operations). This would include maintenance activities (e.g., tank entry, disconnection of piping, repair of equipment such as pumps, etc.) that are required to maintain or regain control of normal production activities. A Radiation Work Permit (RWP) is required for such activities that involve the potential for significant exposure to radioactive materials and for which there are no SOPs. The RWPs dictate the proper type of breathing zone monitoring to be used and identifies procedures for protection against radiological hazards during the course of the work activity. There are certain SOPs that require individual monitoring, such as workers performing tasks such as transferring resin beads, changing the bicarbonate mix system filter media and changing deep disposal filter media.

Sampling is performed with lapel sampler or equivalent. The air filters are counted and compared to the DAC using the same method described for area sampling. Air samplers are calibrated at the manufacturer's recommended frequency or daily before each use using a primary calibration standard.

Measurement of airborne uranium will be performed by gross alpha counting of the air filters using an alpha scaler such as a Ludlum Model 2000 or equivalent. The Derived Air Concentration (DAC) for soluble (D classification) natural uranium of $5x10^{-10}$ μCi/ml from Appendix B to 10 CFR §§20.1001 - 20.2401 will be used. The expected mix of long-lived radionuclides would be predominantly natural uranium with a lesser amount of Ra-226. The DAC for Ra-226 is $3x10^{-10}$ uCi/ml. The DAC for the mixture would be between the natural uranium DAC and the Radium-226 DAC. CBR believes the use of natural uranium DAC for comparison to administrative action levels to be appropriate since most of the expected mixture of airborne radionuclides is natural uranium and the DAC for natural uranium and Radium-226 are similar. An action level of 25% of the DAC for soluble natural uranium will be established at the North Trend Satellite Plant. If an airborne uranium sample exceeds the action level of 25% of the DAC, an investigation of the cause will be performed. If a monthly airborne uranium sample exceeds 25% of the action level, the sampling frequency would be increased from monthly to weekly until the airborne uranium levels do not exceed the action level for four consecutive weeks. The RSO may initiate corrective actions that may reduce future exposures.

No dose is calculated when comparing the measured airborne uranium concentrations to the natural uranium DAC. The purpose for this comparison is to see if the airborne uranium concentration is greater than the administrative action level of 25% DAC which triggers an investigation. If internal doses are required to be estimated pursuant to 10 CFR 20.1202, methods described in Section 5.7.4 of the application will be used.

As per 10 CFR 20.1201 (e), in addition to the annual dose limits, the intake of soluble uranium by an individual is limited to 10 mg in a week in consideration of chemical toxicity. If exposure to soluble uranium exceeds 25% of the weekly allowable intake of 10 mg, which would be 2.5 mg/week, then the RSO would initiate an investigation into the cause of the occurrence and initiate corrective actions that may reduce future exposures. As with any hazardous material handled on the site, the ALARA program would be applied to such potential chemical exposures as described in Section 2.5 of CBR's Health Physics Manual of the SHEQ MS.

Any worker likely to receive, in one year, an occupational dose in excess of 10% of the limits in 10 CFR 20 1201(a) will be monitored. The RSO will use historical and current monitoring and survey data to ensure worker external radiation exposures. The external and internal dose that an individual may be allowed to receive in the current year may be reduced by the amount of occupational dose received or amount of intake while employed by any other person. The record of prior occupational dose that the individual received while performing work involving radiation exposure would be obtained, as per 10 CFR 20.2104. All new employees would be asked to provide their past radiological exposure history and asked to sign an Exposure Release Form so previously radiological exposure history may be obtained. If a complete record of the individual's current and previously accumulated occupation dose is not available, it shall be assumed that in establishing administrative controls under 10 CFR 1201(f) for the current year, that the allowable dose limit for the individual would be reduced by 1.25 rems (12.5 mSv) for each quarter for which records were unavailable and the individual worker engaged in activities that could have resulted in occupational radiation exposure. It would also be assumed that the individual would not be available for planned special exposures. As per 10 CFR 20.2104, CBR would not be required to partition historical data between external dose equivalent(s) and internal committed dose equivalent(s).

5.7.3.2 Radon Daughter Concentration Monitoring

Surveys for radon daughter concentrations will be conducted in the operating areas of the North Trend Satellite Plant on a monthly basis. Sampling locations will be determined in accordance with the guidance contained in USNRC Regulatory Guide 8.25. Section 3.1 of NRC Regulatory Guide 8.25 states "lapel samplers or samplers located within about 1 foot of the workers head may be accepted as representative without further demonstration that the results are representative." Working Level measurements will be made using the Modified Kusnetz method (ANSI-N13.8-1973) which involves taking a grab sample, typically 5 minutes, and analyzing the filter for alpha activity. This grab sample will be taken at locations depicted on Figure 5.7-2 of the amendment application at a height typical of where a worker's breathing zone would exist and within the breathing zone of the worker collecting the sample.

Routine radon daughter monitoring will be performed in accordance with the instructions currently contained in SHEQ MS. Volume IV, *Health Physics Manual.* Samplers will be calibrated at the manufacturer's suggested interval or semiannually with a digital mass flowmeter or other primary calibration standard. Air sampler calibration will be performed in accordance with the instructions currently contained in SHEQ MS. Volume IV, *Health Physics Manual.*

Results of radon daughter sampling are expressed in Working Levels (WL) where one WL is defined as any combination of short-lived radon-222 daughters in one liter of air without regard to equilibrium that emit 1.3×10^5 MeV of alpha energy. The DAC limit from Appendix B to 10 CFR §§ 20.1001 - 20.2402 for radon-222 with daughters present is 0.33 WL. CBR has established an action level of 25% of the DAC or 0.08 WL. The LLD for radon measures would be 0.033 WL, which is 10% of the DAC limit. Radon daughter results in areas with an average concentration in excess of the action level will result in an investigation of the cause and an increase in the sampling frequency to weekly until the radon daughter concentration levels do not exceed the action level for
four consecutive weeks.

