Replacement Pages for
Section 2.7
Hydrology

Replace Section 2.7

Replace pages 2.7-1 through 2.7-54

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 2.7.3) 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.

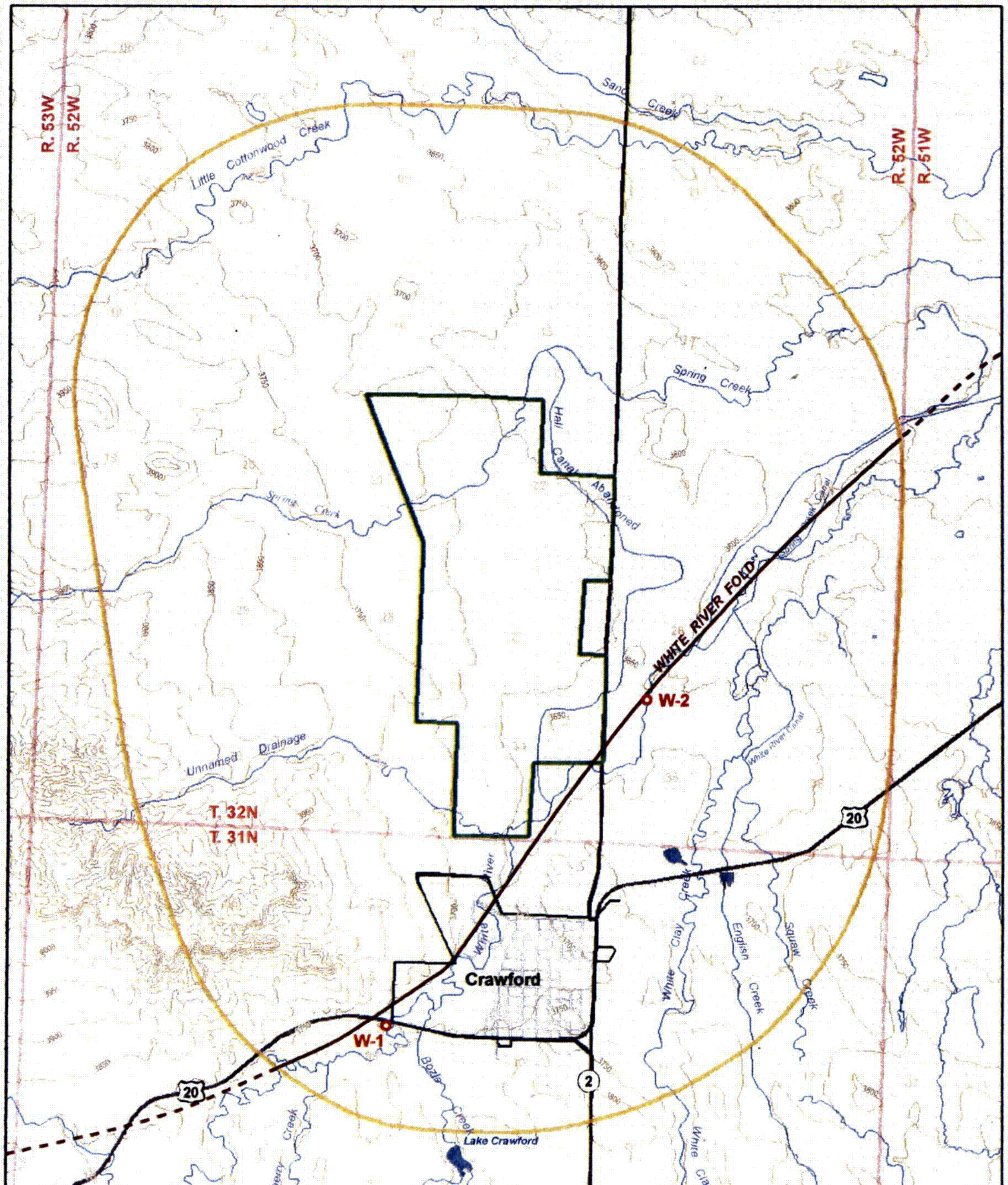
2.7.1.1 Location

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.



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

FILE: K:\.. _UIC\GIS\ArcMaps_TechRpt\2_7-1.MXD

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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, Nebraska, 1992 – 1995, part of 2003 and 2004

Month	1992 (Ft^3/sec)	1993 (Ft^3/sec)	1994 (Ft^3/sec)	1995 (Ft^3/sec)	2003 (Ft3/sec)	2004 (Ft3/sec)
January	21.4	20.7	21.4	20.3	no data	23
February	22.5	23.5	23	21.5	no data	24.8
March	22.3	31.2	23.3	19.7	no data	25.9
April	20	26.1	21.3	22.1	no data	22.7
May	18.8	19.7	19.6	27	no data	21.1
June	18.1	30.6	14	29.8	no data	17.1
July	15.6	25.3	12.3	18.5	no data	17.4
August	12.4	16.4	9.87	12.9	no data	11.3
September	12.4	17.8	11.1	13.6	no data	17.8
October	16	20.9	16.3	18.8	17.5	no data
November	18.8	21.2	17.9	19.8	22.6	no data
December	22.9	26.4	18.8	19.7	23.1	no data
Average	**18.4**	**23.3**	**17.4**	**20.3**	**21.6**	**20.1**

Note: data not available from 1995-2003 on USGS website (see http://waterdata.usgs.gov/nwis/sw)

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).

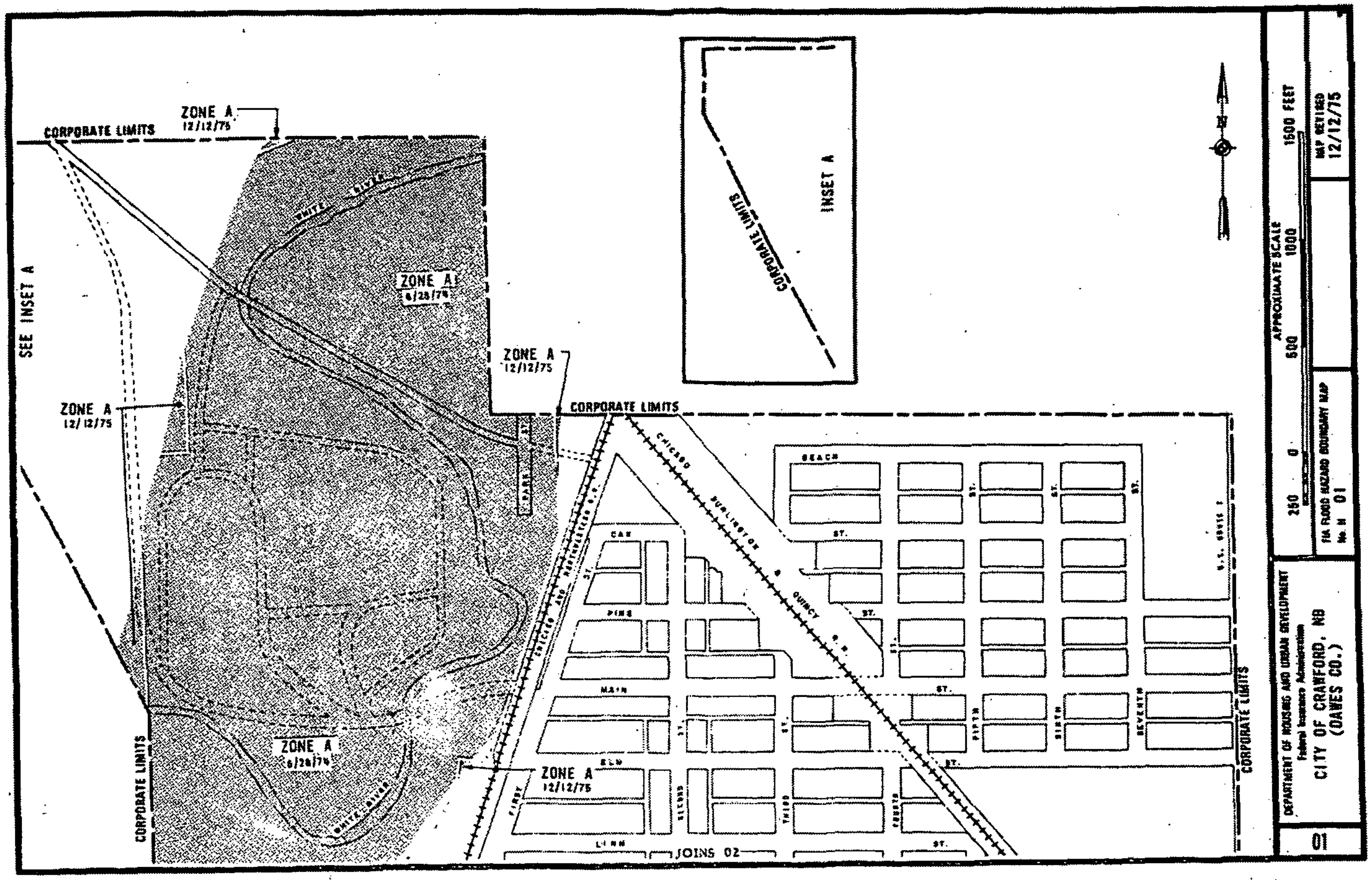
The proposed North Trend surface facilities are to be located in the north-central portion of Section 27, approximately one mile northwest of White River, and approximately 70 feet topographically above the common river elevation. Proposed wellfields are planned for portions of Sections 21, 22, 27, 28, 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

Figure 2.7-1a: FEMA Zone A Flood Map



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

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

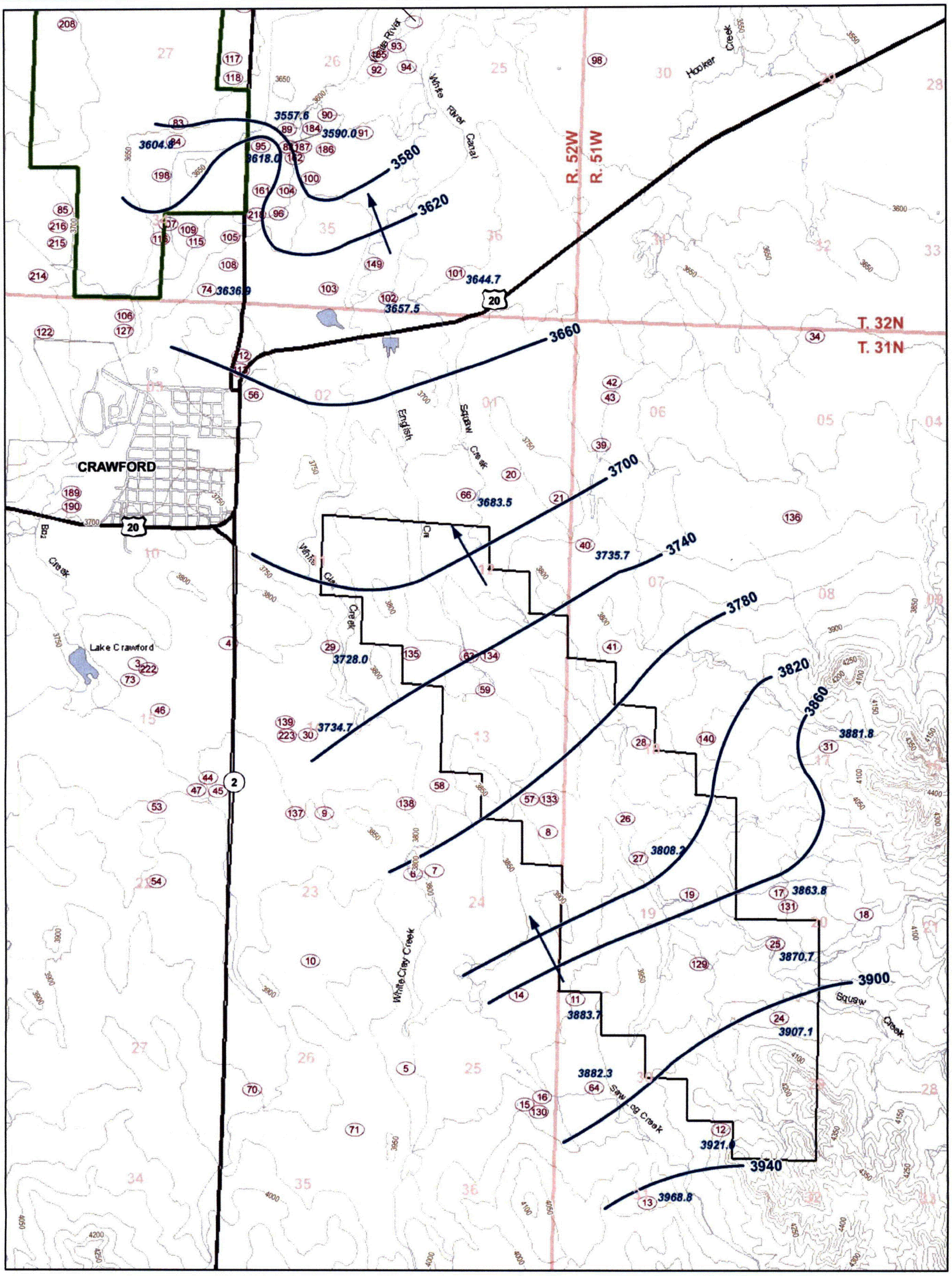
	1982 Sept	Oct	Nov	Dec	1983 Jan	Feb	March	April	May	June	July	August	Sept
RA-2	3737.1	3737	3738.5	3737.9	3739.2	3739.1	3739.7	3740.2	3740.9	3741	3739.9	3739.2	3738.1
RB-3	3962.6	3961.2	3963.5	3963.6	3963.8	3963.8	3963.3	3969.7*	3963.7	3963.7	3964.2	3964.1	3964.2
PM-6	------	3844.9	3844.9	------	3843.5*	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



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

N W E

0 3,000 6,000

Scale in Feet

CROW BUTTE RESOURCES, INC.

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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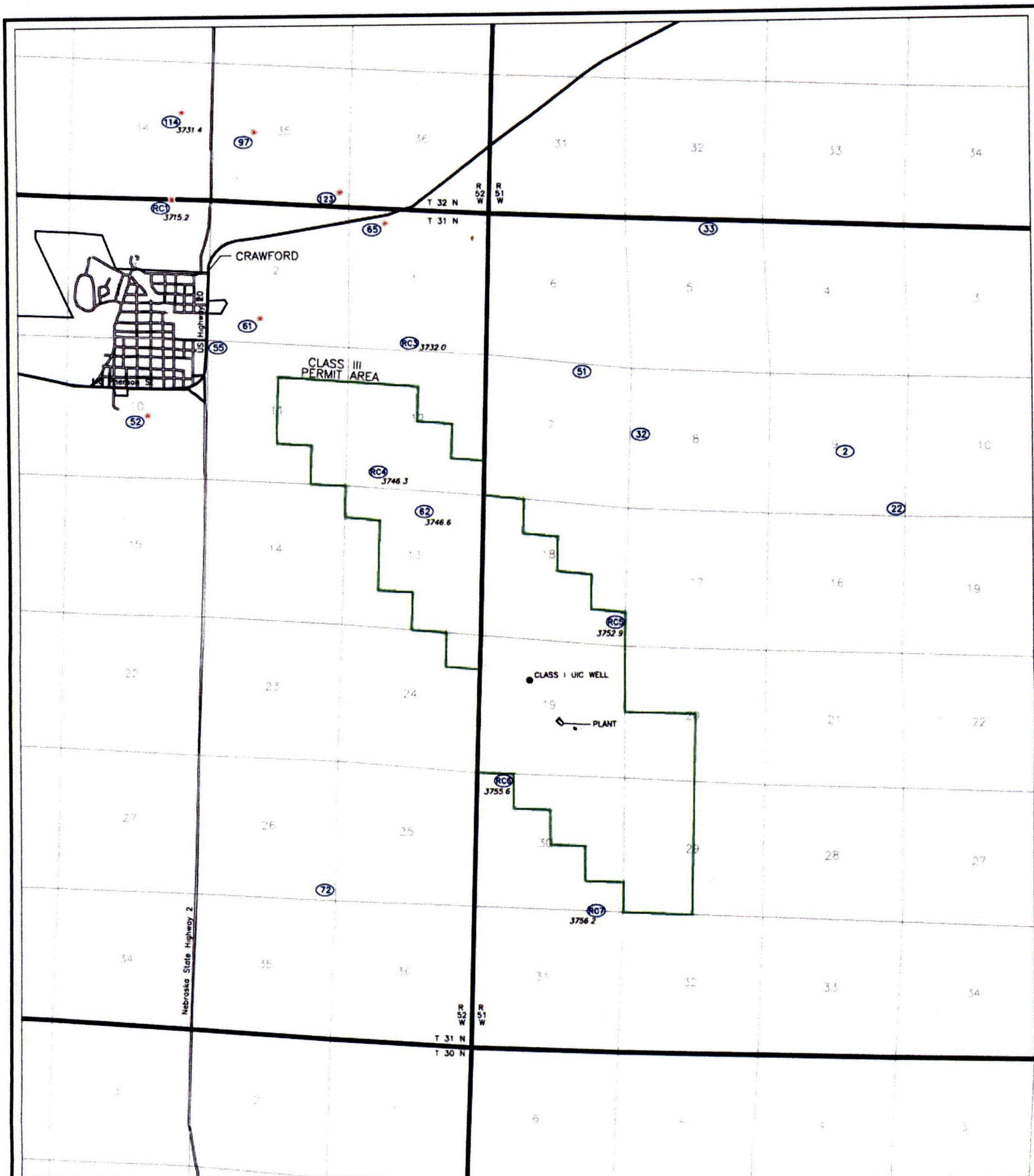


LEGEND

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

Petrotek

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).