5.7.3.3 Respiratory Protection Program

Respiratory protective equipment has been supplied by CBR for activities where engineering controls may not be adequate to maintain acceptable levels of airborne radioactive materials or toxic materials. Use of respiratory equipment at Crow Butte Uranium Project is in accordance with the procedures currently set forth in the SHEQ MS. Volume IV, *Health Physics Manual.* The respirator program is designed to implement the guidance contained in USNRC Regulatory Guide 8.15[11] and USNRC Regulatory Guide 8.31. The respirator program is administered by the RSO as the Respiratory Protection Program Administrator (RPPA).

Since airborne uranium concentrations at the North Trend Satellite Facility during typical operations are not expected to exceed action levels, it is not expected that respirator use will be required for such "normal" operation of the satellite facility. However, anytime the potential exists for elevated exposures to employees, respirators could be required. For example, certain maintenance activities (e.g., tank entry, disassembly of potentially contaminated piping and equipment, and welding/grinding on contaminated piping/equipment), and failure of the process building ventilation system, could require the use of respirators. The use of respirators at North Trend would be determined by CBR Standard Operations Procedures (SOPs) and Radiation Work Permits for specific tasks. CBR's respirator policy and requirements of respirator use are discussed in detail in CBR's above referenced SHEQ MS

5.7.4 EXPOSURE CALCULATIONS

Employee internal exposure to airborne radioactive materials at the North Trend satellite plant will be determined based upon the requirements of 10 CFR § 20.1204 and the guidance contained in USNRC Regulatory Guides 8.30 and 8.7[12]. Following is a discussion of the exposure calculation methods and results.

5.7.4.1 Natural Uranium Exposure

Exposure calculations for airborne natural uranium are carried out using the intake method from USNRC Regulatory Guide 8.30, Section 3. The intake is calculated using the following equation:

$$I_u = b\sum_{i=1}^{n}\frac{X_i \times t_i}{PF}$$

where:

I_u	=	uranium intake, μg or μCi	
t_i	=	time that the worker is exposed to concentrations X_i	(hr)
X_i	=	average concentration of uranium in breathing zone, μg/m^3, μCi/m^3	
b	=	breathing rate, 1.2 m^3/hr	
PF	=	the respirator protection factor, if applicable	
n	=	the number of exposure periods during the week or quarter	

The intake for uranium is calculated and recorded. The intakes are totaled and entered onto each employee's Occupational Exposure Record.

The data required to calculate internal exposure to airborne natural uranium is determined as follows:

Time of Exposure Determination

100% occupancy time is used to determine routine worker exposures. Exposures during non-routine work are always based upon actual time.

When calculating radiological exposures for North Trend, the occupancy time for "routine" operations would be an exposure period based on actual hours worked (12-hours shift period for plant personnel). This would be considered a 100% occupancy time that is used to determine routine worker exposures. For such routine exposures (i.e., 12-hr shift period), it is assumed that the worker was exposed to the measured "work area" average concentration of uranium for the entire work period (exposure 100% of the time). During part of that exposure period, the worker would be expected to spend some time in non-work areas such as the lunch room, office, restroom, hallways, etc. The 100% occupancy time approach generally results in a conservative (i.e., higher than actual) estimate of internal exposure to airborne natural uranium because it does not account for time the employee may have spent outside the work area, such as described above.

The measured average airborne uranium concentration is multiplied by the time of worker exposure (12 hours) to obtain the estimated average worker exposure for that time period. Routine operations refer to the facilities operating in a normal fashion with no upsets, maintenance activities, or other activities that may result in non-routine and elevated exposures. If a worker works more than the normal 12-hour shifts, the measured average airborne uranium concentration and the total hours actually worked are used to establish exposure levels.

For exposures during non-routine work tasks (e.g., maintenance or cleanup), measured exposures are based on actual time. The results of breathing zone samples collected during maintenance activities or Radiation Work Permits (RWP's) are taken over a specific time period and are added to the calculations of routine employee exposures for a given work period. For example, a worker working under a Radiation Work Permit for 2 hours would have exposures based on measurements taken for that time period (actual time), with the exposures for the remaining 10 hours of routine work based on the measured average concentration of airborne uranium.

Airborne Uranium Activity Determination

Airborne uranium activity is determined from surveys performed as described in Section 5.7.3.1.

CBR proposes to institute the same internal airborne uranium exposure calculation methods at the North Trend satellite plant that have been used to date at the Central Processing Plant and which are currently contained in SHEQ MS. Volume IV, *Health Physics Manual.* Exposures to airborne uranium will be compared to the DAC for the "D" solubility class for natural uranium from Appendix B of 10 CFR §§20.1001 - 20.2401 ($5x10^{-10}$ μCi/ml). Footnote 3 in Table 1 of

Appendix B to 10 CFR 20 states "the specific activity for natural uranium is 6.77 E-7 curies per gram U". This is equivalent to 6.77 E-7 μCi per microgram of natural uranium. This is the specific activity CBR will use to calculate the mass of uranium from an activity measurement and vice versa.