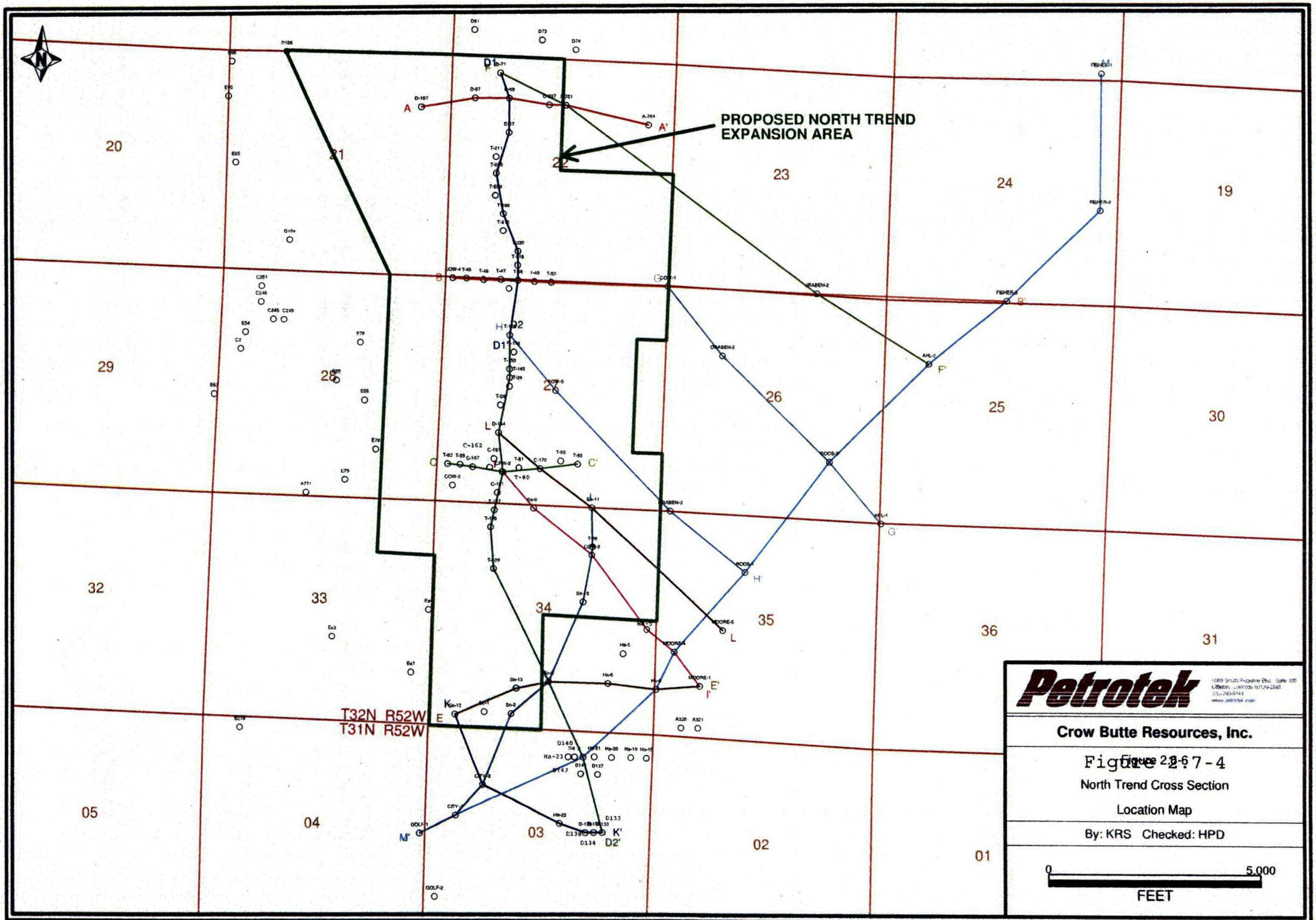
Regionally, the principal water bearing rocks below the Pierre Shale are the G Sand, J Sand, and the Dakota, Morrison and Sundance Formations. The Total Dissolved Solids (TDS) concentrations of the water below the Pierre Shale have been interpreted from deep oil and gas exploration logs. The Dakota Sandstone 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.



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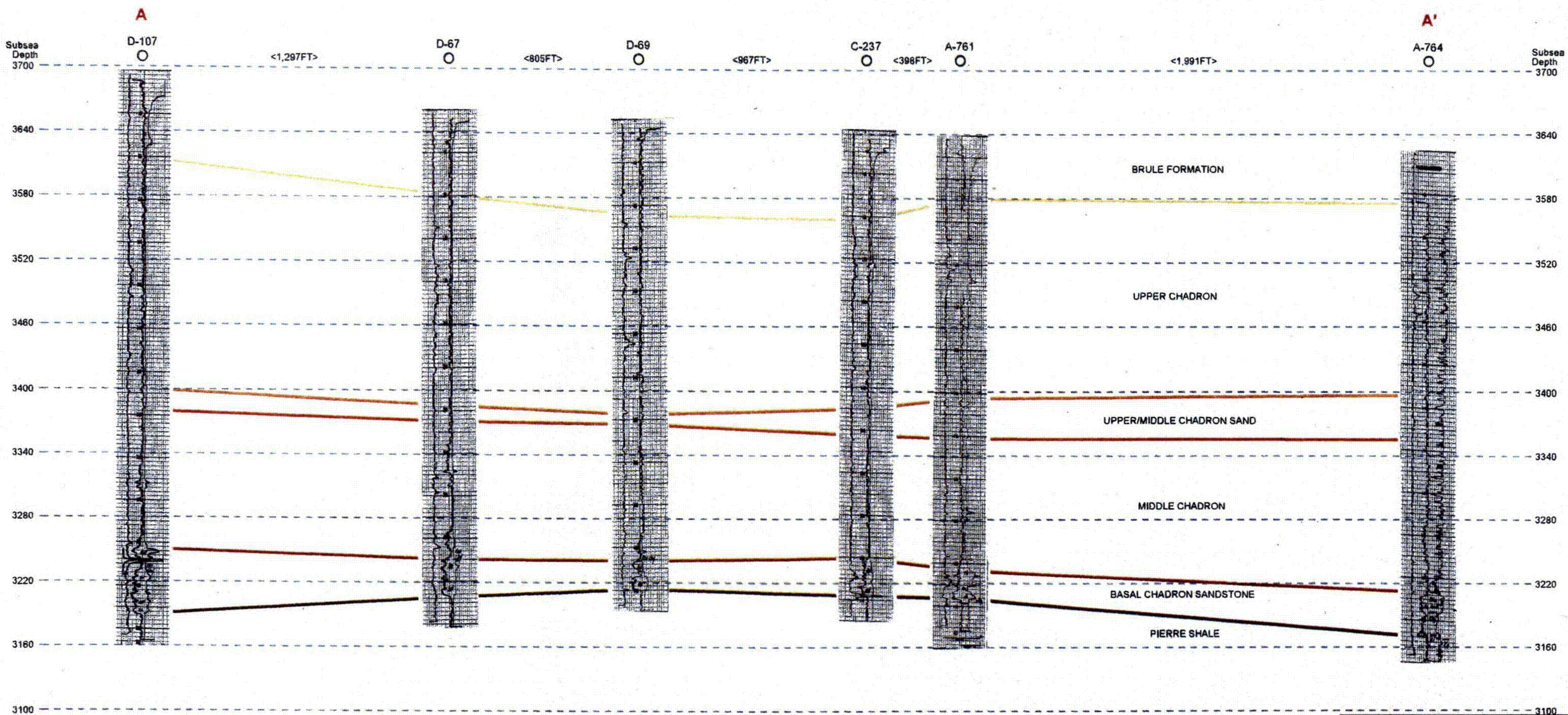

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License Amendment Application

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

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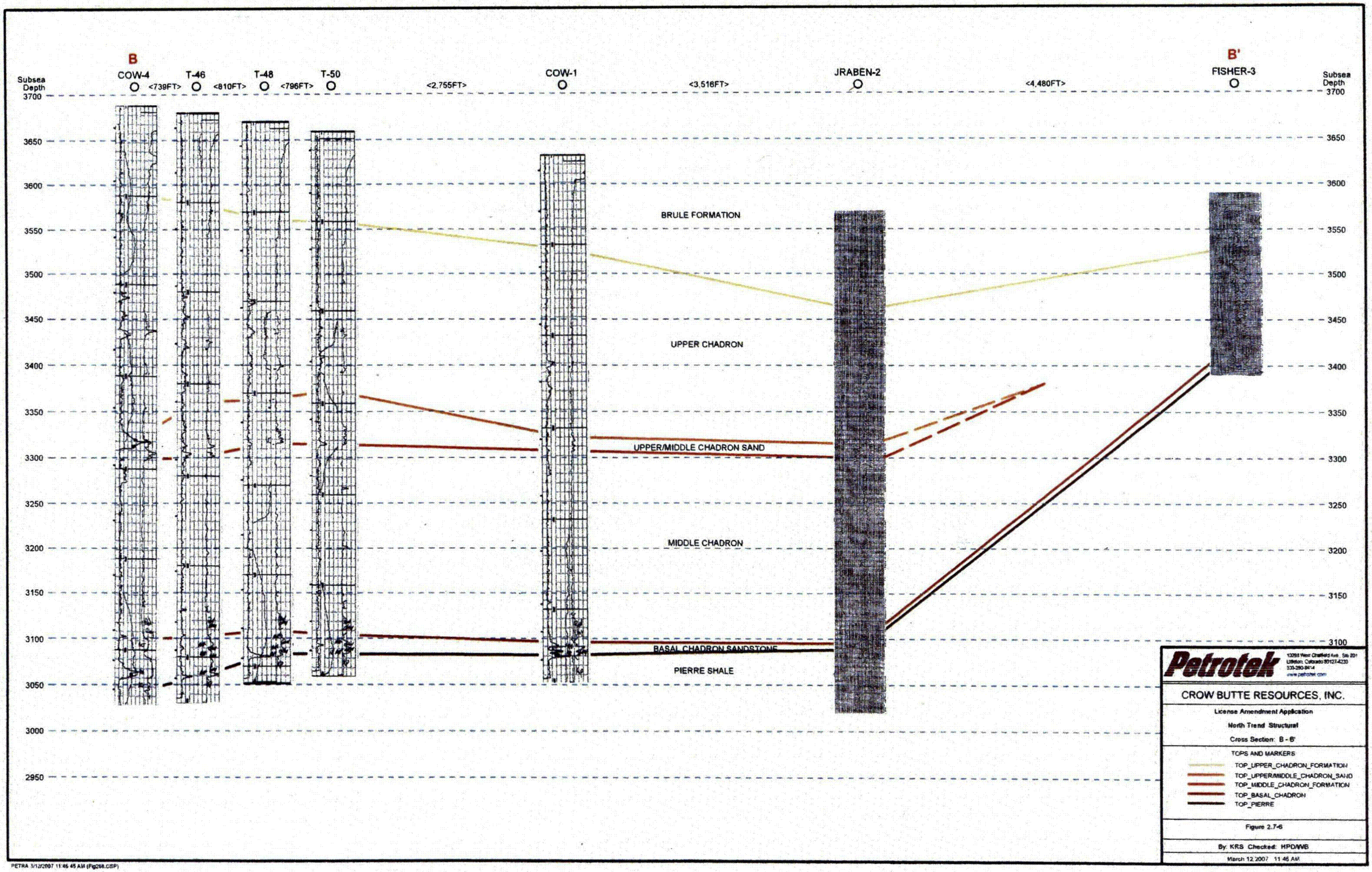

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North Trend Structural

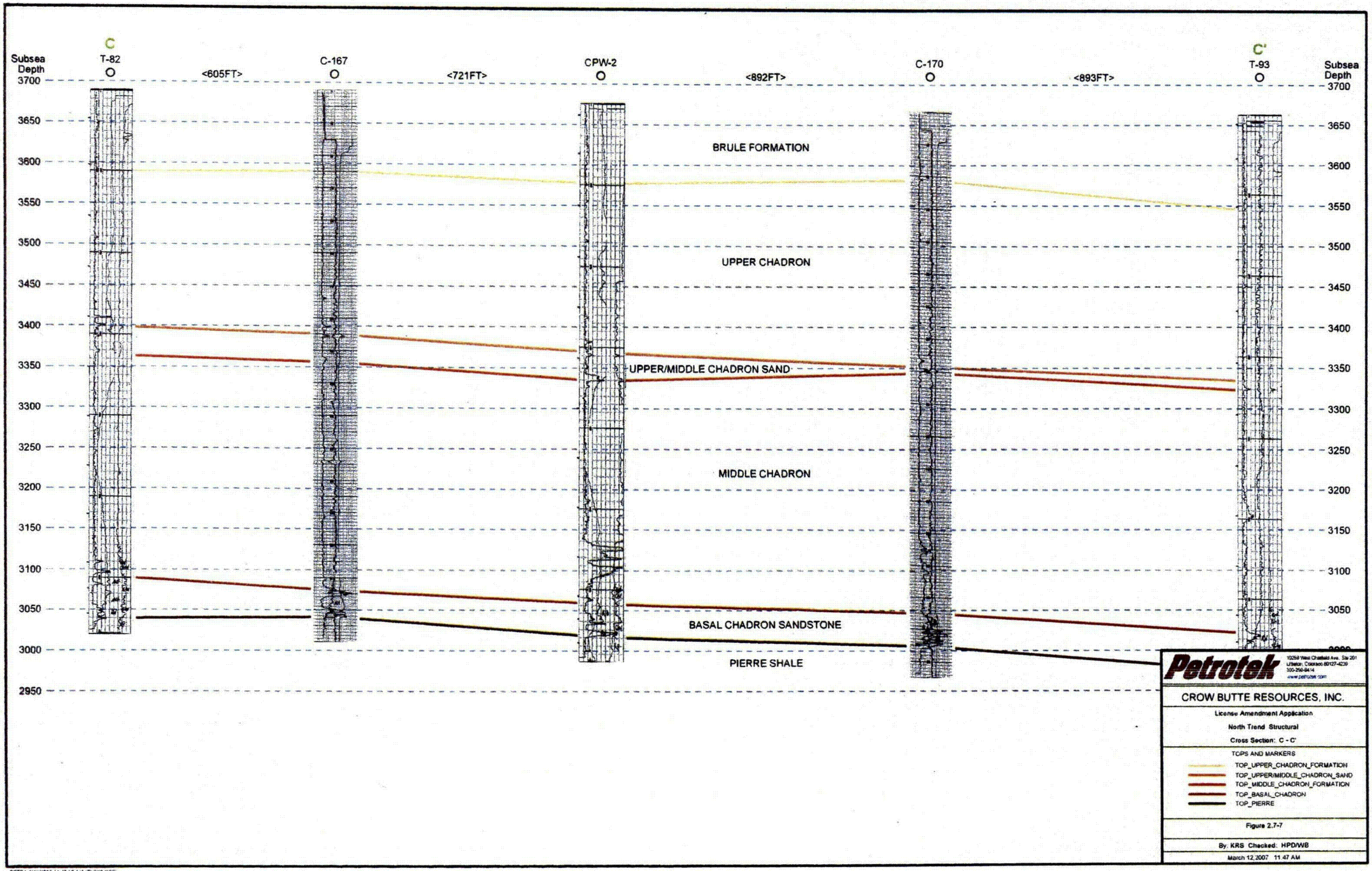
Cross Section: B - B'

Figure 2.7-6

By: KRS Checked: HPD/WB

March 12 2007 11:46 AM

PETRA 3/12/2007 11:46 45 AM (Fig258.CSP)



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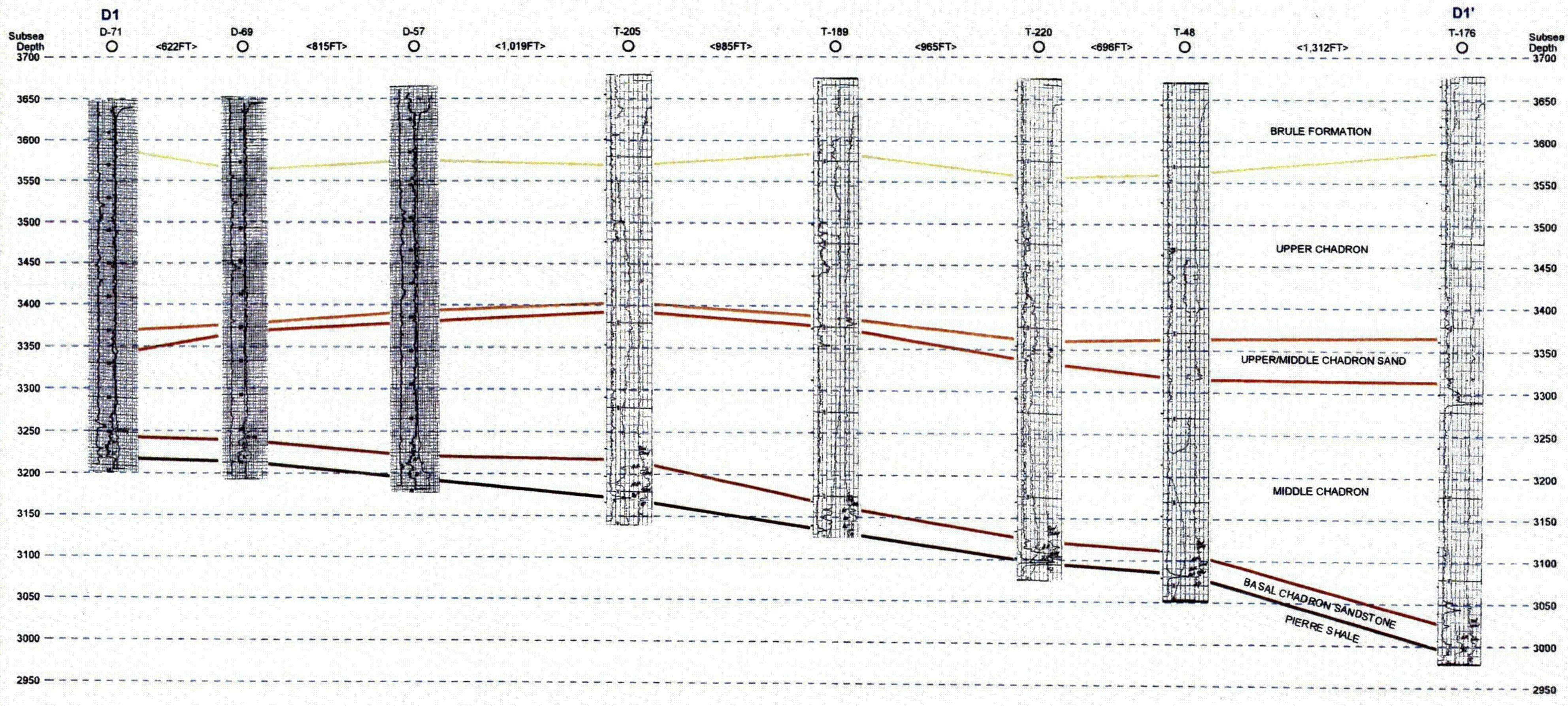

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North Trend Structural

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 2.7-6

By: KRS Checked: HPD/WB

March 13,2007 4:38 PM

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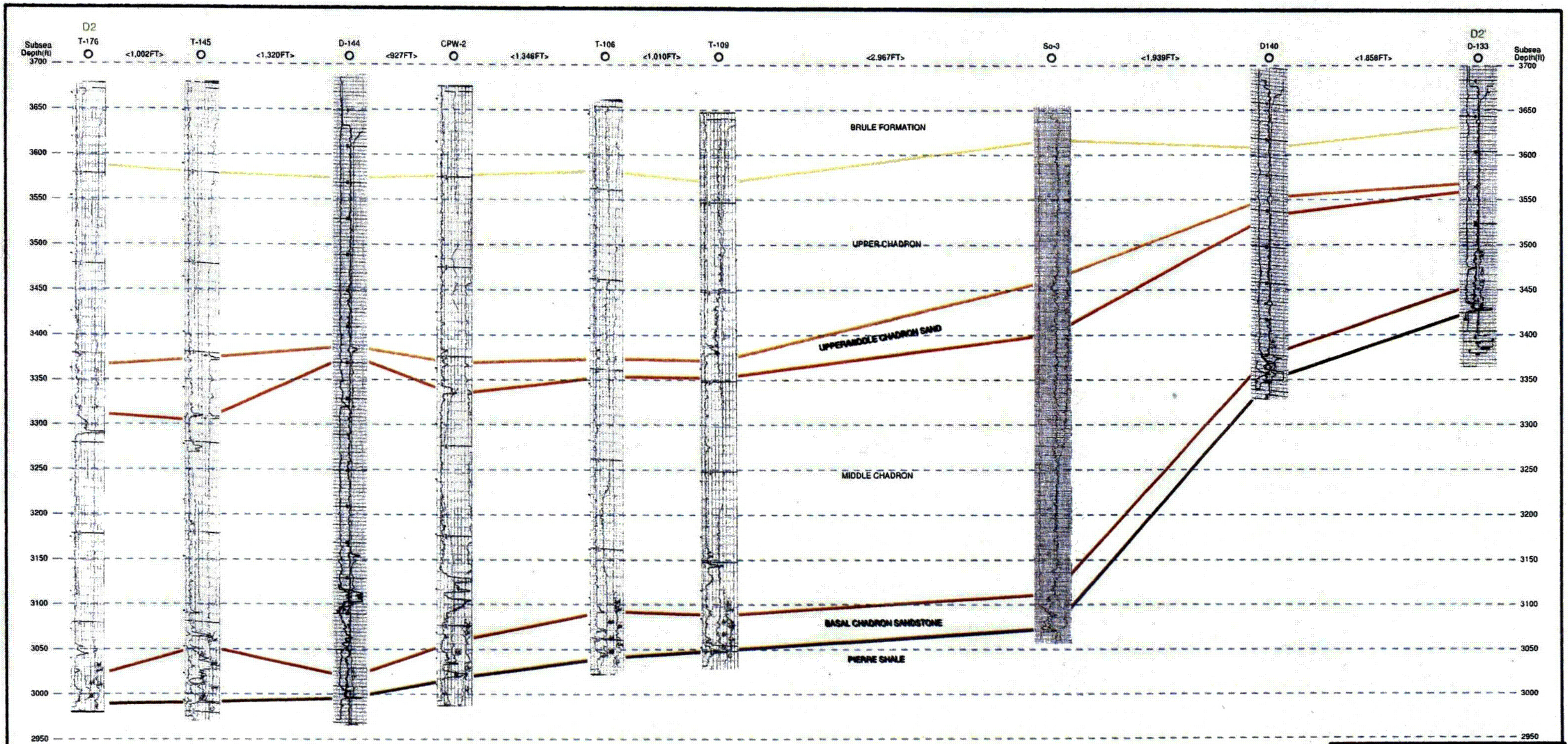

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North Trend Structural

Cross Section: D2 - D2'

TOPS AND MARKERS

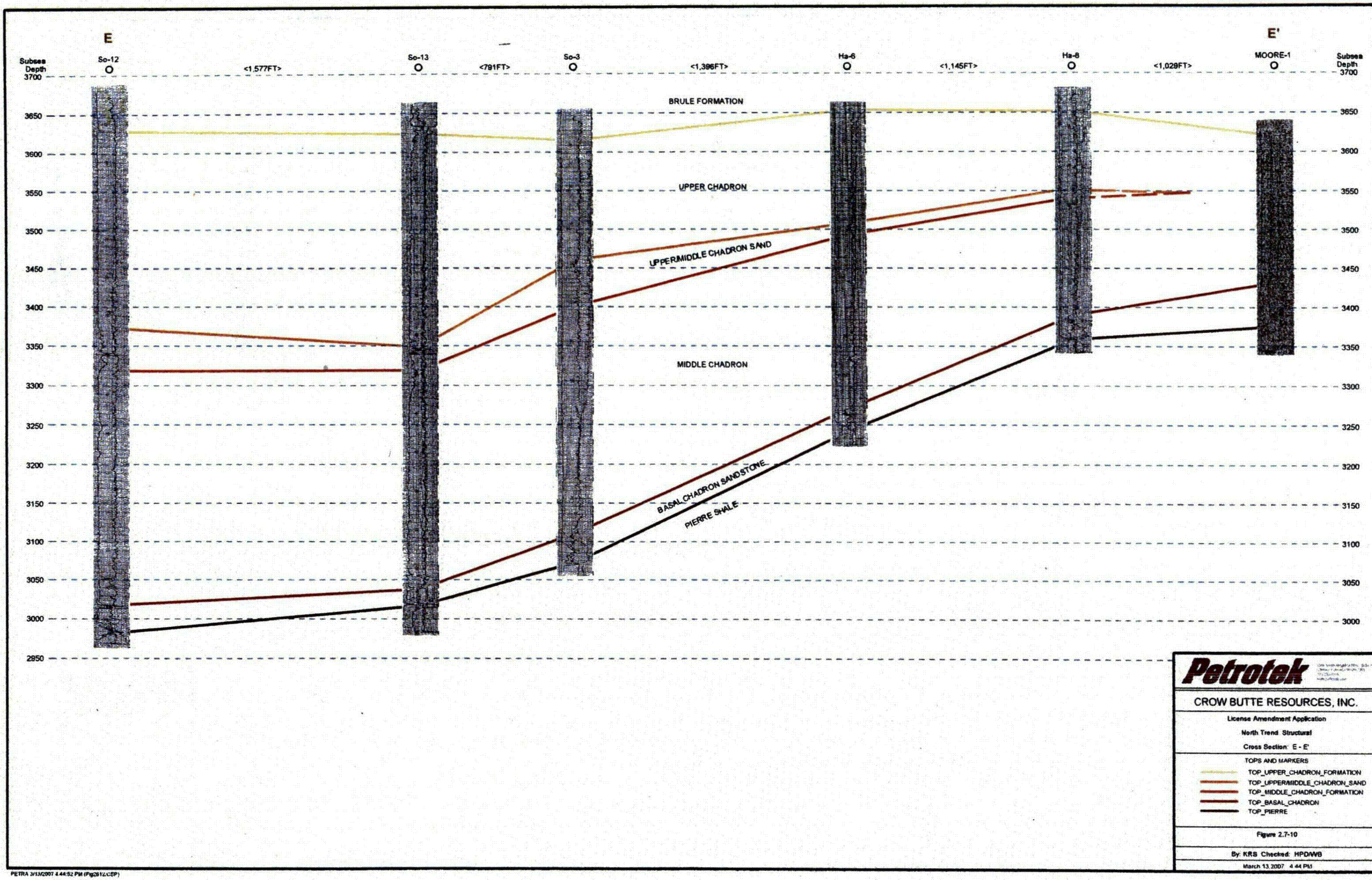
TOP_UPPER_CHADRON_FORMATION
TOP_UPPER/MIDDLE_CHADRON_SAND
TOP_MIDDLE_CHADRON_FORMATION
TOP_BASAL_CHADRON
TOP_PIERRE

Figure 2.7-9

By: KRS Checked: HPD/WB

April 2,2007 3:47 PM

PETRA 4/2/2007 3:47:42 PM (Fig2611.CSP)



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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	T-209	1081533.912	528183.78		3679.773		60	270	284	493	527
Cross Section	T-189	1081717.376	527738.07		3675.38		75	288	300	512	543
from the middle of	T-216	1081713.165	527332.21		3677.565		75	302	326	543	558
Section 22 through	T-220	1082063.03	526836.69		3674.948		73	315	340	553	579
Section 27 down to	T-218	1082053.79	526501.19		3668.89		56	330	345	567	583
the middle of	T-48	1082056.673	526140.59		3670.362		65	307	355	561	587
Section 34 T32N R 52W	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 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).

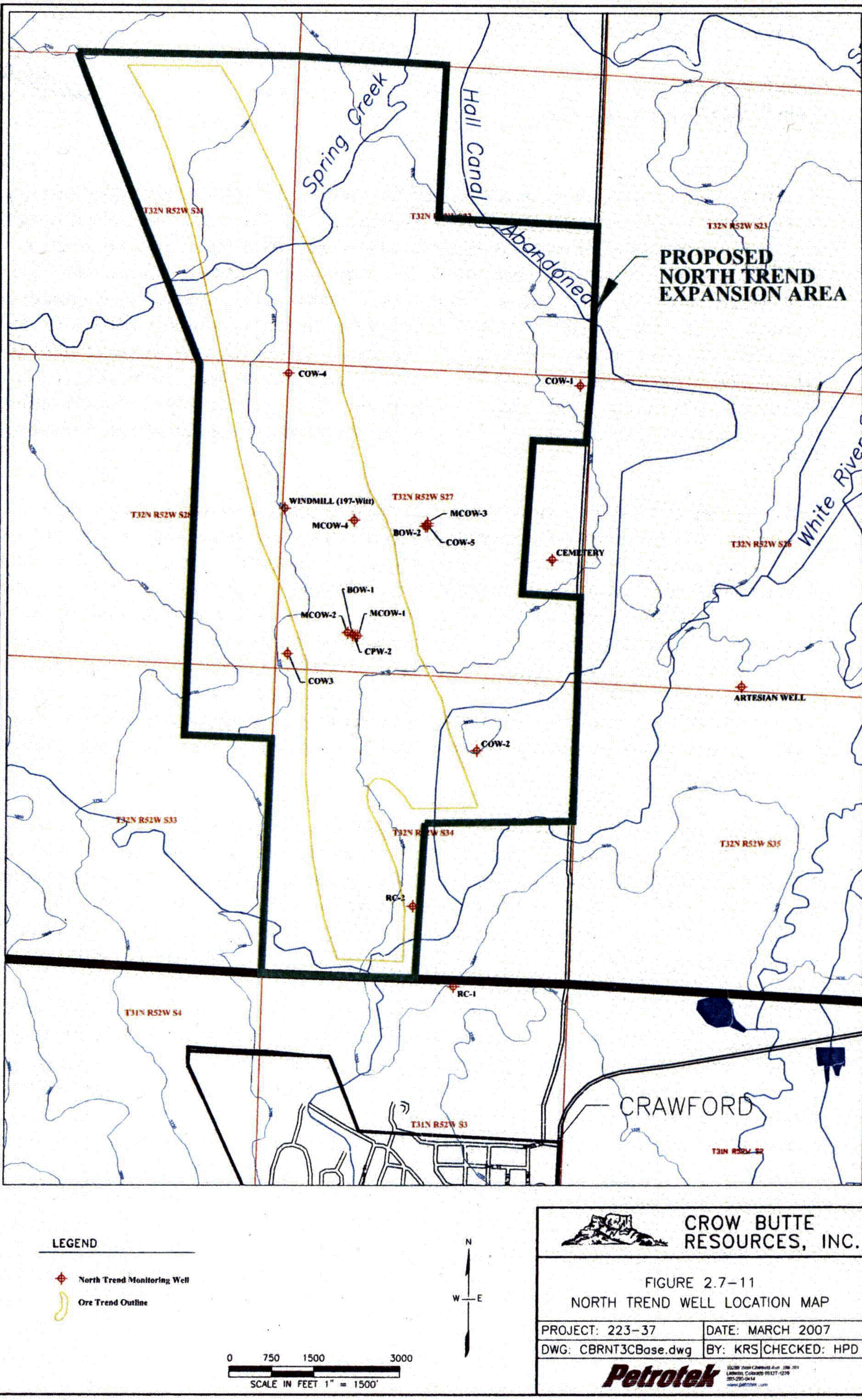

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FIGURE 2.7-11
NORTH TREND WELL LOCATION MAP

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

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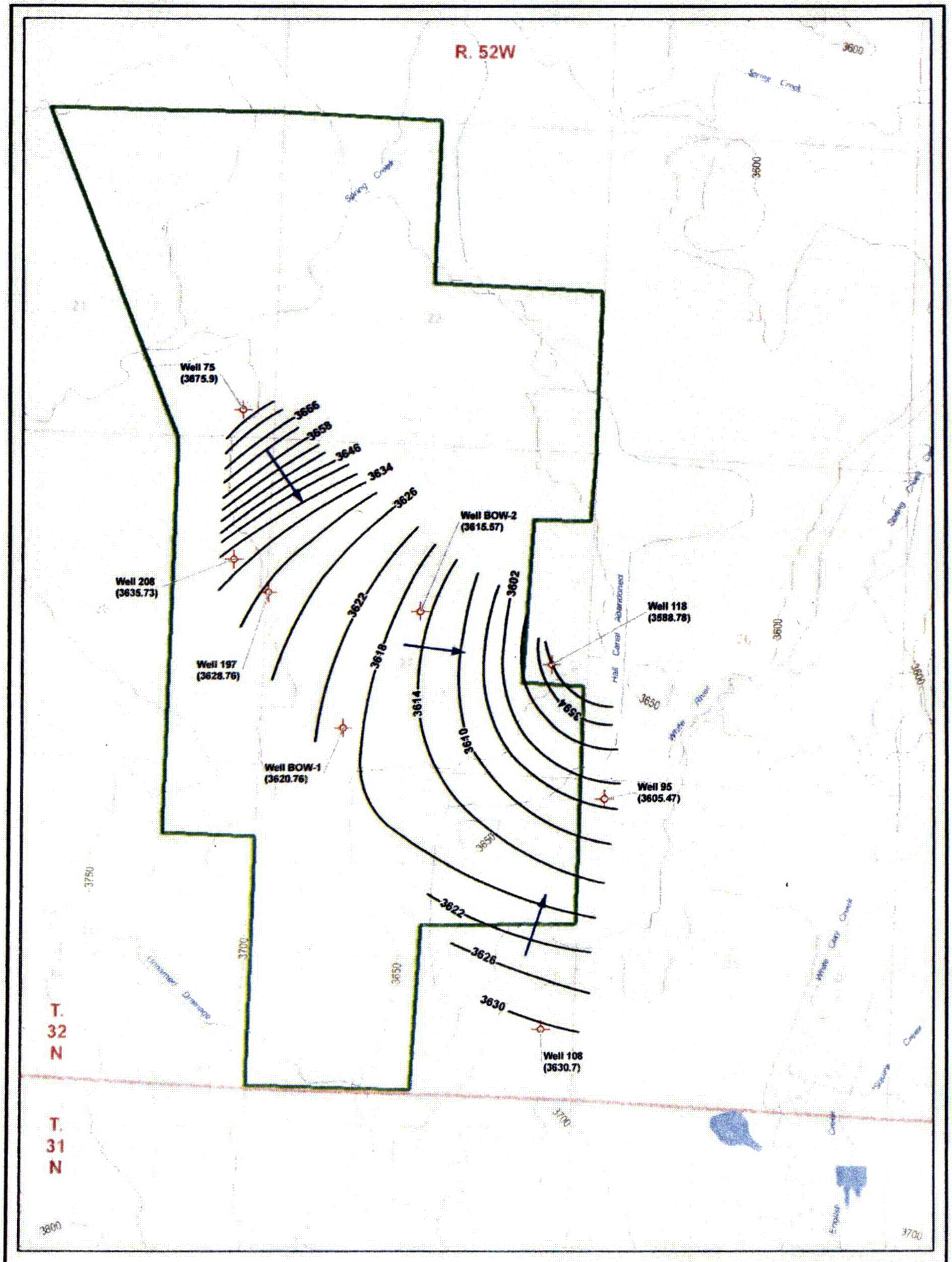

LEGEND

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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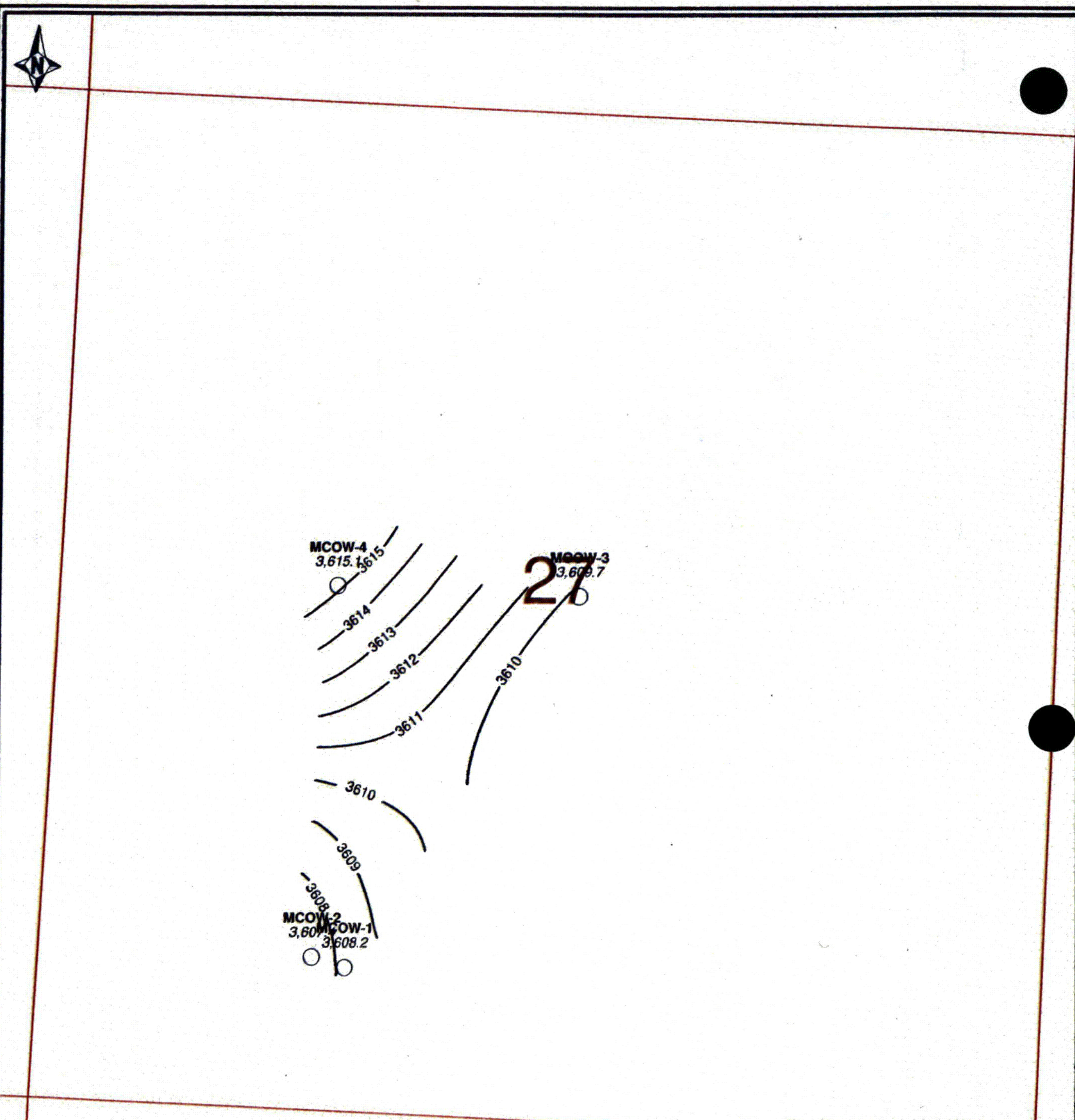