When required by 10 CFR 20.1202, CBR will use methods in NRC Regulatory Guide 8.30 to estimate internal doses. As an example, the Committed Effective Dose Equivalent (CEDE) can be calculated using Equation 2 in NRC Regulatory Guide 8.30 where:

H_{iE} =	Committed effective dose equivalent (CEDE) from radionuclide (rem)
I_i=	is the intake in μCi of Class D natural uranium as determined by the equation in Section 5.7.4.1 of the application
ALI_{iE} =	Value of the stochastic inhalation ALI for natural uranium from Column 2 of Table 1 in appendix B to 10 CFR Part 20 (2 μCi)
5 =	CEDE from intake of 1 ALI (rem)

If an intake (I_i) of 0.5 μCi was determined using the stated equation, the estimate CEDE from this intake would be:

$$H_{iE} = 5*0.5/2 = 1.25 \text{ rem}$$

If an intake (I_i) of 0.5 μg of natural uranium was determined using the stated equation, the estimated CEDE from this intake would be:

$$H_{iE} = 5*0.5*6.77 \text{ E-7}/2 = 8.5 \text{ E-7 rem}$$

It should be noted that the weekly limit for soluble uranium in 10 CFR 20.1202 (e) due to chemical toxicity is 10 milligram (10,000 μg) which would be equivalent to a CEDE of 17 mrem per week or 844 mrem per year. The occupational weekly toxicity limit for Class D natural uranium is more restrictive than the radiological limit.

5.7.4.2 Radon Daughter Exposure

Exposure calculations for airborne radon daughters are carried out using the intake method from USNRC Regulatory Guide 8.30, Section 3. The radon daughter intake is calculated using the following equation:

$$I_r = \frac{1}{170} \sum_{i=1}^{n} \frac{Wi \times t_i}{PF}$$

where:

I_r	=	radon daughter intake, working-level months
t_i	=	time that the worker is exposed to concentrations W_i (hr)
W_i	=	average number of working levels in the air near the worker's breathing zone during the time (t_i)
170	=	number of hours in a working month
PF	=	the respirator protection factor, if applicable
n	=	the number of exposure periods during the year

The data required to calculate exposure to radon daughters is determined as follows:

Time of Exposure Determination

100% occupancy time is used to determine routine worker exposure times. Exposures during non-routine work are always based upon actual time. A clarification of the 100% occupancy time is presented in Section 5.7.4.1 for natural uranium exposure. This explanation would also apply to radon daughter exposure.

Radon Daughter Concentration Determination

Radon-222 daughter concentrations are determined from surveys performed as described in Section 5.7.3.2. The working-level months for radon daughter exposure are calculated and recorded. The working-level months are totaled and entered onto each employee's Occupational Exposure Record.

CBR proposes to institute the same internal radon daughter exposure calculation methods at the North Trend satellite plant that have been used to date and which are currently contained in SHEQ MS. Volume IV, *Health Physics Manual.* Exposures to radon daughters will be compared to the DAC for radon daughters from Appendix B of 10 CFR §§20.1001 - 20.2401 (0.33 WL).

The equation above calculates Working Level Months (WLM). If required by 10 CFR 20.1202, CBR can calculate a CEDE from the WLM estimate using Equation 2 in NRC Regulatory Guide 8.30 where:

H_{iE} = Committed effective dose equivalent (CEDE) from radionuclide (rem)

I_i= is the intake in WLM of radon-222 and its associated progeny as determined by the equation in Section 5.7.4.2 of the application

ALI_{iE} = Value of the stochastic inhalation ALI for radon-222 with progeny present from Column 2 of Table 1 in appendix B to Part 20 (4 WLM)

5 = CEDE from intake of 1 ALI (rem)

If an intake (I_i) of 1 WLM was determined using the stated equation, the estimate CEDE from this intake would be:

$$H_{iE} = 5*1/4 = 1.25 \text{ rem}$$

5.7.4.3 Prenatal and Fetal Exposure

- Dose Equivalent to an Embryo/Fetus

10 CFR §20.1208 requires that licensees ensure that the dose equivalent to an embryo/fetus during the entire pregnancy, due to the occupational exposure of a declared pregnant woman does not exceed 0.5 Rem (5 mSv). Licensees are also required to make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman that would satisfy the 0.5 Rem limit. The dose equivalent to the embryo/fetus is calculated as the sum of (1) the deep-dose equivalent to the declared pregnant woman; and, (2) the dose equivalent to the embryo/fetus resulting from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman. If the dose equivalent to the embryo is determined to have exceeded 0.5 rem (5 mSv), or is within 0.05 rem (0.5 mSv) of this dose, by the time the woman declares the pregnancy to the licensee, the licenses shall be deemed to be in compliance with 10 CFR 20.1208 if the additional dose equivalent to the embryo/fetus does not exceed 0.05 rem (0.5 mSv) during the remainder of the pregnancy.

- Individual Monitoring of External and Internal Occupational Exposure

The dose equivalent to the embryo/fetus is determined by the monitoring of the declared pregnant woman. 10 CFR §20.1502(a)(3) requires monitoring the exposure of a declared pregnant woman when the external dose to the embryo/fetus is likely to receive during the entire pregnancy, from radiation sources external to the body, a deep dose equivalent in excess of 0.1 rem (1 mSv). All of the occupational doses in 10 CFR 20.1201 continue to be applicable to the declared pregnant worker as long as the embryo/fetus dose limit is not exceeded. 10 CFR 20.1502(b)(3) requires the monitoring of occupational intake of radioactive material by and assess the committed effective dose equivalent to a declared pregnant woman likely to receive, during the entire pregnancy, a committed effective dose equivalent in excess of 0.1 rem (1 mSv). Based on this 0.1 rem threshold, the dose to the embryo/fetus must be determined if the intake is likely to exceed 1% of Annual Limit on Intake (ALI) during the entire period of gestation.