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Figure 2.7-13

North Trend Area Local Water Level Map

Middle Chadron Sandstone 02/16/07

REMARKS
Water Level Elevation in feet (amsl)
Contour Interval = 1'

By: KRS Checked: HPD

0 1,000
FEET

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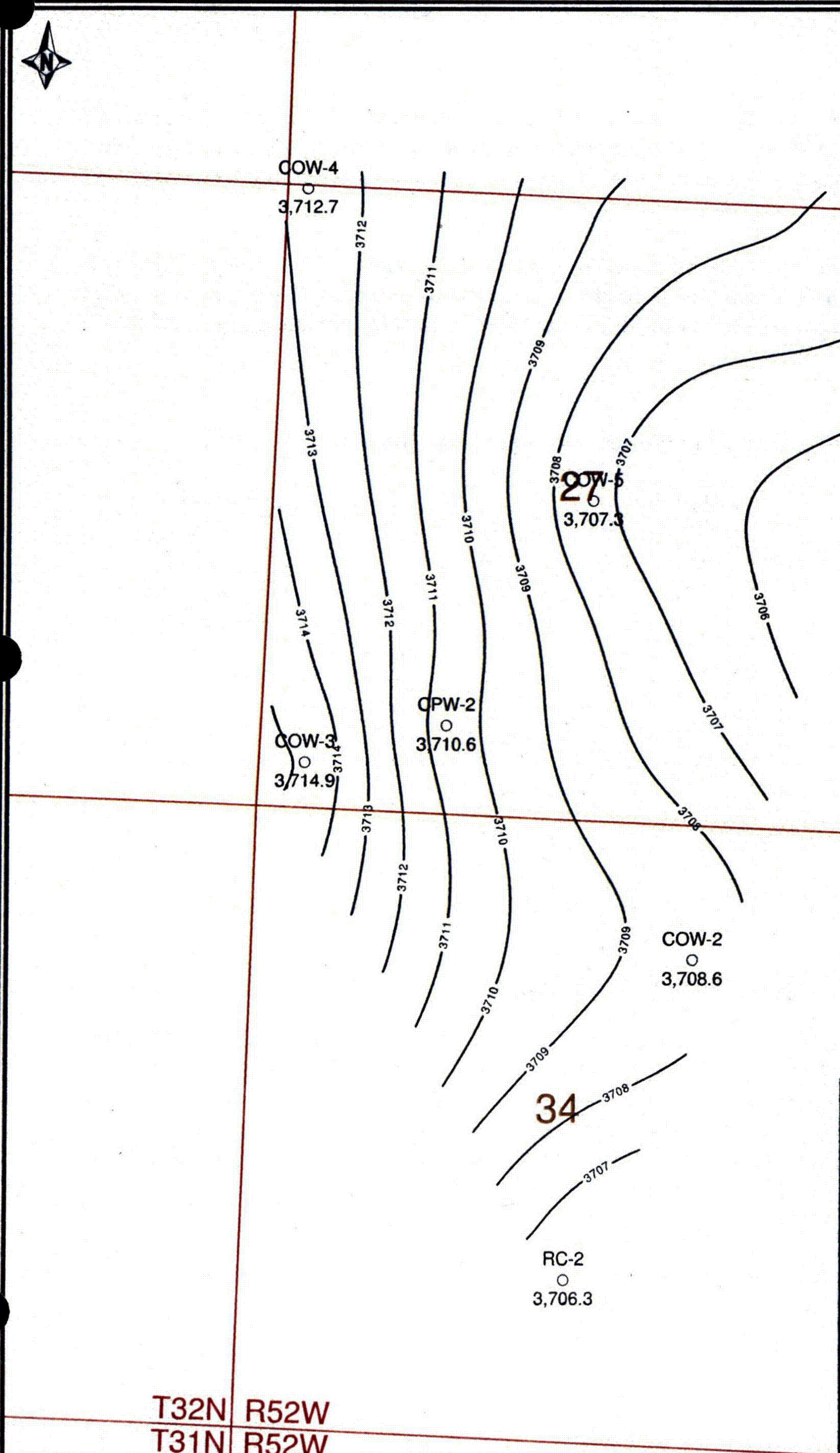

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Figure 2.7-14

North Trend Area Local Water Level Map

Basal Chadron Sandstone 02-16-07

REMARKS
Water Level Elevation in feet (amsl)
Contour Interval = 1'

By: KRS Checked: HPD

0 1,000 2,000
FEET

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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.

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)	138.56 3	91.513	168.52 7	161.91 2	154.55 2	172.51 4	160.29 1	172.77 6	no data	174.52 8	159.43 7

* 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

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

			RESULTS				
Nickel (Ni)	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	<0.05
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.

2.7.5 REFERENCES

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http://msc.fema.gov

Replacement Pages for
Section 2.9
Background Radiological Characteristics

Replace Section 2.9, pages 2.9-1 through 2.9-54

Includes new Figure 2.9-4

2.9 BACKGROUND RADIOLOGICAL CHARACTERISTICS

2.9.1 Introduction

This section discusses the environmental sampling program that CBR implemented to assess preoperational radiological background conditions in the vicinity of the North Trend Expansion Area. 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 expansion facilities.

Initial background radiological monitoring in the North Trend Expansion Area was performed over a period of one year beginning in July 1996 and lasting until June 1997. As part of this 1996 monitoring program, samples were collected and analyzed for the concentration of radionuclides in the pre-mining environment. The program was designed to meet the criteria outlined in USNRC Regulatory Guide 4.14[1] and was described in a preoperational environmental monitoring plan[2]. 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 by CBR in the project 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 North Trend Expansion Area between July 2004 and June 2005. The purpose of this monitoring was to incorporate the guidance contained in NUREG-1569[3] and 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.

The pre-mining North Trend data collected in 1996 and 2004 indicates 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 operational monitoring sites proposed for the North Trend satellite facility will be the same as those used to determine preoperational concentrations of radon in 2004. Operational monitoring of radon concentrations will continue as long as uranium recovery and restoration activities are in progress.

The results of the North Trend Expansion Area preoperational radiological monitoring are presented in this section. The results 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

USNRC Regulatory 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 selected in 1996 as follows:

- One sample at the nearest affected residence to the projected location of the satellite plant (location NE-1);
- Four samples at the approximate 1996 North Trend Expansion license boundary locations (locations NE-2 through NE-5); and
- The background location recommended by Regulatory Guide 4.14. This location was identified as AM-6, which is used as the background control location for the current licensed operation. AM-6 is located on the eastern edge of the Town of Crawford and is approximately one mile from the southern boundary of the North Trend Expansion Area.

CBR based the sample locations for the radon air monitoring program on the projected satellite plant 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. Data sources for the meteorological conditions are the Climatological Summary for Chadron, Nebraska and an on-site monitoring station which was located near the Crow Butte facility. The monitoring station on the Crow Butte site 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 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 plant location. As can be seen in the wind rose presented in Section 2.5 for the Crow Butte Project, 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.

Figure 2.9-1 contains a map of the North Trend Expansion Area showing the 1996 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).

In general, the 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 plant 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 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.

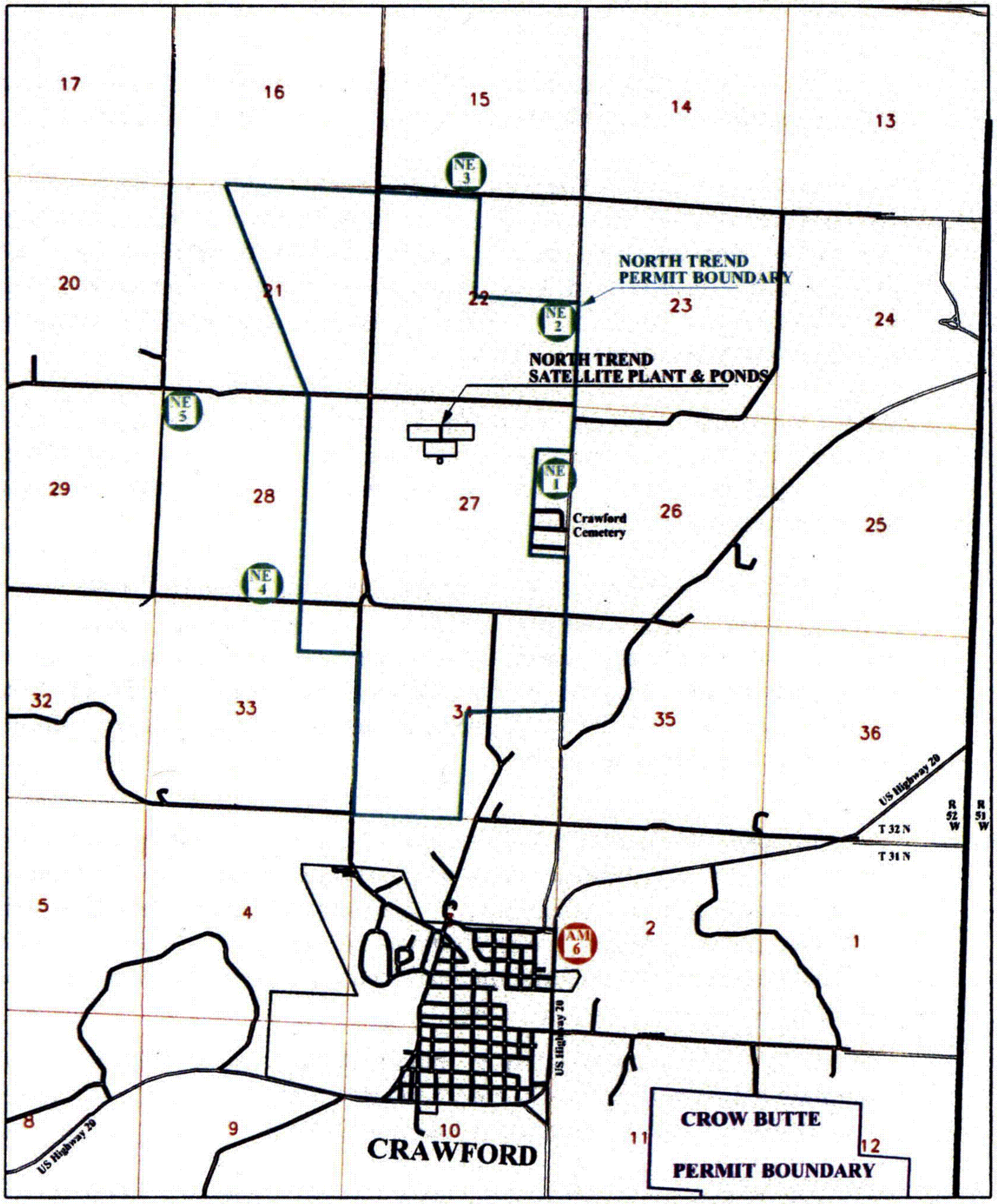
- NE-3 was determined to be unnecessary due to the location of AM-10 at the north boundary and was not monitored in 2004.

- NE-4 was moved approximately ½ mile east to a nearby residence that is in close proximity to the proposed satellite plant location. NE-4 was redesignated AM-12.

- NE-5 was redesignated AM-11 and was used to monitor the west license boundary.

FIGURE 2.9-1

1996 - 1997 Preoperational Radiological Sampling Locations



Air Monitoring Stations

AM-6 - Radon, Gamma, Air Particulates (Control Station)
NE-1 - Radon, Gamma
NE-2 - Radon, Gamma
NE-3 - Radon, Gamma
NE-4 - Radon, Gamma
NE-5 - Radon, Gamma

SCALE 0 ½ 1 1½ 2 MILES

N

FIGURE 2.9-1

CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

1996 – 1997 Preoperational Radiological Sampling Locations

Prepared By : WB

Drawn By: WB **Date: 1/07**

- 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 town 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 town 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 North Trend Expansion Area showing the 2004 monitoring locations.

2.9.2.2 Radon Gas Monitoring Program

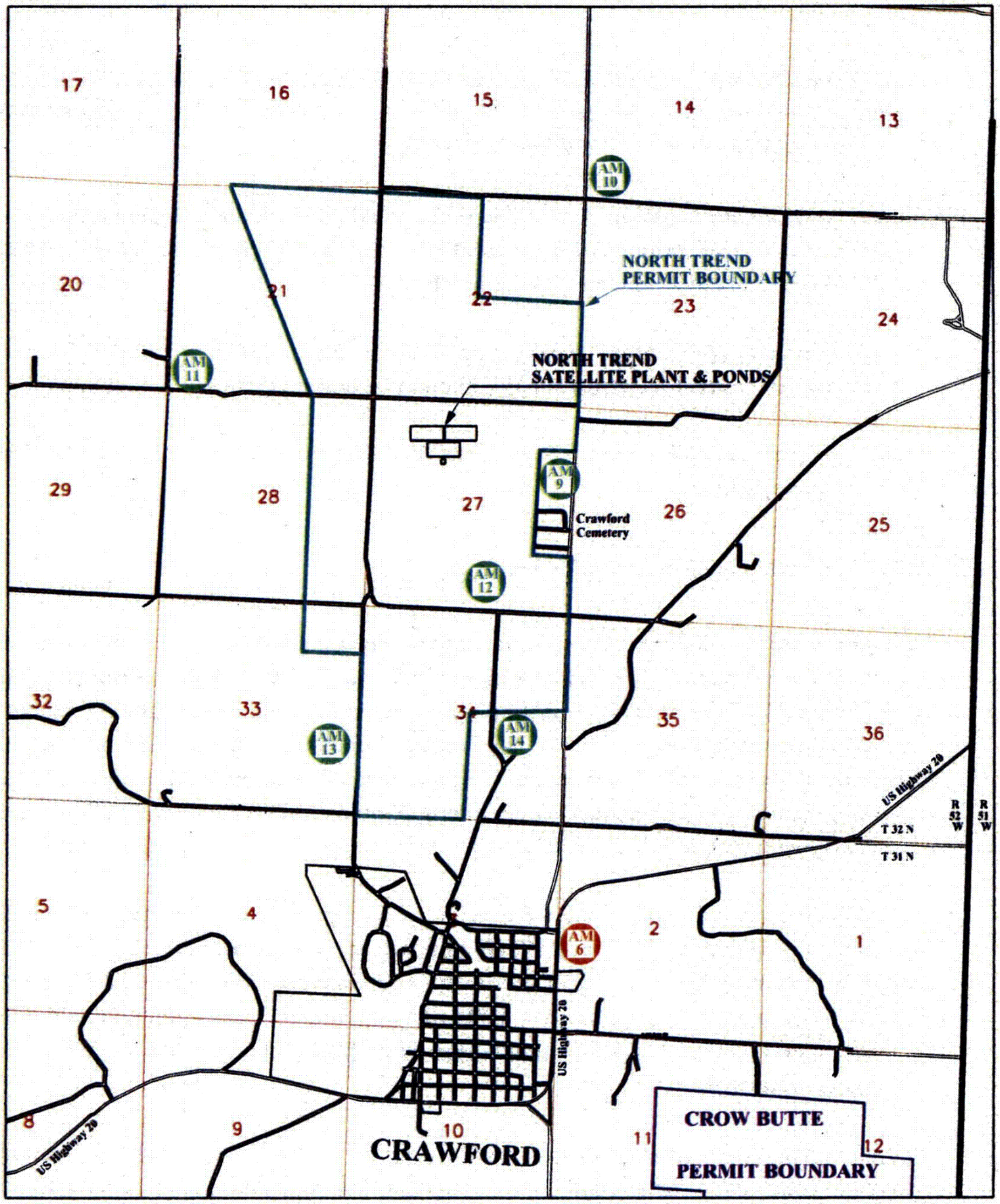
Air monitoring in 1996 involved radon gas sampling performed at quarterly intervals at air monitoring locations NE-1 through NE-5 and AM-6. Monitoring was performed using RadTrak® Type DRNF outdoor air radon detectors. RadTrak® cups contain a sensitized chip covered with a selectively permeable material 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 Regulatory Guide 4.14 and to be consistent with the semiannual intervals approved by NRC for the current operational monitoring.

Air monitoring for radon gas was performed for the North Trend Expansion Area 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 radon sampling are presented in Table 2.9-1.This table gives the concentration of radon in air that were 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.

FIGURE 2.9-2
2004 - 2005 Preoperational Radiological Sampling Locations



Air Monitoring Stations

AM-6 - Radon, Gamma, Air Particulates (Control Station)
AM-9 - Radon, Gamma
AM-10 - Radon, Gamma, Air Particulates
AM-11 - Radon, Gamma
AM-12 - Radon, Gamma
AM-13 - Radon, Gamma
AM-14 - Radon, Gamma

SCALE 0 1/2 1 1 1/2 2 MILES

N

FIGURE 2.9-2

CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

2004 - 2005 Preoperational Radiological Sampling Locations

Prepared By : WB

Drawn By: WB **Date: 1/07**

Table 2.9-1

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

Table 2.9-1 (continued)
Ambient Atmospheric Radon-222 Concentration
North Trend Expansion Area (1996 – 1997)

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
Second Quarter 1997			
Location	**Date**	**Concentration μCi/ml x 10^{-9}**	**Error Estimate μCi/ml x 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

Table 2.9-1 (continued)
Ambient Atmospheric Radon-222 Concentration
North Trend Expansion Area (1996 – 1997)

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

The results of the 2004 radon sampling are presented in Table 2.9-2. 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.