Prior to declaration of pregnancy, the woman may not have been subject to monitoring based on the conditions specified in 10 CFR 20.1502. In this case, CBR will estimate the exposure during the period monitoring was not provided, using any combination of surveys or other available data (for example, air monitoring, area monitoring, and bioassay). Exposure calculations will be performed as recommended in USNRC Regulatory Guide 8.36[13].

- External Dose to the Embryo/Fetus

The deep-dose equivalent to the declared pregnant woman during the gestation period will be taken as the external dose for the embryo/fetus. The determination of external dose will consider all occupational exposures of the declared pregnant woman since the estimated date of

conception and will be based on the methods discussed in Section 5.7.2. External dose to the declared pregnant woman after declaration for the duration of the pregnancy shall be accomplished by personnel dosimetry with exchanges on a monthly basis.

- Internal Dose to the Embryo/Fetus

The internal dose to the embryo/fetus will consider the exposure to the embryo/fetus from radionuclides in the declared pregnant woman and in the embryo/fetus. The dose to the embryo/fetus will include the contribution from any radionuclides in the declared pregnant woman (body burden) from occupational intakes occurring prior to conception.

The intake for the declared pregnant woman will be determined as discussed in Sections 5.7.3.1 and 5.7.3.2.

5.7.5 BIOASSAY PROGRAM

CBR has implemented a urinalysis bioassay program at the Crow Butte Uranium Project facilities that meets the guidelines contained in USNRC Regulatory Guide 8.22[14]. The primary purpose of the program is to detect uranium intake in employees who are regularly exposed to uranium. The bioassay program consists of the following elements:

1. Prior to assignment to the facility, all new employees are required to submit a baseline urinalysis sample. Upon termination, an exit bioassay is required from all employees.

2. During operations, urine samples are collected from workers on a quarterly basis. Employees who have the potential for exposure to dried yellowcake submit bioassay samples on a monthly basis or more frequently as determined by the RSO. Samples are analyzed for uranium content by a contract analytical laboratory. Blank and spiked samples are also submitted to the laboratory with employee samples as part of the Quality Assurance program. The measurement sensitivity for the analytical laboratory is 5 μg/l.

3. Action levels for urinalysis are established based upon Table 1 in USNRC Regulatory Guide 8.22.

Elements of the quality assurance requirements for the Bioassay Program are based upon the guidelines contained in USNRC Regulatory Guide 8.22. These elements included the following:

1. Each batch of samples submitted to the analytical laboratory is accompanied by two blind control samples. The control samples are from persons that have not been occupationally exposed and are spiked to a uranium concentration of 10 to 20 μg/l and

40 to 60 μg/l. The results of analysis for these samples are required to be within ± 30% of the spiked value

2. The analytical laboratory spikes 10 to 30% of all samples received with known concentrations of uranium and the recovery fraction determined. Results are reported to CBR.

CBR proposes to continue to implement the Bioassay Program described in this section for operations at the North Trend Satellite Plant. The plant and wellfield operators will be included in a personnel dosimetry (exchanged on quarterly basis) and bioassay program, with urine samples collected on a quarterly basis. The program will be implemented in accordance with the guidance contained in USNRC Regulatory Guide 8.22 and with the instructions currently contained in SHEQ MS. Volume IV, *Health Physics Manual.*

5.7.6 CONTAMINATION CONTROL PROGRAM

CBR will perform surveys for surface contamination in operating and clean areas of the North Trend Satellite Plant in accordance with the guidelines contained in USNRC Regulatory Guide 8.30. Surveys for total alpha contamination in clean areas will be conducted weekly. In designated clean areas, such as lunchrooms, offices, change rooms, and respirator cabinets, the target level of contamination is nothing detectable above background. If the total alpha survey indicates contamination that exceeds 250 dpm/100 cm^2 (25% of the removable limit) a smear survey must be performed to assess the level of removable alpha activity. If smear test results indicate removable contamination greater than 250 dpm/100 cm^2, the area will be promptly cleaned and resurveyed.

All personnel leaving the restricted area will be required to perform and document alpha contamination monitoring. In addition, personnel who could come in contact with potentially contaminated solutions outside a restricted area such as in the wellfields will be required to monitor themselves prior to leaving the area. All personnel receive training in the performance of surveys for skin and personal contamination. All contamination on skin and clothing is considered removable, so the limit of 1,000 dpm/100 cm^2 is applied to personnel monitoring. Personnel will also be allowed to conduct contamination monitoring of small, hand-carried items for use in wellfield and controlled areas as long as all surfaces can be reached with the instrument probe and the item does not originate in yellowcake areas. All other items are surveyed as described below.

Consistent with Regulatory Guide 8.31, the RSO, the radiation safety staff, or qualified employees will perform surveys of all items removed from the restricted areas with the exception of small, hand-carried items described above. Due to the remoteness of the North Trend operations site from the current CBR processing facility where the RSO and radiation staff has offices, it is necessary to have properly trained full-time personnel at the North Trend site available to perform surveys for releasing items from the restricted area.

Lead Operators and plant/wellfield operators with a minimum of six months experience, will be trained by the RSO or radiation staff in the use of applicable radiation survey instruments and procedures including hands-on use of the instrumentation. These operators will have also received job-specific training as operators as well as the radiation safety training described in Section 5.6.1.3. In addition, they would also be subject to additional hands-on training as to the survey instruments and procedures.

The release limits for beta gamma contamination are 0.2 mrad average and 1.0 mrad maximum at 10 cm as required by the *"Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses For Byproduct or Source Materials"*, USNRC, May 1987.

Surveys are performed with the following equipment:

1. Total surface activity will be measured with an appropriate alpha survey meter. A Ludlum Model 2241 scaler or a Ludlum Model 177 Ratemeter with a Model 43-65 or Model 43-5 alpha scintillation probe, or equivalent, will be used for the surveys.

2. Portable GM survey meter with a beta/gamma probe with an end window thickness of not more than 7 mg/cm^2, a Ludlum Model 3 survey meter with a Ludlum 44-38 probe or equivalent.

3. Swipes for removable contamination surveys as required.

Survey equipment is calibrated annually or at the manufacturer's recommended frequency, whichever is more frequent. Surface contamination instruments are checked daily when in use. Alpha survey meters for personnel surveys are response checked before each use with other checks performed weekly.

As recommended in USNRC Regulatory Guide 8.30, CBR conducts quarterly unannounced spot checks of personnel to verify the effectiveness of the surveys for personnel contamination. A spot check of the employees assigned to the North Trend satellite plant site will be conducted, concentrating on plant operators and maintenance personnel. The purpose of the surveys is to ensure that employees are adequately surveying and decontaminating themselves prior to exiting the restricted areas.

The contamination control program for the North Trend satellite plant will be implemented in accordance with the instructions currently contained in SHEQ MS. Volume IV, *Health Physics Manual.*

5.7.7 AIRBORNE EFFLUENT AND ENVIRONMENTAL MONITORING PROGRAMS

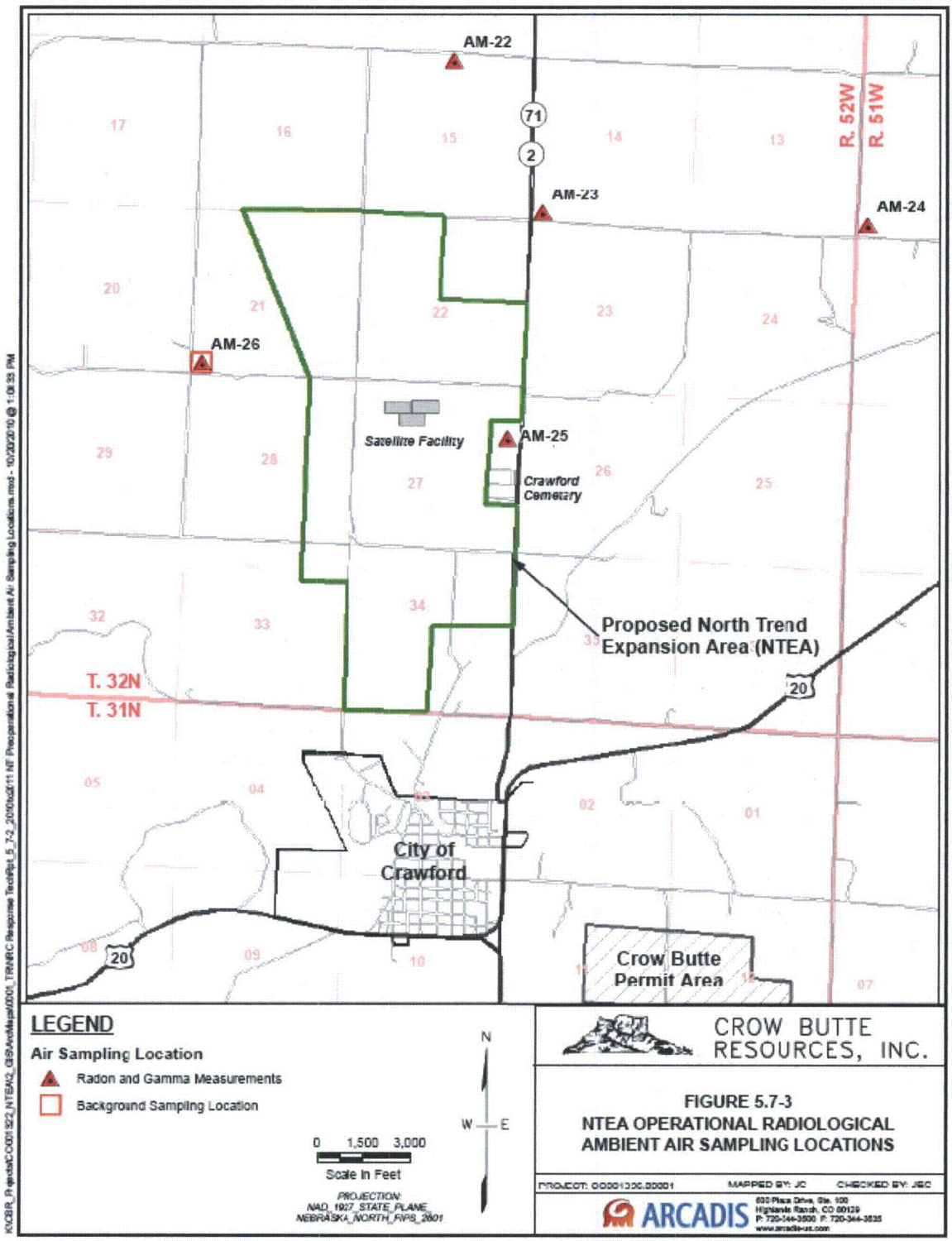
Radon

The radon gas effluent released to the environment from North Trend operations will be monitored at the same air monitoring locations (AM-9 through AM-14) that were used for baseline determination of radon concentrations as described in Section 2.9.2. Sampling locations are shown on Figure 5.7-3. Monitoring will be performed using Track-Etch radon cups. The cups will be exchanged on a semiannual basis in order to achieve the required lower limit of detection (LLD) of $2x10^{-10}$. SHEQ Program Volume IV, *Health Physics Manual* currently provides the instructions for environmental radon gas monitoring. In addition to the manufacturer's Quality Assurance program, CBR will expose one duplicate radon Track Etch cup per monitoring period.