Table 2.9-2: 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

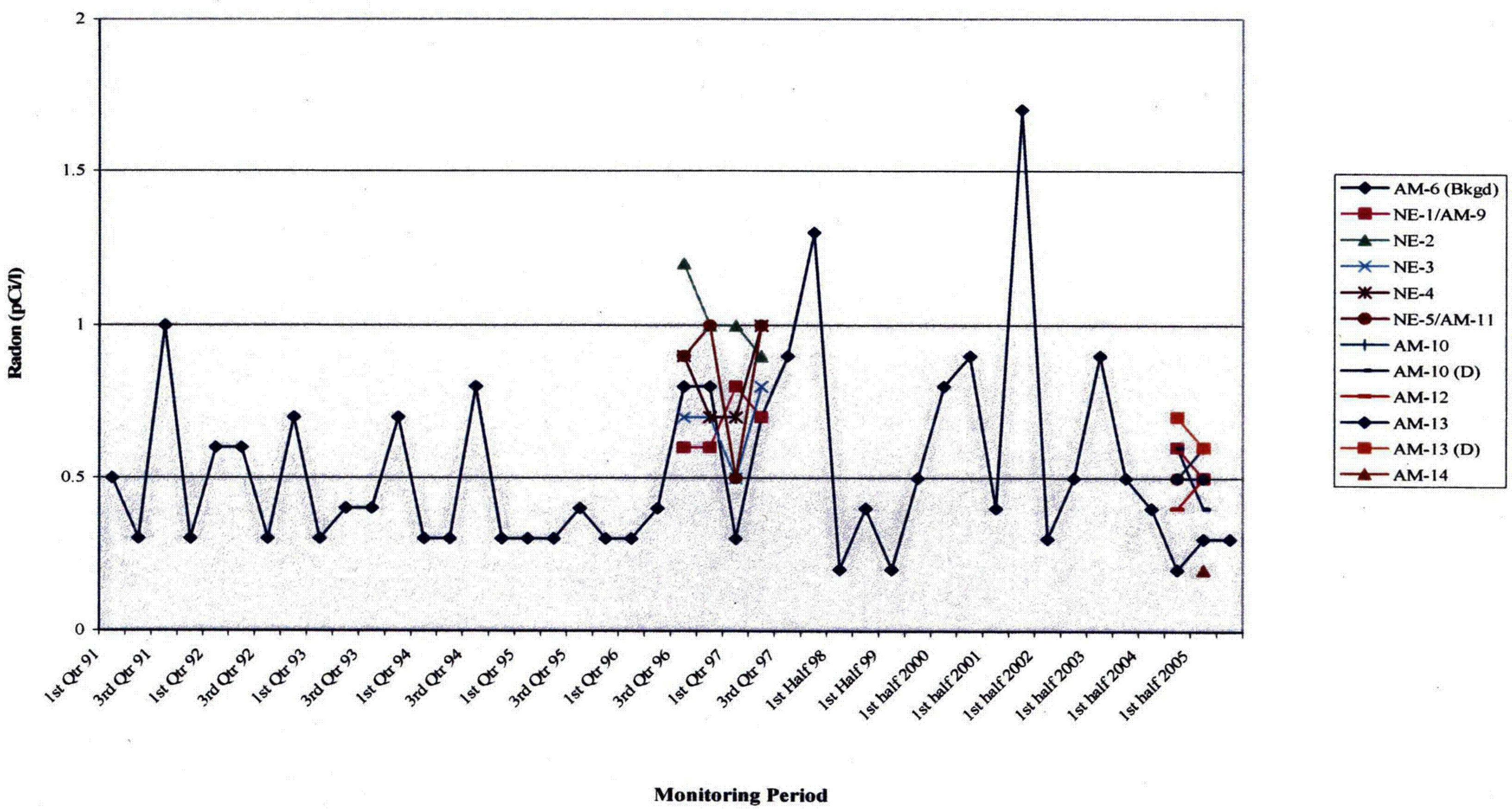
Mean 2004 – 2005 Radon Concentration	
Location	Mean Concentration $\mu Ci/ml \times 10^{-9}$
AM-6 (Bkgd)	0.25
AM-9 (NE-1)	0.55
AM-10	0.55
AM-10 (D)	0.50
AM-11 (NE-5)	0.50
AM-12	0.45
AM-13	0.50
AM-13 (D)	0.65
AM-14	0.2

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 2.9-3 is a plot of the results of radon monitoring from the North Trend air monitoring locations from the 1996 and 2004 baseline programs. The monitoring results for the background station AM-6 from January 1991 through June 2005 are also included for comparison.

The operational monitoring sites proposed for the North Trend satellite facility will be the same as those used to determine preoperational concentrations of radon in 2004. Operational monitoring of radon concentrations will continue as long as uranium recovery and restoration activities are in progress.

Figure 2.9-3
North Trend Baseline Environmental Radon Monitoring



2.9.2.3 Air Particulate Monitoring Program

For the 1996 baseline monitoring program, CBR determined that air particulate monitoring was not appropriate for the North Trend Expansion Area. Activities at North Trend will involve the operation of a satellite facility, which will not include drying, handling, or packaging of yellowcake. All drying and packaging operations will be performed at the current Central Plant facility. Therefore, there are no operations at the satellite plant that could cause a release of airborne particulate radionuclides and the 1996 monitoring program did not include air particulate monitoring.

For the 2004 monitoring period, CBR determined in discussions with USNRC staff that it would be useful to add a baseline preoperational air particulate monitoring station at the north end of the North Trend Expansion Area to provide additional regional background radiological information. This air monitoring station was designated as AM-10. Data from this station may be compared with air particulate data from AM-6, which is located south of the North Trend Expansion Area 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 standard Chain of Custody Procedures. 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 USNRC Regulatory 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 is 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 Uranium Project.

As discussed with NRC staff in 2004, CBR does not propose 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 will continue airborne particulate sampling at the air monitoring stations AM-1 through AM-8 for the current license area to monitor drying and packaging operations at the central processing Plant.

Air particulate monitoring for the North Trend Expansion Area was performed at locations AM-6 (background) and AM-10 (north boundary) during the third and fourth quarters of 2004 the first and second quarters of 2005. The results of the air particulate sampling are presented in Table 2.9-3. This table gives the concentrations of natural uranium, radium-226, and lead-210 in air that were obtained at the air monitoring stations.

2.9.2.4 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}
Radon-222	2×10^{-10}	3×10^{-10} (1996 - 1997 data) 2×10^{-10} (2004 - 2005 data)
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.

Table 2.9-3

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 2.9-3 (continued)

Airborne Particulate Concentrations
North Trend Expansion Area (2004 - 2005)

Location	Radionuclide	Date	Concentration µCi/ml	Error Estimate µCi/ml	LLD µCi/ml
Second Quarter 2005					
AM-6	Uranium	4/1/05 – 7/5/05	1.24 E^{-16}	N/A	1.00 E^{-16}
	Radium 226		<1.00 E^{-16}	N/A	1.00 E^{-16}
	Lead 210		1.08 E^{-14}	1.27 E^{-15}	2.00 E^{-15}
AM-10	Uranium	4/1/05 – 7/5/05	1.81 E^{-16}	N/A	1.00 E^{-16}
	Radium 226		<1.00 E^{-16}	N/A	1.00 E^{-16}
	Lead 210		1.22 E^{-14}	1.29 E^{-15}	2.00 E^{-15}

2.9.3 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 North Trend Expansion Area 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 2.9-4.

Table 2.9-4: 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

CBR updated the water user survey for the current license area, the North Trend area, and the town 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 EPA Guidelines. 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 2.9-5 contains the results of the analyses for radionuclides for all private wells sampled for the North Trend Expansion Area 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.

Table 2.9-5
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 2.9-5 (continued)
Private Well Monitoring
Fourth Quarter 1996

Location	Radionuclide	Date	Concentration $\mu Ci/ml \times 10^{-9}$	Error Estimate $\mu Ci/ml \times 10^{-9}$	LLD $\mu Ci/ml \times 10^{-9}$
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 2.9-5 (continued)
Private Well Monitoring
First Quarter 1997

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 2.9-5 (continued)
Private Well Monitoring
Second Quarter 1997

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 2.9-5 (continued)
Private Well Monitoring
Third Quarter 2004

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 2.9-5 (continued)
Private Well Monitoring
Fourth Quarter 2004

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 2.9-5 (continued)
Private Well Monitoring
First Quarter 2005

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 2.9-5 (continued)
Private Well Monitoring
Second Quarter 2005

Location	Radionuclide	Date	Concentration $\mu Ci/ml \times 10^{-9}$	Error Estimate $\mu Ci/ml \times 10^{-9}$	LLD $\mu Ci/ml \times 10^{-9}$
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 2.9-5 (continued)
Private Well Monitoring
Third Quarter 2005

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

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 North Trend Expansion Area 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 North Trend Expansion Area (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.

2.9.3.1 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 USNRC also specifies analytical quality requirements in USNRC Regulatory 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 x 10^{-10}	2 x 10^{-10}
Thorium-230	2 x 10^{-10}	2 x 10^{-10}
Radium-226	2 x 10^{-10}	2 x 10^{-10}
Polonium-210	1 x 10^{-9}	1 x 10^{-9}
Lead-210	1 x 10^{-9}	1 x 10^{-9}

2.9.4 Baseline Surface Water Monitoring

The White River is located south of the North Trend Expansion Area, with the river flowing in close proximity to the southern end of the NTEA project boundary (Figure 2.7-1). CBR performed preoperational monitoring on the White River at sampling locations W-1, and W-2, as shown in Figure 2.7-1. 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, south 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 2.7-1).

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 NRC[4]. 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 2.9-6). 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.

Table 2.9-6
Surface Water Monitoring

Location	Radionuclide	Date	Concentration $\mu Ci/ml \times 10^{-9}$	Error Estimate $\mu Ci/ml \times 10^{-9}$	LLD $\mu Ci/ml \times 10^{-9}$
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 2.9-6 (continued)
Surface Water Monitoring

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.

2.9.4.1 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 USNRC also specifies analytical quality requirements in USNRC Regulatory 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

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 2.9-7. 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

Table 2.9-7
Vegetation Monitoring

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

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.

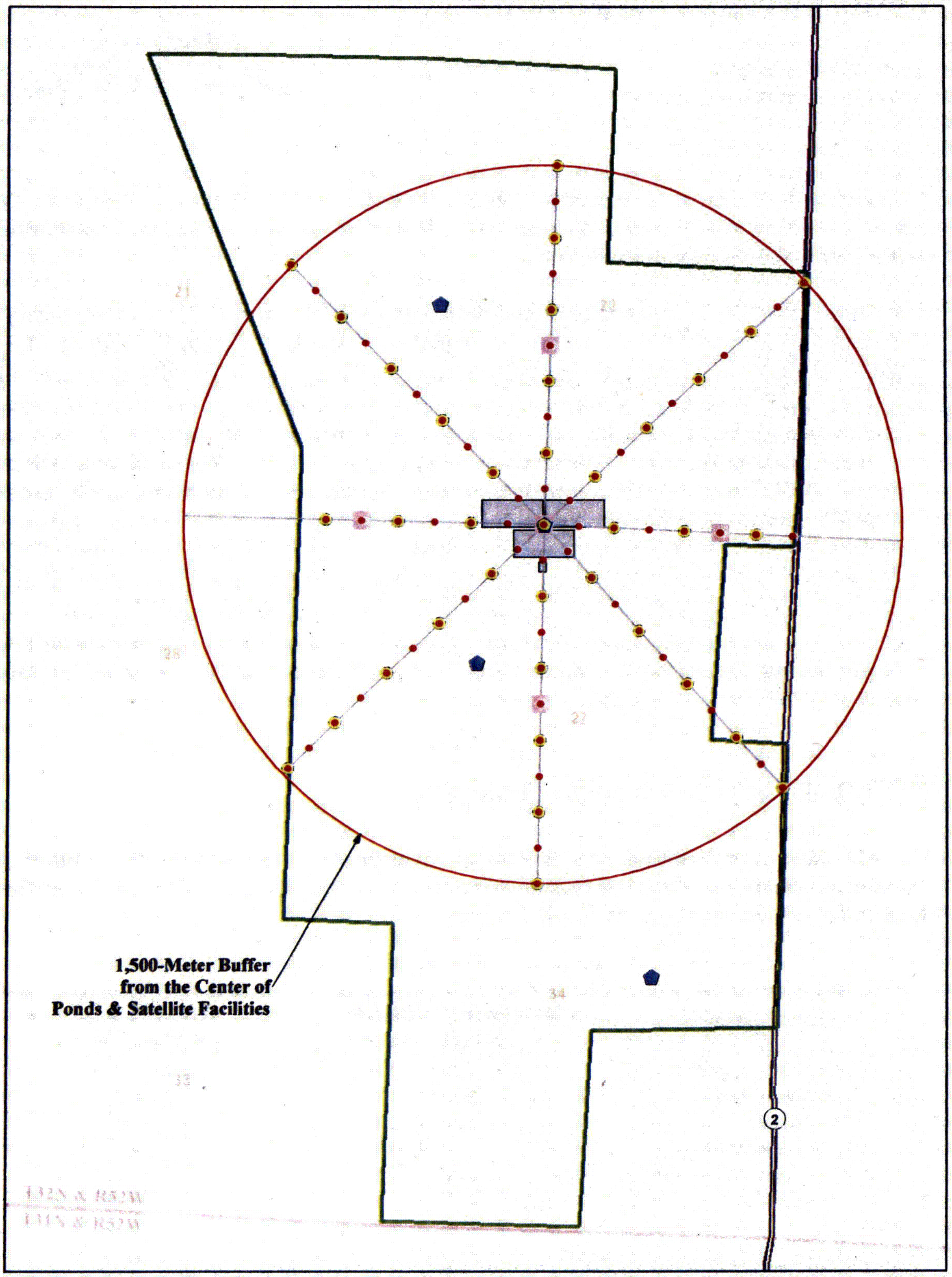
Vegetation samples will also be collected within and near the North Trend site boundary. The sampling protocol for vegetation presented in USNRC Regulatory Guide 4.14 is based on air particulates from the processing facility. Since North Trend operations will not have a yellowcake drying and packaging unit, and generate very few air particulates, collecting samples in areas with the highest predicted air particulate concentrations does not appear to be meaningful. However, background samples will be taken at locations within the NTEA to allow for comparison of background levels to contaminant levels at sites potentially impacted due to spills during cleanup operations. Therefore vegetation samples will be collected in areas representative of wellfield locations (Figure 2.9-4). There will be a total of 3 vegetation samples collected, as shown in Figure 2.94. These 3 samples will be representative of proposed Mine Units: (a) NT-8 and NT-5, (b) NT-1 through NT-4 and Satellite Facility and (c) NT-6, NT-7 and NT-9. Three samples will be collected during the grazing season and analyzed for Natural Uranium, Ra-226, Th-230, Pb-210 and Po-210.

2.9.5.1 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 NRC.



LEGEND

- Gamma Survey Location
- Surface Soil Sampling Location
- Vegetation Sampling Location
- Subsurface Soil Sampling Location
- Proposed North Trend Expansion Area (NTEA)
- Satellite Facilities & Ponds

N
W E

NOTE:
Preoperational radiological sampling locations for air monitoring stations are shown in Figure 2.9-2

0 1,500 3,000
Scale in Feet

CROW BUTTE RESOURCES, INC.

FIGURE 2.9-4
PREOPERATIONAL RADIOLOGICAL SAMPLING LOCATIONS FOR SOILS, VEGETATION AND GAMMA SURVEYS WITHIN NTEA SITE BOUNDARY

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ARCADIS
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630 Plaza Drive, Ste 100
Highlands Ranch, CO 80129
P: 720-344-3500 F: 720-344-3535
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2.9.6 Baseline Soil Monitoring

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 NUREG-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 2.9-8.

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 North Trend 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 2.9-9.

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 2.9-5 and 2.9-6 respectively. Figure 2.9-5 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.

Additional grab surface soil samples will be collected at or near the North Trend site, as per USNRC Regulatory Guide 4.14 (Figure 2.9-4). Where feasible, soils samples will be collected at 300 meter intervals to a distance of 1500 meters in each of 8 directions

Table 2.9-8
Soil Sampling
Air Monitoring Locations

Location	Radionuclide	Date	Concentration $\mu Ci/g \times 10^{-6}$	Error Estimate $\mu Ci/g \times 10^{-6}$	LLD $\mu Ci/g \times 10^{-6}$
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 2.9-8 (continued)
Soil Sampling
Air Monitoring Locations

Location	Radionuclide	Date	Concentration $\mu Ci/g \times 10^{-6}$	Error Estimate $\mu Ci/g \times 10^{-6}$	LLD $\mu Ci/g \times 10^{-6}$
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 2.9-8 (continued)
Soil Sampling
Air Monitoring Locations

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 2.9-9
Soil Sampling
Proposed Satellite Processing Area

Location	Radionuclide	Date	Concentration $\mu Ci/g \times 10^{-6}$	Error Estimate $\mu Ci/g \times 10^{-6}$	LLD $\mu Ci/g \times 10^{-6}$
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