Monitoring of radon gas releases from the satellite facility building and ventilation discharge points is not deemed to be practicable. Section 3.3 of Regulatory Guide 8.37 indicates that where monitoring effluent points is not practicable, an estimate can be made of the magnitude of these releases, with such estimated releases used in demonstrating compliance with the annual dose limit. In 10 CFR 20.1302, allowance is made for demonstrating by measurement or calculation that the total effective dose equivalent to the individual likely to receive the highest dose from licensed operations does not exceed the annual dose limit of 100 mrem.

The North Trend Satellite Facility would use pressurized downflow ion exchange columns, which do not routinely release radon gas except during resin transfer and column backwashing. The design and operation of these systems result in the majority of the radon in the production fluid to stay in solution and is not released from the columns. Radon may be released from occasional venting of process vessels and tanks, small leaks in ion exchange equipment, and maintenance of equipment. Therefore, releases via the vent stacks would not have a consistent concentration of radon or flow rate, making it impracticable to try to use such data for public exposure estimates.

CBR has used MILDOS-Area to model the dose from facility operations resulting from releases of radon gas. Discussions are presented in Section 7.3.3. In determining the source term for MILDOS-Area for North Trend, radon gas release was estimated at 25% of the radon-222 in the production fluid from the wellfields and an additional 10% in the ion exchange circuit in the satellite building. The release of radon-222 at this concentration did not result in significant public dose.


AM-22
AM-23
AM-24
AM-25
AM-26
71
2
20
R. 52W
R. 51W
T. 32N
T. 31N
Satellite Facility
Crawford Cemetery
Proposed North Trend Expansion Area (NTEA)
City of Crawford
Crow Butte Permit Area
LEGEND
Air Sampling Location
Radon and Gamma Measurements
Background Sampling Location
0 1,500 3,000
Scale in Feet
N
W E
PROJECTION: NAD_1927_STATE_PLANE_NEBRASKA_NORTH_FIPS_2601
CROW BUTTE RESOURCES, INC.
FIGURE 5.7-3
NTEA OPERATIONAL RADIOLOGICAL AMBIENT AIR SAMPLING LOCATIONS
ARCADIS

The closest resident in the downwind direction for the satellite facility had the highest estimated TEDE of 5.8 mrem/yr, which is approximately 6% of the public dose limit of 100 mrem. This is based on an occupancy factor of 100% or 8760 hours per year. The effect of the satellite facility operations on nearby residents of the existing Crow Butte facility is less than 1 mrem/yr.

Environmental monitoring and estimated release of radon from process operations will be reported in the semi-annual reports required by 10 CFR § 40.65 and License SUA-1534 License Condition Number 12.1.

Air Particulate Monitoring

In-plant operational air particulate monitoring is discussed in Section 5.7.3.1. As a "wet facility" negligible particulate emissions are expected at the NTEA. Based upon experience the CPF, and the MILDOS Area simulation, air particulate monitoring is not contemplated as part of the airborne effluent and environmental monitoring program. This conclusion is further supported by the current license which only requires particulate monitoring when the yellowcake dryer is in operation

Surface Soil

Surface soil has been sampled as described in Section 2.9. Surface soil samples will be taken at the monitoring locations (AM-9 through AM-14) following conclusion of operations and will be compared to the results of the preoperational monitoring program.

Surface soil will also be sampled at the plant location as described in Section 2.9. Post operational surface soil samples will be taken following conclusion of operations and will be compared to the results of the preoperational monitoring program.

Subsurface Soil

Subsurface soil will be sampled at the plant location as described in Section 2.9. Post operational subsurface soil samples will be taken following conclusion of operations and will be compared to the results of the preoperational monitoring program.

Vegetation

Preoperational vegetation samples from the North Trend Expansion Area were collected in 1996-1997 at the air monitoring locations as described in Section 2.9. Vegetation sampling was discontinued at the CPF when the NRC approved the 1998 license renewal. It is reasonable to expect that the NTEA, without yellowcake drying and packaging, would also satisfy the criteria considered by the NRC when approving discontinuance of vegetation monitoring at the CPF.

CBR does not perform operational vegetation sampling at the environmental monitoring stations for the current production area and does not propose to perform operational vegetation sampling for the North Trend Expansion Area. In accordance with the provisions of USNRC Regulatory Guide 4.14[13], Footnote (o) to Table 2 requires that "*vegetation and forage sampling need be carried out only if dose calculations indicate that the ingestion pathway from grazing animals is a potentially significant exposure pathway...*" defined as a pathway which would expose an individual to a dose in excess of 5% of the applicable radiation protection standard. This pathway was evaluated by MILDOS-Area and is discussed further in Section 7.3.

Based upon the prior NRC determination to cease vegetation sampling at the Crow Butte CPF, application of the above noted exclusion to the NTEA is appropriate. As a result, crop and livestock sampling is not contemplated.

Fish

If the results of sediment and surface water sampling indicate upward trends in contaminant concentrations, CBR will develop and implement a fish sampling program.

Direct Radiation

Environmental gamma radiation levels will be monitored continuously at the air monitoring stations (AM-9 through AM-14). Gamma radiation will be monitored through the use of environmental dosimeters obtained from a NVLAP certified vendor. Dosimeters will be exchanged on a quarterly basis.

Sediment

Reg. Guide 4.14 recommends that sediment samples be collected from sediments of surface water passing through the project site or offsite surface waters that may be subject to drainage from potentially contaminated areas or that could be affected by a tailings impoundment failure. Samples are to be collected once following spring runoff and late summer following a period of extended low flow. Samples are to be analyzed for natural uranium, radium-226, thorium-230, and lead-210.

Sediment samples will be collected at the sample locations that have been established for surface water sampling (**Figure 2.9-5**). Samples shall be collected and analyzed annually for natural uranium, ra-226, and pb-210. Sediment sampling procedures shall be the same as described in the preoperational monitoring plan (Section 2.9.9.2).

The proposed operational radiological monitoring program for sediment is summarized in **Table 5.7-1.** Sediment monitoring results will be submitted in the semi-annual environmental and effluent reports submitted to the USNRC.

5.7.8. GROUNDWATER/SURFACE WATER MONITORING PROGRAM

5.7.8.1 Program Description

During operations at the North Trend satellite plant, a detailed water sampling program will be conducted to identify any potential impacts to water resources of the area. CBR's operational water monitoring program includes the evaluation of groundwater on a regional basis, groundwater within the permit or licensed area and surface water on a regional and site specific basis.

5.7.8.2 Groundwater Monitoring

The groundwater excursion monitoring program is designed to detect excursions of lixiviant into the ore zone aquifer outside of the wellfield being leached and into the overlying water bearing strata. The Pierre Shale below the ore zone is over 1200 feet thick and contains no water bearing strata. Therefore, it is not necessary to monitor any water bearing strata below the ore zone.

- Private Well Monitoring

All private wells within one kilometer of the wellfield area boundary are sampled on a quarterly basis with the landowner's consent. CBR will perform similar private well monitoring around the North Trend Expansion Area. Groundwater samples are taken in accordance with the instructions contained in SHEQ MS. Volume VI, *Environmental Manual.* Samples are analyzed for natural uranium and radium-226.

- Monitor Well Baseline Water Quality

After delineation of the production unit boundaries, monitor wells are installed no further than 300 feet from the wellfield boundary and no further than 400 feet apart. After completion, wells are washed out and developed (by air flushing or pumping) until water quality in terms of pH and specific conductivity appears stable and consistent with the anticipated quality of the area. After development, wells are sampled to obtain baseline water quality. For baseline sampling, wells are purged before sample collection to ensure that representative water is obtained. All monitor wells including ore zone and overlying monitor wells are sampled three times at least fourteen (14) days apart. Samples are analyzed for chloride, conductivity, and total alkalinity as specified in License Condition 10.4. Results from the samples are averaged arithmetically to obtain an average baseline value as well as a maximum value for determination of upper control limits for excursion detection. Well development and sampling activities are performed in accordance with the instructions contained in SHEQ MS. Volume VI, *Environmental Manual.*

- Upper Control Limits and Excursion Monitoring

After baseline water quality is established for the monitor wells for a particular production unit, upper control limits (UCL's) are set for chemical constituents which would be indicative of a migration of lixiviant from the well field. The constituents chosen for indicators of lixiviant migration and for which UCLs are set are chloride, conductivity, and total alkalinity. Chloride was chosen due to its low natural levels in the native groundwater and because chloride is introduced into the lixiviant from the ion exchange process (uranium is exchanged for chloride on the ion exchange resin). Chloride is also a very mobile constituent in the groundwater and will show up very quickly in the case of a lixiviant migration to a monitor well. Conductivity was chosen because it is an excellent general indicator of overall groundwater quality. Total alkalinity concentrations should be affected during an excursion as bicarbonate is the major constituent added to the lixiviant during mining. Water levels are obtained and recorded prior to each well sampling. However, water levels are not used as an excursion indicator. Upper control limits are set at 20% above the maximum baseline concentration for the excursion indicator. For excursion indicators with a baseline average below 50 mg/l, the UCL may be determined by adding 5 standard deviations or 15 mg/l to the baseline average for the indicator.

Operational monitoring consists of sampling the monitor wells on a biweekly basis and analyzing the samples for the excursion indicators chloride, conductivity, and total alkalinity. License SUA-1534 Condition 11.2 currently requires that monitor wells be sampled no more than 14 days apart except in the event of certain situations. These situations include inclement weather, mechanical failure, holiday scheduling, or other factors that may result in placing an employee at risk or potentially damaging the surrounding environment. In these situations, CBR documents the cause and the duration of any delays. In no event is sampling delayed for more than five days.

- Excursion Verification and Corrective Action

During routine sampling, if two of the three UCL values are exceeded in a monitor well, or if one UCL value is exceeded by 20 percent, the well is resampled within 48 hours and analyzed for the excursion indicators. If the second sample does not exceed the UCLs, a third sample is taken within 48 hours. If neither the second or third sample results exceeded the UCLs, the first sample is considered in error.

If the second or third sample verifies an exceedance, the well in question is placed on excursion status. Upon verification of the excursion, the USNRC Project Manager is notified by telephone or email within 48 hours and notified in writing within seven (7) days.

If an excursion is verified, the following methods of corrective action are instituted (not necessarily in the order given) dependent upon the circumstances:

- A preliminary investigation is completed to determine the probable cause;

- Production and/or injection rates in the vicinity of the monitor well are adjusted as necessary to increase the net over recovery, thus forming a hydraulic gradient toward the production zone; and

- Individual wells are pumped to enhance recovery of mining solutions.

Injection into the well field area adjacent to the monitor well may be suspended. Recovery operations continue, thus increasing the overall bleed rate and the recovery of wellfield solutions.

In addition to the above corrective actions, sampling frequency of the monitor well on excursion status is increased to weekly. An excursion is considered concluded when the concentrations of excursion indicators do not exceed the criteria defining an excursion for three consecutive one-week samples.

5.7.8.3 Surface Water Monitoring

Reg. Guide 4.14 recommends that surface water samples (drainages, streams and rivers) be collected the same as in the surface water preoperational monitoring program discussed in Section 2.9.4.2. Grab samples should be analyzed quarterly for dissolved and suspended natural uranium, radium-226, thorium-230, lead-210 and polonium-210.