Figure 2.9-5 General Area of Proposed North Trend Satellite Facility

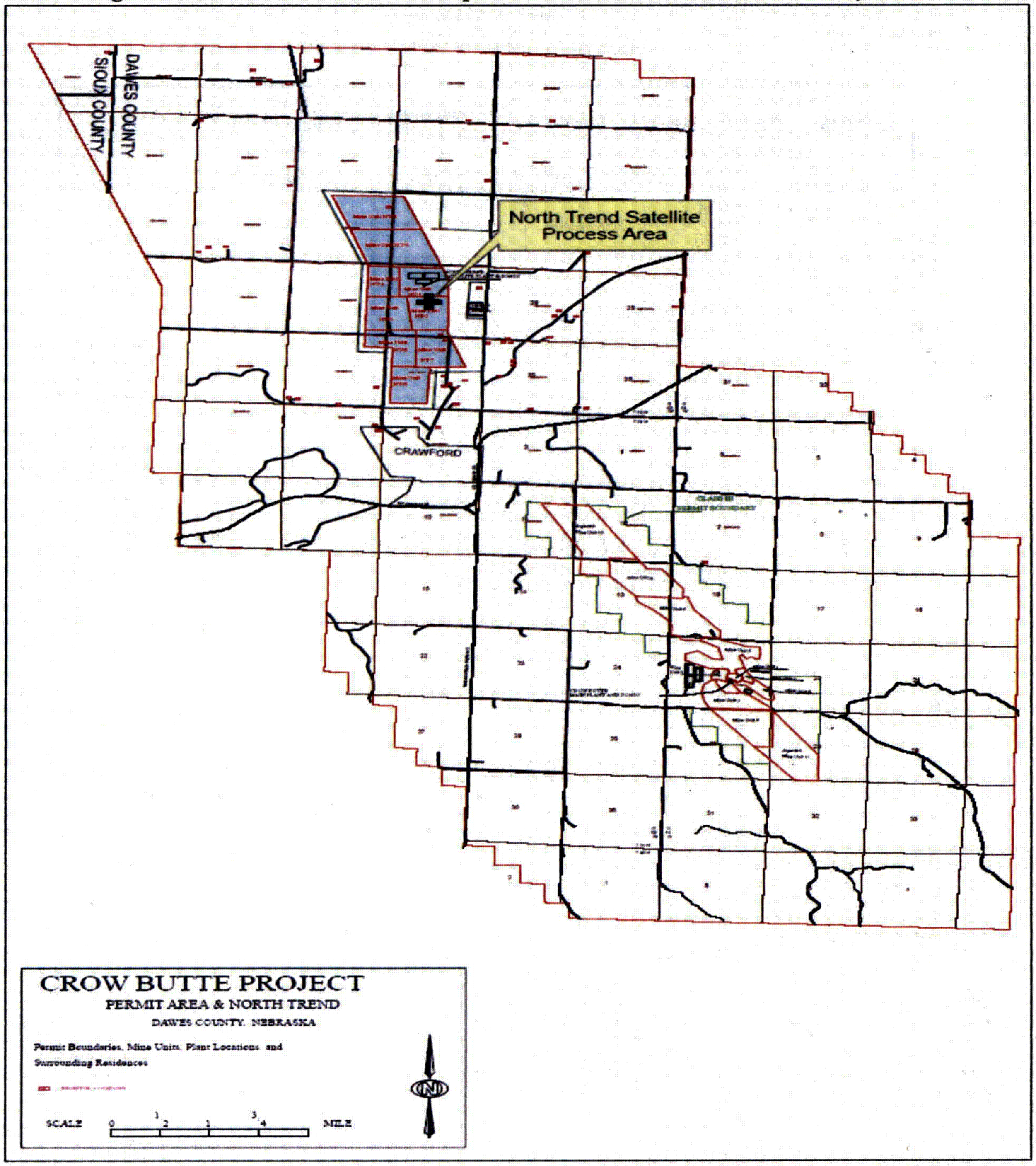
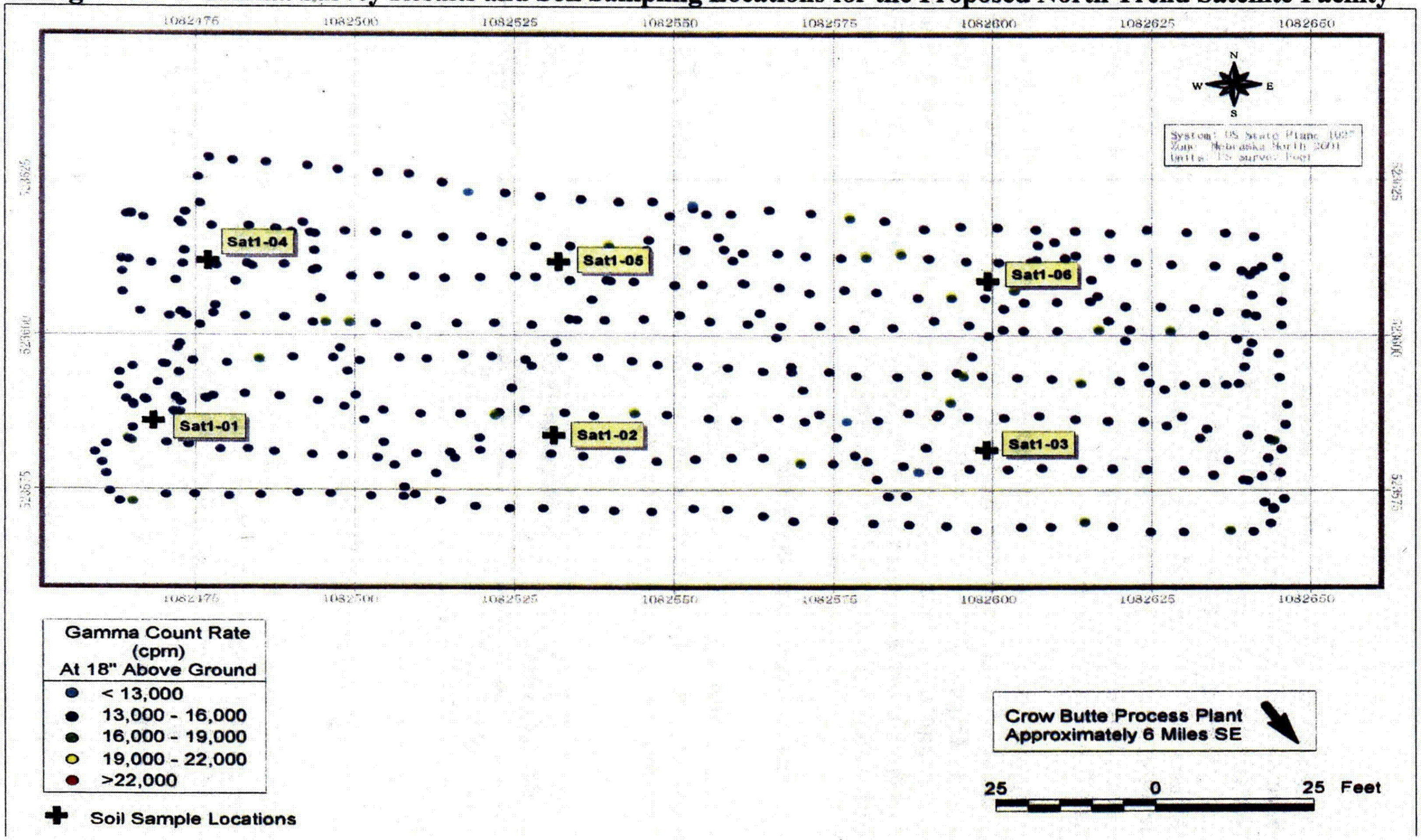


Figure 2.9-6 Gamma Survey Results and Soil Sampling Locations for the Proposed North Trend Satellite Facility



from the center of the North Trend Satellite Facility. However, 4 of the 8 directional lines have a distance less than 1500 meters, and therefore only a total of 10 samples will be collected versus 20 specified by USNRC Regulatory Guide 4.1.4. This will result in a total of 30 samples versus up to 40 specified in the above referenced regulatory guide. Soil samples will be collected once prior to construction. The samples will be collected to a depth of 5 cm. Any areas disturbed by excavation, leveling or contouring will be resampled. Samples will be analyzed for Ra-226 and 10% of the samples for Natural Uranium, Th-230, and Pb-210.

Five subsurface samples will be collected once at a center reference location (North Trend Satellite Facility) and at distances of 750 meters in each of four directions from the center point (Figure 2.9-4). Any areas disturbed by excavation, leveling or contouring will be resampled. Subsurface soil profile samples will be collected to a depth of one meter. Samples will be divided into three equal sections for analysis. All samples will be analyzed for Ra-226 and ones set of samples for Natural Uranium, Th-230, and Pb-210.

2.9.6.1 Quality of Soil Measurements

The accuracy of monitoring data is critical to ensure that the soil monitoring program precisely reflects radionuclide concentrations. Regulatory 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}

2.9.7 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.

Sediments in the White River were sampled as part of the North Trend Expansion Area preoperational baseline monitoring program. Sediment samples were collected at the same locations as surface water samples. 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 NRC staff. The results from the analysis of the sediment samples are listed in Table 2.9-10.

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 North Trend Expansion Area are comparable with the results of the historical sampling.

2.9.7.1 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	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)

Table 2.9-10
Sediment Sampling Results

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

2.9.8 Baseline Direct Radiation Monitoring

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 NRC Regulatory 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.

2.9.8.1 Integrated Radiation Monitoring Results

As part of the preoperational monitoring program for the North Trend Expansion Area, 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. 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. 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 2.9-11 summarizes the environmental direct gamma monitoring results from the North Trend Expansion Area.

The average background gamma level in the Western Great Plains has been reported to be 0.014 mR/hr[4], which corresponds well to the results obtained with the TLD gamma monitors.

Table 2.9-11
Environmental Thermoluminescent Detector Results

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

2.9.8.2 Direct Gamma Radiation Measurement Results

In addition to the environmental gamma monitors, NRC recommends that the background gamma radiation in the area of the facility be measured with a scintillometer. As per USNRC Regulatory Guide 4.14, CBR will perform preoperational gamma radiation measurements at 150-meter intervals in each of eight compass directions from the center point of the North Satellite Facility out to a distance of 1,500 meters from the center of the "milling" area (Figure 2.9-4). These measurements will be made once prior to construction, and repeated for area disturbed by site preparation or construction. The type of survey instrument and procedures will be as described below for measurements previously conducted at the proposed Satellite Facility.

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 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 2.9-6. In addition, exposure rate measurement were collected at each satellite processing area soil sample location described in Section 2.9.6 using a Ludlum Model 19 µR meter. Summary data for the gamma direct gamma radiation measurements are presented in Table 2.9-12.

Table 2.9-12
Gamma Survey Results for Proposed Satellite Processing Area

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

Table 2.9-12
Gamma Survey Results for Proposed Satellite Processing Area

Location	Dates	Gamma Exposure Rate (μR/hr)*	Standard Deviation (μR/hr)	95% Confidence Interval (μR/hr)
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 2.9-13

1996-1997 Radiological Preoperational Monitoring Program
North Trend Expansion Area

Type of Sample	Number	Sample Collection			Sample Analysis	
		Location	Method	Frequency	Frequency	Type of Analysis
Air Monitoring						
Radon Gas	One	Nearest residence (NE-1)	Continuous using RadTrak® Type DRNF	Quarterly	Quarterly	Rn-222
	Four	Site boundary (NE-2 – NE-5)	Continuous using RadTrak® Type DRNF	Quarterly	Quarterly	Rn-222
	One	Control (Background) location (AM-6)	Continuous using RadTrak® Type DRNF	Quarterly	Quarterly	Rn-222

Table 2.9-13

1996-1997 Radiological Preoperational Monitoring Program
North Trend Expansion Area

Type of Sample	Number	Sample Collection			Sample Analysis	
		Location	Method	Frequency	Frequency	Type of Analysis
Water Monitoring						
Groundwater	One from representative water supply wells	Representative wells within 1 km of license area boundary	Grab	Quarterly for one year	Quarterly	Natural Uranium, Th-230, Ra-226, Pb-210, Po-210
Vegetation Monitoring						
Vegetation	One each	Air monitoring stations (NE-1 – NE-5)	Composite of dominant vegetation present	Once during grazing season	Each sample	Natural Uranium, Th-230, Ra-226, Pb-210, Po-210
Soil Monitoring						
Surface Soil	One each	Air monitoring stations (NE-1 – NE-5)	Grab	Once	Each sample	Natural Uranium, Ra-226
Direct Radiation Monitoring						
Continuous	One each	Air monitoring stations (NE-1 – NE-5, AM-6)	Dosimeter	Continuous	Quarterly	Gamma exposure using a continuous integrating device

Table 2.9-14
2004-2005 Radiological Preoperational Monitoring Program
North Trend Expansion Area

Type of Sample	Number	Sample Collection			Sample Analysis	
		Location	Method	Frequency	Frequency	Type of Analysis
Air Monitoring						
Air Particulate	Two	Control background location and north of expansion area (AM-6 and AM-10)	Continuous	Weekly filter change	Quarterly composites of weekly samples	Natural uranium, Ra-226, Pb-210
Radon	One	Nearest residence (AM-9)	Continuous using RadTrak® Type DRNF	Quarterly	Quarterly	Rn-222
	Five	Site boundary (AM-10 – AM-14)	Continuous using RadTrak® Type DRNF	Quarterly	Quarterly	Rn-222
	One	Control (Background) location (AM-6)	Continuous using RadTrak® Type DRNF	Quarterly	Quarterly	Rn-222

Table 2.9-14
2004-2005 Radiological Preoperational Monitoring Program
North Trend Expansion Area

Type of Sample	Number	Sample Collection			Sample Analysis	
		Location	Method	Frequency	Frequency	Type of Analysis
Water Monitoring						
Groundwater	One from representative water supply wells	Representative wells within 1 km of license area boundary	Grab	Quarterly	Quarterly	Natural Uranium, Th-230, Ra-226, Pb-210, Po-210
Surface water	Two from surface water that could be impacted by satellite plant	Surface water features within the license area or offsite that could be affected by mining operations consisting of one sample upstream and one sample downstream of site boundary (W-1 and W-2)	Grab	Quarterly	Each sample	Natural Uranium, Th-230, Ra-226, Pb-210, Po-210
Sediment Monitoring						
Sediment	One	One from each surface water monitoring location (W-1 and W-2)	Grab	Twice	Each sample	Natural Uranium, Ra-226, Pb-210

Table 2.9-14
2004-2005 Radiological Preoperational Monitoring Program
North Trend Expansion Area

Type of Sample	Number	Sample Collection			Sample Analysis	
		Location	Method	Frequency	Frequency	Type of Analysis
Soil Monitoring						
Surface	One each	Air Monitoring stations (AM-6, AM-9 through AM-14)	5 cm composite	Once	Each sample	Natural Uranium, Ra-226, Pb-210
Surface	One each	Air Monitoring stations (AM-6, AM-9 through AM-14)	15 cm composite	Once	Each sample	Natural Uranium, Ra-226, Pb-210
Surface	Six each	Proposed Satellite Plant locations	Grab	Once	Each sample	Natural Uranium, Ra-226
Direct Radiation Monitoring						
Continuous	One each	Air Monitoring stations (AM-6, AM-9 through AM-14)	Dosimeter	Continuous	Quarterly	Gamma exposure using a continuous integrating device
Survey	422 measurements	Proposed Satellite Plant locations	Grab	Once	Once	Gamma exposure using Sodium Iodide scintillometer

2.9.9 References

[1] USNRC Regulatory Guide 4.14, *Radiological Effluent and Environmental Monitoring at Uranium Mills* (1980).

[2] Resource Technologies Group, Inc., *Preoperational Environmental Monitoring Plan for Mining Expansion, Crow Butte Mine, Dawes County, Nebraska* (1996).

[3] USNRC, *Standard Review Plan for In Situ Leach Uranium Extraction License Applications*, NUREG-1569, November 2002.

[4] Ferret Exploration Company of Nebraska, Inc., *Application and Supporting Environmental Report for USNRC for Commercial Source Material License*, 1987.

[5] USNRC, *Environmental Assessment for Renewal of Source Material License SUA-1534*, February 1998.

[4] USNRC, *Description of the United States Uranium Resource Areas and Supplement to the Generic Environmental Impact Statement on Uranium Milling*, NUREG-0597, June 1979.

Replacement Pages for Section 3.0 Description of Proposed Facility

Replace Section 3.0, pages 3.1-1 through 3.4-39

3 DESCRIPTION OF PROPOSED FACILITY

Production of uranium by in-situ leach (ISL) mining techniques involves a mining step and a uranium recovery step. Mining is accomplished by installing a series of injection wells through which the leach solution is pumped into the ore body. Corresponding production wells and pumps promote flow through the ore body and allow for the collection of uranium-rich leach solution. Uranium is removed from the leach solution by ion exchange, and then from the ion exchange resin by elution. The leach solution can then be reused for mining purposes. The elution liquid containing the uranium (the "pregnant" eluant) is then processed by precipitation, dewatering, and drying to produce a transportable form of uranium.

The North Trend Expansion Area is being developed by Crow Butte Resources in conjunction with their Crow Butte Uranium Project and the Central Processing Plant currently licensed under USNRC Source Material License SUA-1534. The North Trend Expansion Area will be developed by constructing independent wellfields and mining support facilities while utilizing existing processing equipment to the greatest extent possible for uranium recovery. Transfer of recovered leach solutions from the area is prohibitive because of the distance that a relatively large stream would have to be pumped. Therefore, a satellite facility will be constructed in the North Trend Expansion Area to provide chemical makeup of leach solutions, recovery of uranium by ion exchange, and restoration capabilities. The ion exchange processes at the satellite facility serve to recover the uranium from the leach solution in a form (loaded ion exchange resin) that is relatively safe and simple to transport by tanker truck to the Central Processing Plant for elution and further processing of recovered uranium. Regenerated resin is then transported back to the satellite facility for reuse in the ion exchange circuit.

3.1 SOLUTION MINING PROCESS AND EQUIPMENT

3.1.1 Orebody

In the current Licensed Area, uranium is recovered by in-situ leaching from the Chadron Sandstone at a depth that varies from 400 feet to 800 feet. The overall width of the mineralized area varies from 1000 feet to 5000 feet. The orebody ranges in grade from less than 0.05 to greater than 0.5% U_3O_8, with an average grade estimated at 0.20% U_3O_8.

In the North Trend Expansion Area, uranium will also be recovered from the Chadron Sandstone. The depth in the North Trend Expansion Area ranges from 400 to 800 feet. The width varies from 100 feet to 1,000 feet.

Typical stratigraphic intervals to be mined by the in situ mining method were shown in the geologic cross sections contained in Section 2.6. For ISL wellfields, the production zone is the geological sandstone unit where the leaching solutions are injected and recovered.

3.1.2 Well Construction and Integrity Testing

Three well construction methods and appropriate casing materials are used for the construction and installation of production and injection wells.

3.1.2.1 Well Materials of Construction

The well casing material will be polyvinyl chloride (PVC). PVC well casing is 4.5 inch SDR-17 (or equivalent). The PVC casing joints normally have a length of approximately 20 feet each. With SDR-17 PVC casing, each joint is connected by a water tight o-ring seal which is located with a high strength nylon spline.

There are two types of well screen that will be used for development of the NTEA – polyvinyl chloride (PVC) and stainless steel (SS). Both types of screens have been used historically for the existing Crow Butte production, injection and monitor wells. SS screens are much tougher than PVC screens, are rated for much deeper depths than PVC screens, and can achieve better flow. The SS screens are significantly more expensive than the PVC screens. Currently CBR primarily uses SS screens, but would maintain the option to use PVC screens as applicable to site conditions and purpose of the borehole.

The PVC well screen consists of a perforated 3-inch PVC pipe. PVC rods run longitudinally along the sides of the pipe. Keystone shaped PVC wire is helically wrapped around the outsides of the pipe and ribs and solvent-welded to the pipe. Spacing between consecutive wraps of the wire varies depending upon the screen ordered. Slot sizes from 0.010 to 0.020 have been used successfully at Crow Butte. In most cases, a slot size of 0.020 is sufficient to keep the well from allowing sand to enter the screens.

The SS well screen consists of longitudinal ribs of SS with a SS "V" shaped wire wrapped helically around the interior ribbing. The wire is welded to the circular rib array for support. As with PVC screens, slot sizes of 0.010 to 0.020 have been used at Crow Butte historically.

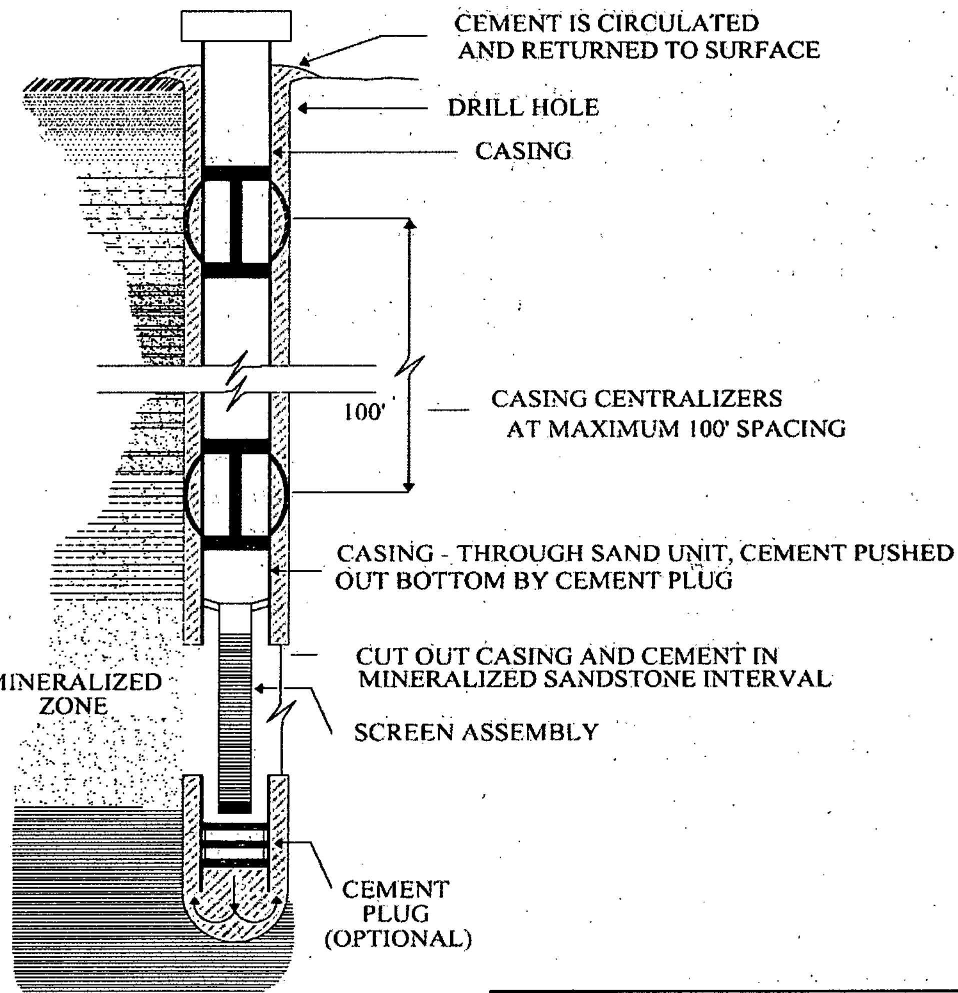
3.1.2.2 Well Construction Methods

Pilot holes for monitor, production, and injection wells are drilled to the top of the target completion interval with a small rotary drilling unit using native mud and a small amount of commercial drilling fluid additive for viscosity control. The hole is logged, reamed, casing set, and cemented to isolate the completion interval from all other aquifers.

Three well construction methods are described in this section. Of the three methods, CBR primarily uses Method 1 shown in Figure 3.1-1 on a routine basis. Method 2 shown in Figure 3.1-2 may be used by the CBR Geology staff when there is a need or desire to install the well without effecting the water quality or geologic properties that are present in the target zone. Method 2 is primarily used for monitor well completion where the drilling and cementing of the well through the formation will cause a mixing of drilling and cementing fluids with the water present, and may affect water quality results. Method 3 shown in Figure 3.1-3 is no longer routinely used, but this method is maintained as an option so that the method (including minor modifications) can be used if warranted for specific geological formations. All of these methods are appropriate for monitor wells and have been approved by the NDEQ under the UIC Permit.

- Method 1

For this method, the well is drilled to depth in the Pierre Shale, and then logged. Based upon the e-log, geological staff will pick a casing depth, and will then begin to review the local area wells for the best location (depth) to pick the screened interval. The well is cased through the mining zone and cemented in place. Cement is pumped down the inside of the casing, exits out the bottom, and flows back up the annulus to the surface. Cement is removed from the inside of the casing by pushing a rubber wiper plug to the bottom of the casing using fresh water displacement. This rubber plug remains in the bottom of the casing. On deeper wells, a variation of this method displaces the cement using only fresh water to push the cement without a wiper plug. If the cement is displaced with water only, a rig will need to drill the excess cement out of the casing prior to under-reaming and setting screens. If the cement is displaced using a cement plug, then nothing further is required prior to under-reaming. The under-reaming process begins with a rig tripping (inserting in borehole) a specialized drill bit into the depths to be screened. Blades on the bit open outward and cut away and remove the casing and cement grout from the area to be screened. When the interval to be screened has been cut away, the drill rig removes this section of the pipe, and the hole is logged to make certain that the cut is accurate. If the cut-check depths are determined to be satisfactory, the rig is used to place the screen assembly at the selected depth and then development of the well begins. Method 1 is the primary method used for all injection and production wells. A slight variation of this method may be used for monitor wells. Monitor wells that are installed using this variation of Method 1 are cased to the top of the target zone, and cemented using water displacement. Time is allowed for the cement to set up (harden), the excess cement is drilled out of the casing and the well is completed into



CROW BUTTE RESOURCES, INC.

FIGURE 3.1-1
TYPICAL MINERALIZED ZONE COMPLETION FOR INJECTION/PRODUCTION WELLS
METHOD NO.1

PROJECT : CO001322 MAPPED: JC CHECKED: J. CEARLEY

FILE: Figure N_1-123.dwg @ 1/23/2009 11:18 AM

ARCADIS
630 Plaza Drive, Ste. 100
Highlands Ranch, CO 80129
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www.arcadis-us.com

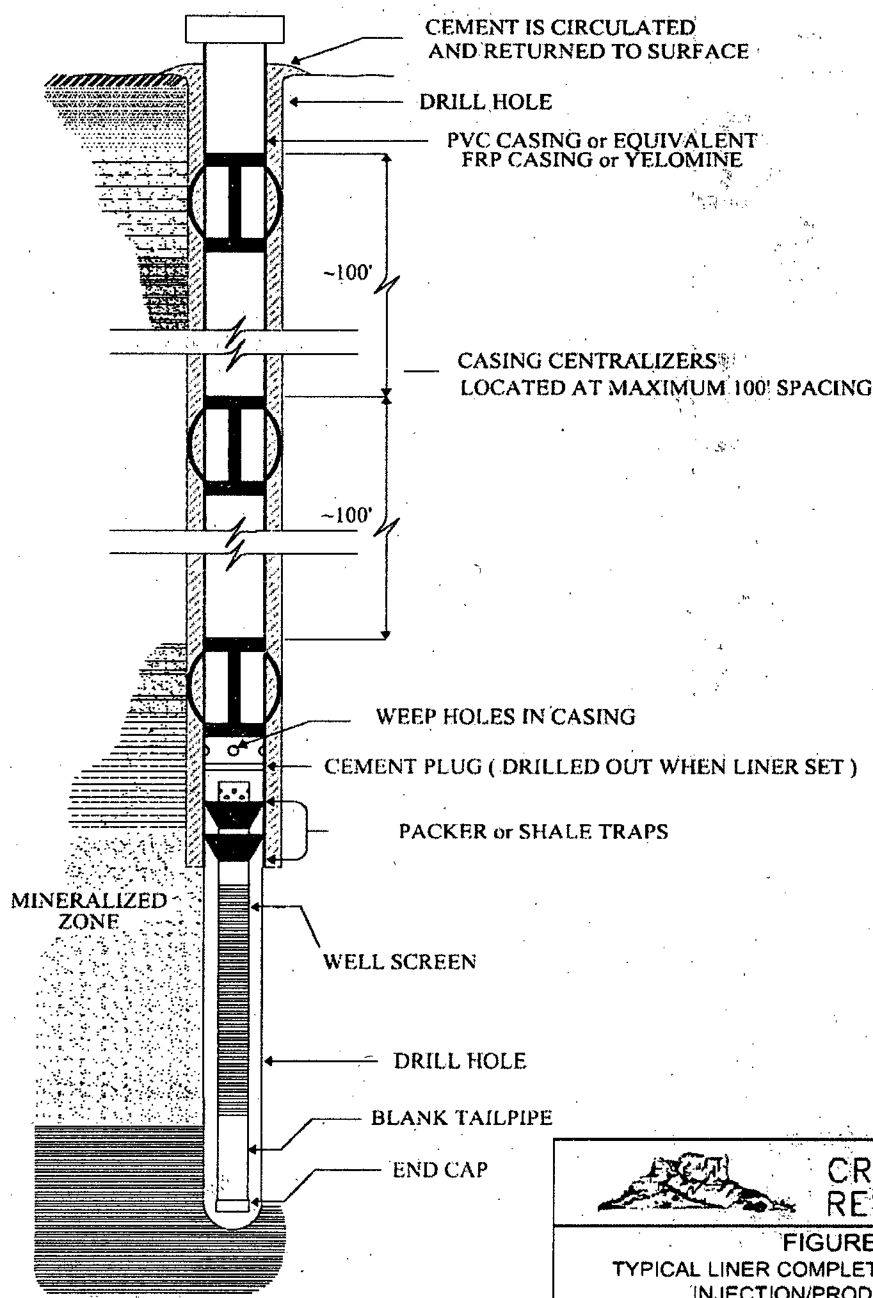

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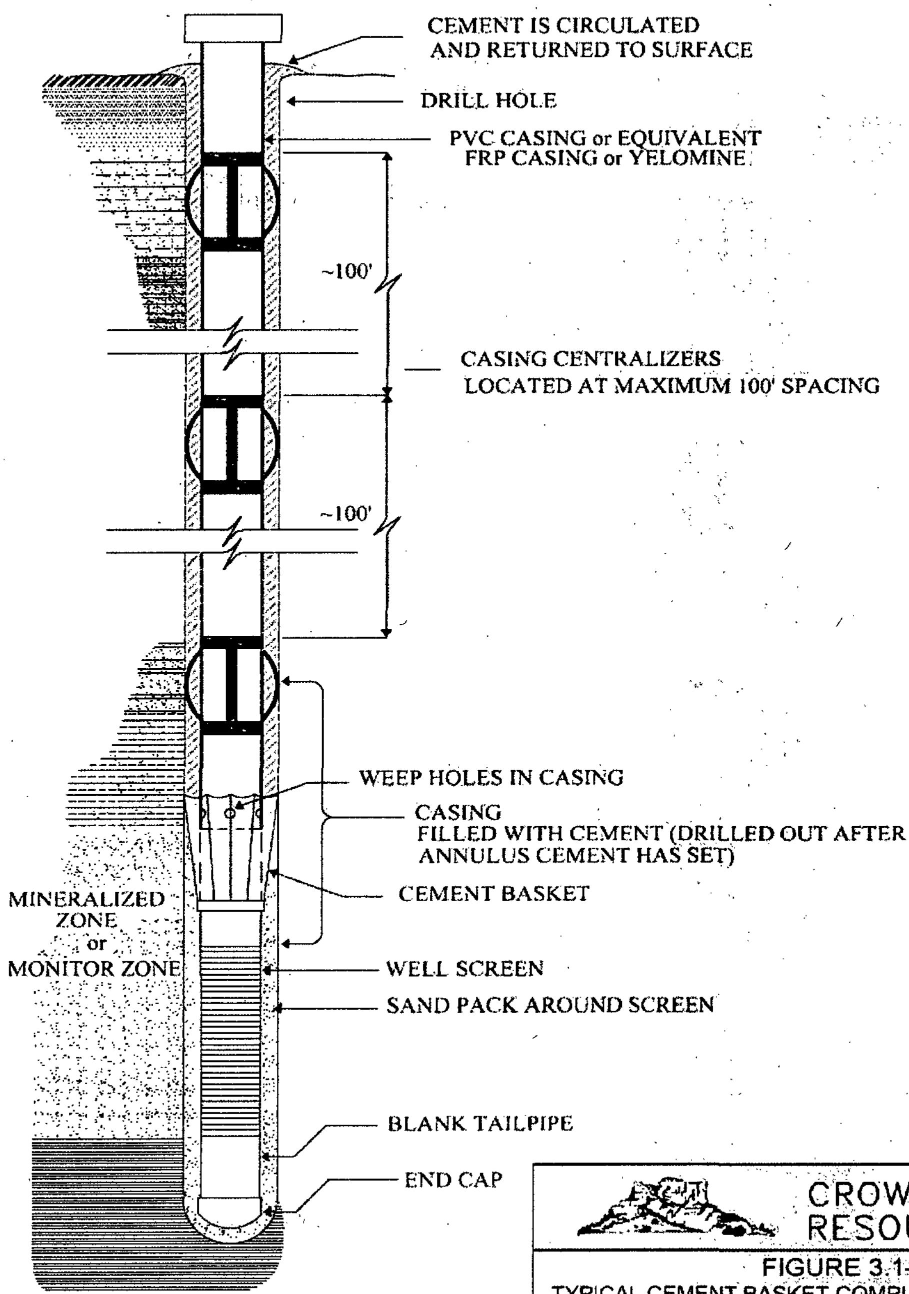
FIGURE 3.1-2
TYPICAL LINER COMPLETION FOR MONITOR OR INJECTION/PRODUCTION WELLS
METHOD NO.2

PROJECT : CO001322 MAPPED: JC CHECKED: J. CEARLEY

FILE: Figure N_1-123.dwg @ 1/23/2009 11:16 AM

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



CROW BUTTE RESOURCES, INC.

FIGURE 3.1-3
TYPICAL CEMENT BASKET COMPLETION FOR MONITOR OR INJECTION/PRODUCTION WELLS
METHOD NO.3

PROJECT : CO001322	MAPPED: JC	CHECKED: J. CEARLEY

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ARCADIS 630 Plaza Drive, Ste. 100 Highlands Ranch, CO 80129 P. 720-344-3500 F. 720-344-3535 www.arcadis-us.com the Pierre Shale. The well is logged to determine where to place the well screens, and using the rig, the screens are set at the proper depth.

Method 1 is similar to Method 2, except that a bottom plug and weep holes are not used.

- Method No. 2

Method 2 uses a screen telescoped down inside the cemented casing. A hole is drilled and geophysically logged to locate the desired screen interval. The hole is then reamed if necessary only to the top of the desired screen interval. Next a string of casing with a bottom plug at the lower end and weep holes just above the plug is set into the hole. Cement is then pumped down the casing and out the weep holes. It returns to the surface through the annulus. After the cement has cured, the residual cement in the casing and bottom plug are drilled out, with the drilling continuing through the desired zone. The screen with a K-packer and/or shale traps is then telescoped through the casing and set in the desired interval. The packer and/or shale traps serve to hold the screen in the desired position while acting as a fluid seal. Well development is again accomplished by airlifting or pumping. Minor variations from these procedures may be used as conditions require.

Method 2 is an improvement over Method 3 due to drilling only to the top of the mining zone. At that point the well is cased and cemented. Because the drill hole does not penetrate through the mining zone, no cement basket must be used. A bottom plug and weep holes are used to place the cement.

- Method No. 3

This method involves the setting of an integral casing/screen string. The method consists of drilling a hole to the Pierre Shale, geophysically logging the hole to define the desired screen interval, and reaming the hole, if necessary, to the desired depth and diameter. Next, a string of casing with the desired length of screen attached to the lower end is placed into the hole. A cement basket is attached to the blank casing just above the screen to prevent blinding of the screen interval during cementing. The cement is pumped down the inside of the casing to a plug set just below the cement basket. The cement passes out through weep holes in the casing and is directed by the cement basket back to the surface through the annulus between the casing and the drill hole. After the cement has cured sufficiently, the residual cement and plug are drilled out, and the well is developed by airlifting or pumping.

For all three well completion methods, casing centralizers, located at maximum 100-foot spacing, are run on the casing to ensure it is centered in the drill hole and that an effective cement seal is provided. The purpose of the cement is to stabilize and strengthen the casing and plug the annulus of the hole to prevent vertical migration of solutions. The volume of cement used in each well is determined by estimating the volume required to fill the annulus and ensure cement returns to the surface. In almost all cement jobs, returns to the surface are observed. In rare instances, however, the drilling may result in a larger annulus volume than anticipated and cement may not return all the way to the surface. In these cases the upper portion of the annulus will be cemented from the surface to backfill as much of the well annulus as possible and stabilize the wellhead. This procedure is performed by placement of a tremie hose from the surface as far down into the annulus as possible. Cement is pumped into the annulus until return to the surface is observed.

Screening

The exact size of the screen slot is determined by analyzing the formation samples brought to the surface during the drilling process, and is selected at the discretion of the Crow Butte Geology staff. The location and amount of drill screen to be set in a well is based upon the geologic and economic factors as determined by the Geology staff. Well screens are placed at a selected depth using the drilling rig. The screens are secured in place using a rubber K-packer and blank assembly that is attached to the top of the screens. The K-packer suspends the screens in the open portion of the well until well development creates a natural gravel pack surrounding the screen.

For injection and production wells, the screen interval is determined by the Geologic staff based on the location of sands and ore grade material. Correlating and selecting the zones to be mined, and making certain that the screened intervals between wells are hydrologically connected, are completed by reviewing geophysical logs. Typically, an interval of approximately 18 feet is screened; however, individual intervals may range from 6 feet to 35 feet in length.

For monitor wells, a slightly different process is followed for placement of the screens. When the monitor well is drilled, the total thickness of the mining zone is calculated. The amount of screens to be placed in the well must cover more than one-half of the total thickness of the mining zone and target the sand horizons that are impacted by nearby mining wells.

A well completion report is completed on each well. This data is kept available on-site for review.

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 EHSMS 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