Reg. Guide 4.14 recommends an operational monitoring program for surface impoundments. However, there are no surface impoundments within, or in close proximity of the NTEA that could be impacted by discharges from NTEA operations. Therefore, there will be no such operational monitoring program,

Surface water samples will be collected from the surface sampling points identified in **Figure 2.9-5**, providing sufficient flow is available. Samples shall be collected quarterly and analyzed for dissolved and suspended natural uranium, radium-226, thorium-230, lead-210 and polonium-210. If thorium-230 is not detected above background in the first year of operational monitoring, thorium-230 will be eliminated as an operational surface water analyte.

The radiological monitoring program for surface water is summarized in **Table 5.7-1.** Surface water monitoring results will be submitted in the semi-annual environmental and effluent reports submitted to the USNRC.

5.7.8.4 Evaporation Pond Leak Detection Monitoring

The evaporation pond will be lined and equipped with a leak detection system. During operations, the leak detection standpipes will be checked for evidence of leakage. Visual inspection of the pond embankments, fences and liners and the measurement of pond freeboard will also be performed during normal operations. The current CBR Pond Inspection Program

will be adapted for the North Trend Satellite Plant and will meet the guidance contained in USNRC Regulatory Guide 3.11 and USNRC Regulatory Guide 3.11.1.

A minimum freeboard of 5 feet is allowed for the current commercial ponds during normal operations. Anytime six (6) inches or more of fluid is detected in a leak detection system standpipe, it will be analyzed for specific conductivity. Should the analyses indicate that the liner is leaking (by comparison to chemical analyses of pond water), the following actions will be taken:

- The USNRC will be notified by telephone or email within 48 hours of leak verification;
- The level of the leaking pond will be lowered by transferring its contents into an adjacent pond. While lowering the water level in the pond, inspections of the liner will be made to determine the cause and location of the leakage. The area of investigation first centers around the pond area specific for the particular standpipe which contains fluid;
- Once the source of the leakage is found, the liner will be repaired and water will be reintroduced to the pond; and
- A written report will be submitted to the USNRC within 30 days of leak verification. The report will include analytical data and describe the cause of the leakage, corrective actions taken and the results of those actions.

5.7.9 QUALITY ASSURANCE PROGRAM

A quality assurance program is in place at Crow Butte Uranium Project for all relevant operational monitoring and analytical procedures. The objective of the program is to identify any deficiencies in the sampling techniques and measurement processes so that corrective action can be taken and to obtain a level of confidence in the results of the monitoring programs. The QA program provides assurance to both regulatory agencies and the public that the monitoring results are valid.

The QA program addresses the following:

- Formal delineation of organizational structure and management responsibilities. Responsibility for both review/approval of written procedures and monitoring data/reports is provided;
- Minimum qualifications and training programs for individuals performing radiological monitoring and those individuals associated with the QA program;

- Written procedures for QA activities. These procedures include activities involving sample analysis, calibration of instrumentation, calculation techniques, data evaluation, and data reporting;

- Quality control (QC) in the laboratory. Procedures cover statistical data evaluation, instrument calibration, duplicate sample programs and spike sample programs. Outside laboratory QA/QC programs are included; and

- Provisions for periodic management audits to verify that the QA program is effectively implemented, to verify compliance with applicable rules, regulations and license requirements, and to protect employees by maintaining effluent releases and exposures ALARA.

The SHEQ MS. developed by CBR is a critical step to ensuring that quality assurance objectives are met. Current procedures exist for a variety of areas, including but not limited to:

1. Environmental monitoring procedures;

2. Testing procedures;

3. Exposure procedures;

4. Equipment operation and maintenance procedures;

5. Employee health and safety procedures; and,

6. Incident response procedures.

5.8 REFERENCES

[1] USNRC Regulatory Guide 8.31, *Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Reasonably Achievable* (Revision 1, May 2002).

[2] USNRC Regulatory Guide 8.2, *Guide For Administrative Practices In Radiation Monitoring* (February 1973).

[3] USNRC Regulatory Guide 3.11.1, *Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mill Tailings* (Revision 1, October 1980).

[4] USNRC Regulatory Guide 8.29, *Instructions Concerning Risks from Occupational Radiation Exposure* (Revision 1, February 1996).

[5] USNRC Regulatory Guide 8.13, *Instruction Concerning Prenatal Radiation Exposure* (Revision 3, June 1999).

[6] USNRC Regulatory Guide 3.56, *General Guidance For Designing, Testing, Operating, and Maintaining Emission Control Devices at Uranium Mills* (May 1986).

[7] USNRC Regulatory Guide 3.11, *Design, Construction and Inspection of Embankment Retention Systems for Uranium Mills* (Revision 2, December 1977).

[8] USNRC Regulatory Guide 8.30, *Health Physics Surveys in Uranium Recovery Facilities* (Revision 1, May 2002).

[9] USNRC Regulatory Guide 8.34, *Monitoring Criteria and Methods To Calculate Occupational Radiation Doses* (July 1992).

[10] USNRC Regulatory Guide 8.25, *Air Sampling in the Workplace* (Revision 1, June 1992).

[11] USNRC Regulatory Guide 8.15, *Acceptable Programs for Respiratory Protection* (Revision 1, October 1999).

[12] USNRC Regulatory Guide 8.7, *Instructions for Recording and Reporting Occupational Radiation Exposure Data* (Revision 1, June 1992).

[13] USNRC Regulatory Guide 4.14, *Radiological Effluent and Environmental Monitoring at Uranium Mills* (Revision 1, April 1980).