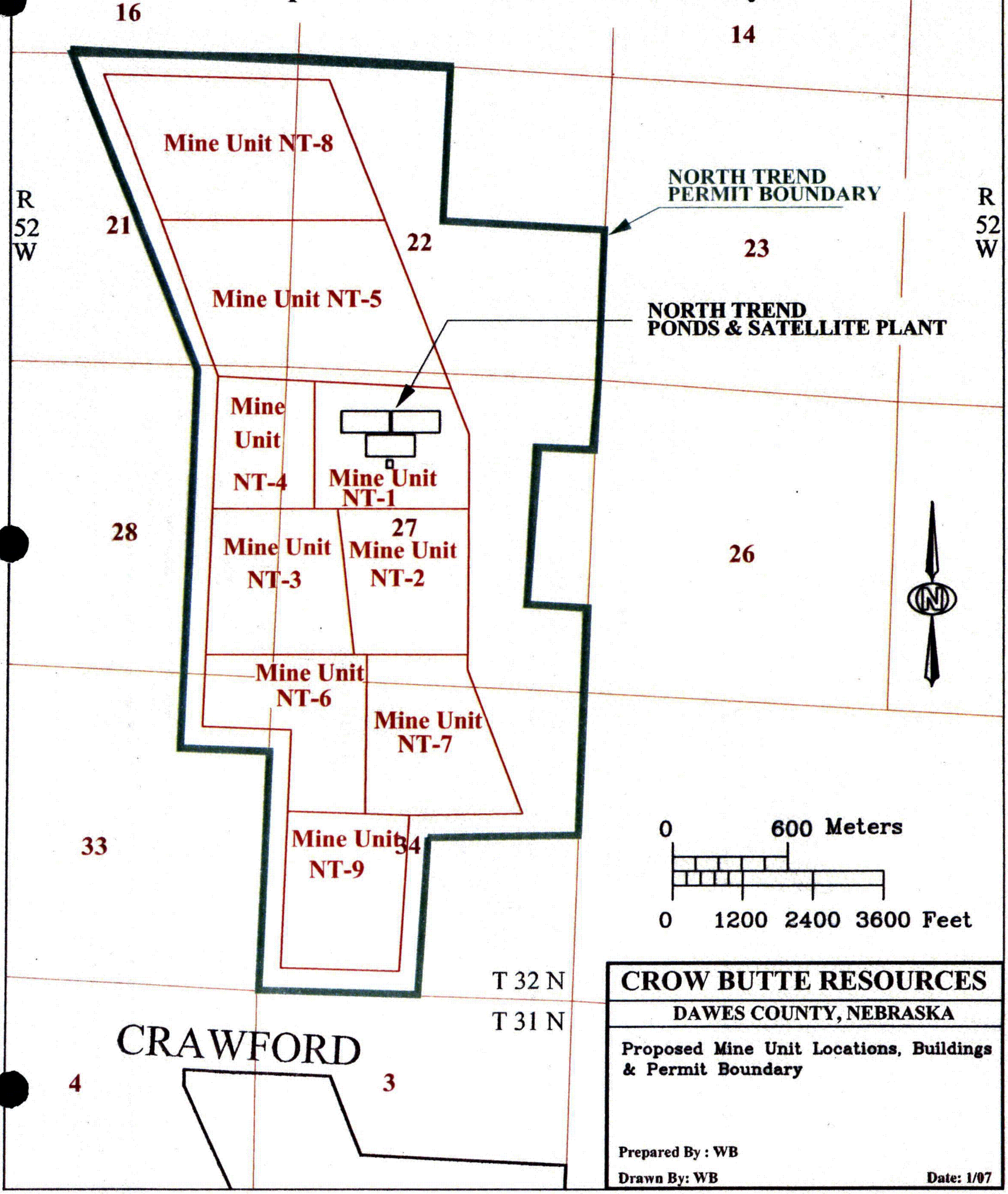
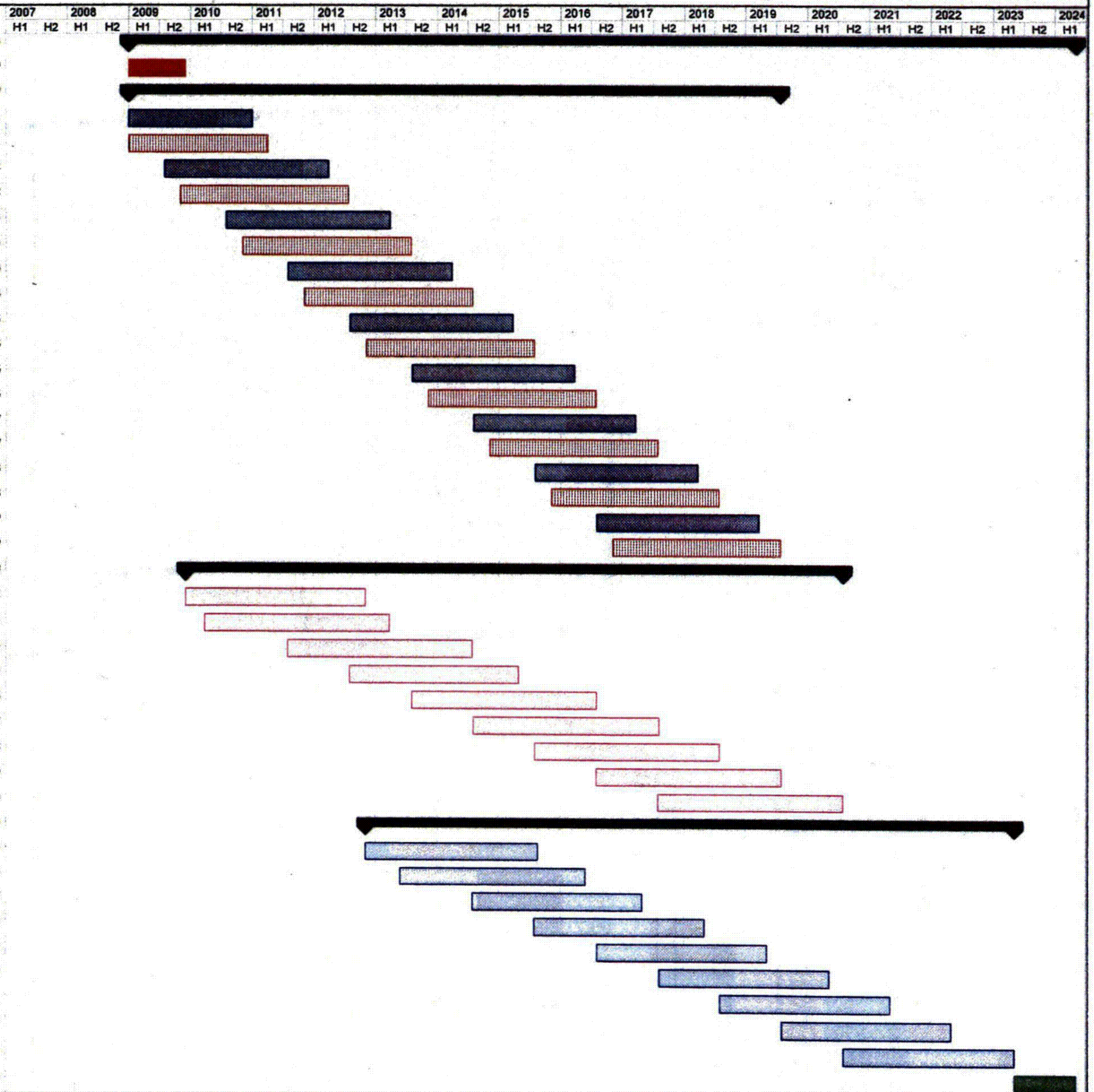


Figure 3.1-5 North Trend Mine Unit Schedule

ID	Task Name	Start	Finish
1	**North Trend Mine Unit Schedule**	Mon 1/5/09	Wed 5/8/24
2	**North Trend Facility Construction**	Mon 1/5/09	Fri 12/4/09
3	**North Trend Wellfield Construction**	Mon 1/5/09	Fri 7/26/19
4	Mine Unit NT-1 Well Development Drilling and Casing	Mon 1/5/09	Wed 1/5/11
5	Mine Unit NT-1 Surface Construction	Mon 1/5/09	Tue 4/5/11
6	Mine Unit NT-2 Well Development Drilling and Casing	Mon 8/3/09	Fri 3/30/12
7	Mine Unit NT-2 Surface Construction	Mon 11/2/09	Mon 7/23/12
8	Mine Unit NT-3 Well Development Drilling and Casing	Tue 8/3/10	Fri 3/29/13
9	Mine Unit NT-3 Surface Construction	Mon 11/8/10	Mon 7/29/13
10	Mine Unit NT-4 Well Development Drilling and Casing	Wed 8/3/11	Fri 3/28/14
11	Mine Unit NT-4 Surface Construction	Tue 11/8/11	Tue 7/29/14
12	Mine Unit NT-5 Well Development Drilling and Casing	Fri 8/3/12	Fri 3/27/15
13	Mine Unit NT-5 Surface Construction	Thu 11/8/12	Wed 7/29/15
14	Mine Unit NT-6 Well Development Drilling and Casing	Mon 8/5/13	Fri 3/25/16
15	Mine Unit NT-6 Surface Construction	Fri 11/8/13	Fri 7/29/16
16	Mine Unit NT-7 Well Development Drilling and Casing	Tue 8/5/14	Fri 3/24/17
17	Mine Unit NT-7 Surface Construction	Mon 11/10/14	Fri 7/28/17
18	Mine Unit NT-8 Well Development Drilling and Casing	Wed 8/5/15	Fri 3/23/18
19	Mine Unit NT-8 Surface Construction	Tue 11/10/15	Fri 7/27/18
20	Mine Unit NT-9 Well Development Drilling and Casing	Fri 8/5/16	Fri 3/22/19
21	Mine Unit NT-9 Surface Construction	Thu 11/10/16	Fri 7/26/19
22	**North Trend Production**	Fri 12/4/09	Mon 8/3/20
23	Mine Unit NT-1	Fri 12/4/09	Sat 11/3/12
24	Mine Unit NT-2	Mon 3/29/10	Tue 3/26/13
25	Mine Unit NT-3	Mon 8/1/11	Tue 7/29/14
26	Mine Unit NT-4	Wed 8/1/12	Thu 4/30/15
27	Mine Unit NT-5	Mon 8/5/13	Fri 8/5/16
28	Mine Unit NT-6	Tue 8/5/14	Tue 8/8/17
29	Mine Unit NT-7	Mon 8/3/15	Fri 8/3/18
30	Mine Unit NT-8	Wed 8/3/16	Fri 8/2/19
31	Mine Unit NT-9	Tue 8/1/17	Mon 8/3/20
32	**Groundwater Restoration**	Mon 11/5/12	Tue 5/9/23
33	Mine Unit NT-1	Mon 11/5/12	Fri 8/21/15
34	Mine Unit NT-2	Tue 5/28/13	Mon 5/30/16
35	Mine Unit NT-3	Wed 7/30/14	Tue 5/2/17
36	Mine Unit NT-4	Fri 7/31/15	Thu 5/3/18
37	Mine Unit NT-5	Mon 8/8/16	Fri 5/10/19
38	Mine Unit NT-6	Wed 8/9/17	Tue 5/12/20
39	Mine Unit NT-7	Mon 8/6/18	Fri 5/7/21
40	Mine Unit NT-8	Mon 8/5/19	Fri 5/6/22
41	Mine Unit NT-9	Wed 8/5/20	Tue 5/9/23
42	**Final Site Reclamation**	Wed 5/10/23	Wed 5/8/24



monitored in the satellite Control Room. The North Trend Expansion Area wellfields will be designed in a manner consistent with the existing CBR wellfields.

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). CBR will 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.

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.

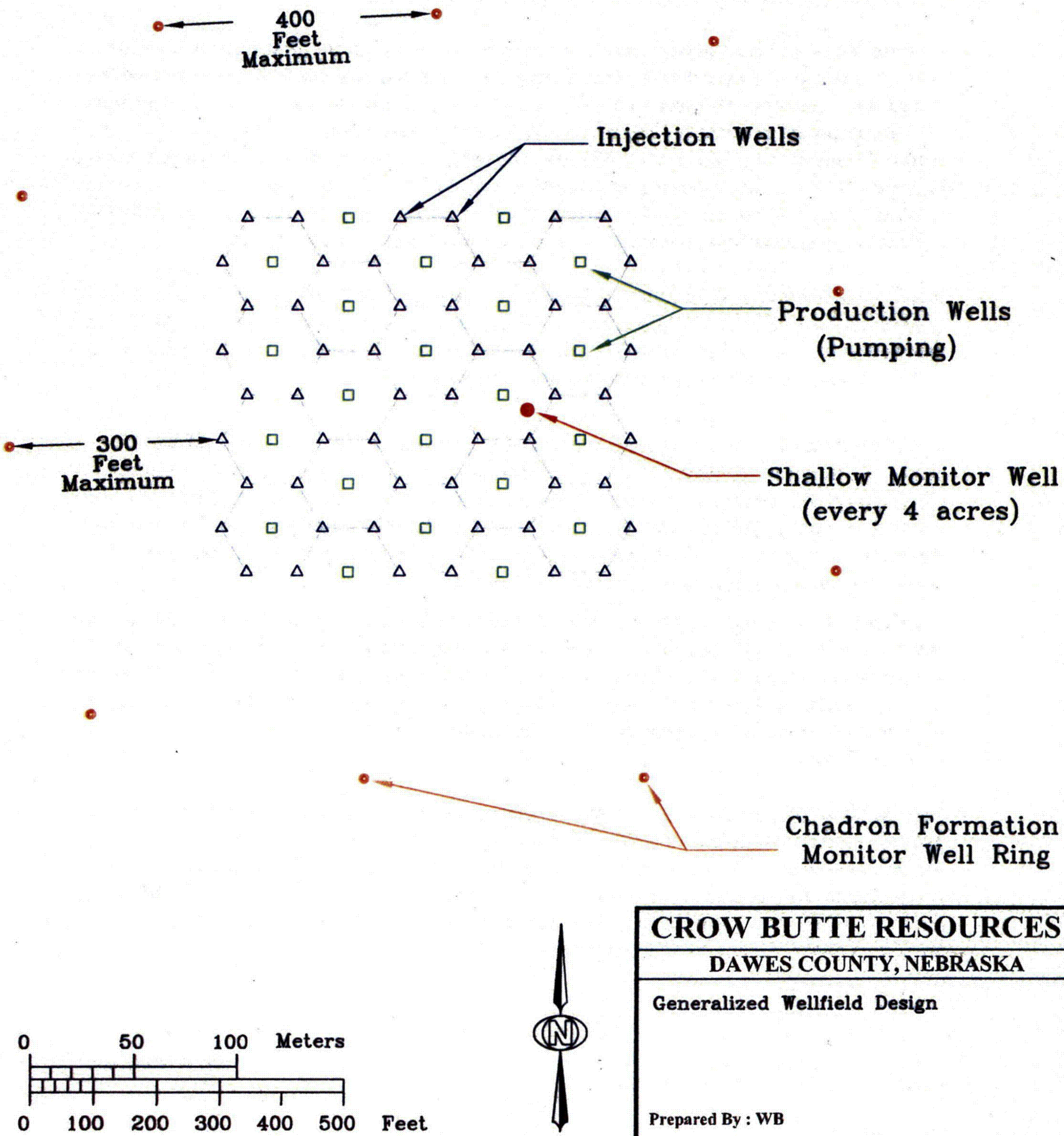
The cell dimensions vary depending on the formation and the characteristics of the ore body. The injection wells in a normal pattern are expected to be between 65 feet and 150 feet apart. A typical wellfield layout is shown in Figure 3.1-6. The wellfield is a repeated seven spot design, with the spacing 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

FIGURE 3.1-6

Typical Wellfield Layout



CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

Generalized Wellfield Design

Prepared By : WB

Drawn By: WB

Date: 1/07

the amount of water produced and injected is the wellfield "bleed." The minimum over production or bleed rates will be a nominal 0.5% of the total wellfield production rate and the maximum bleed rate typically approaches 1.5%. Over-production is adjusted as necessary to ensure that the perimeter ore zone monitor wells are influenced by the cone of depression resulting from the wellfield production bleed.

Monitor wells will be placed in the Chadron Formation and in the first significant water-bearing Brule sand above the Chadron Formation. All monitor wells will be completed by one of the three methods discussed above and developed prior to leach solution injection. The development process for monitor wells includes establishing baseline water quality before the initiation of mining operations. The typical locations of monitor wells for the proposed North Trend mine map are shown in Figure 3.1-7. As previously noted, the map is preliminary, based on CBR's current knowledge of the area. As the North Trend Expansion Area is developed, the mine unit map will be developed further.

Injection of solutions for mining will be at a rate of 4,500 gpm with a 0.5% to 1.5% production bleed stream. Production solutions returning from the wells to the production manifold will be monitored with a totalizing flow meter. All pipelines and trunklines will be leak tested and buried prior to production operations.

A water balance for the proposed North Trend Expansion Facility is shown on Figure 3.1-8. The liquid waste generated at the satellite plant will be primarily the production bleed which, at a maximum scenario, is estimated at 1.5% of the production flow. At 4,500 gpm the volume of liquid waste would be 35,478,000 gallons per year. Crow Butte Resources proposes to adequately handle the liquid waste through the combination of deep disposal well injection and evaporation ponds.

Regional information, previous CBR permit submittals, and historical operational practices indicate that the minimum pressure that could initiate hydraulic fracture is 0.63 psi per foot of well depth. This value has historically and successfully been applied to CBR operations. As such, the injection pressure is limited to less than 0.63 psi per foot of well depth. Injection pressures also will be limited to the pressure at which the well was integrity tested.

As discussed in Section 2.7, a regional pump test has been conducted to assess the hydraulic characteristics of the Basal Chadron Sandstone, and overlying confining units. Pump tests also will be performed for each mine unit to demonstrate hydraulic containment above the production zone, demonstrate communication between the production zone mining and exterior monitor wells, and to further evaluate the hydrologic properties of the Basal Chadron Sandstone.

FIGURE 3.1-7

North Trend Monitor Well Layout

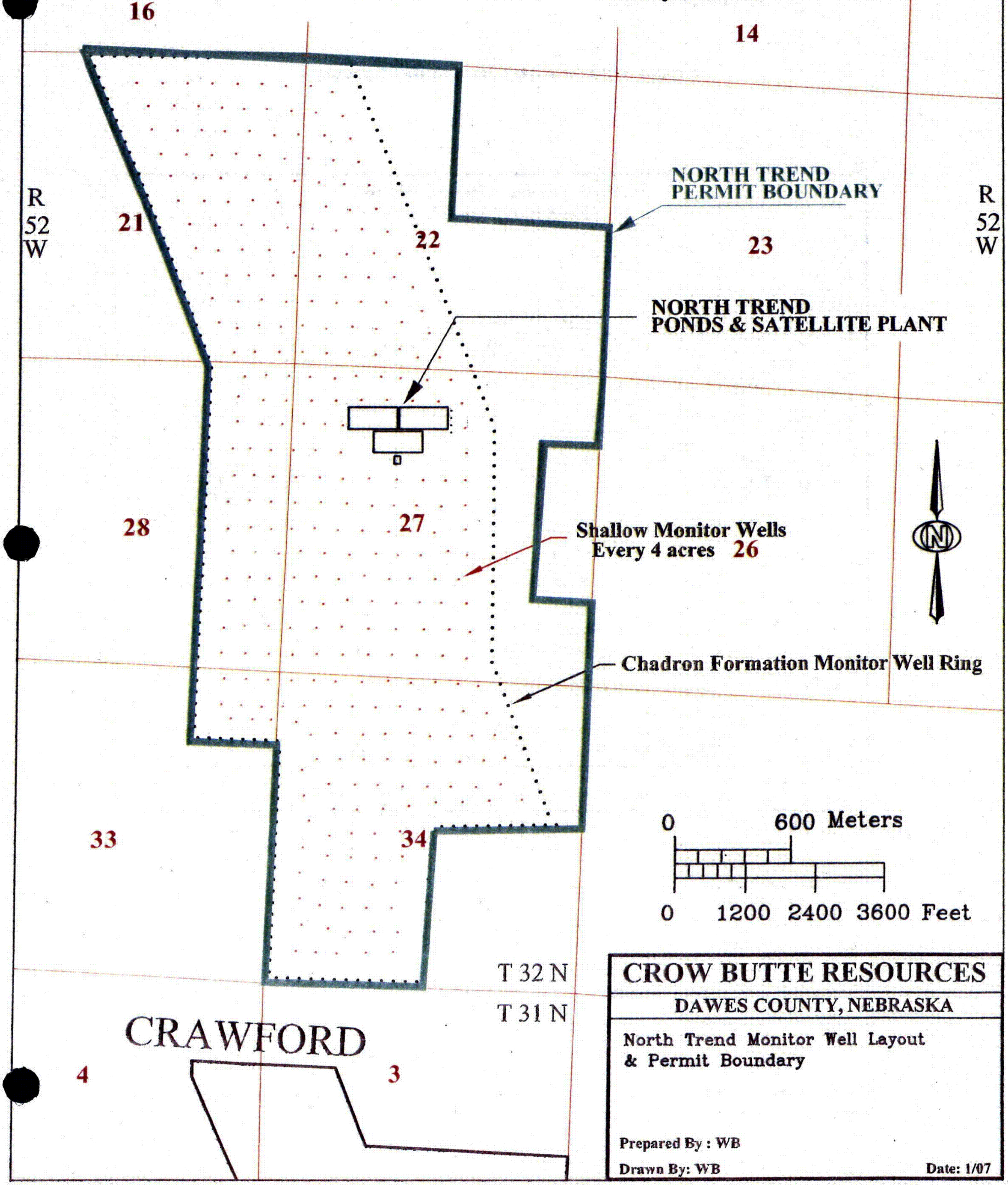
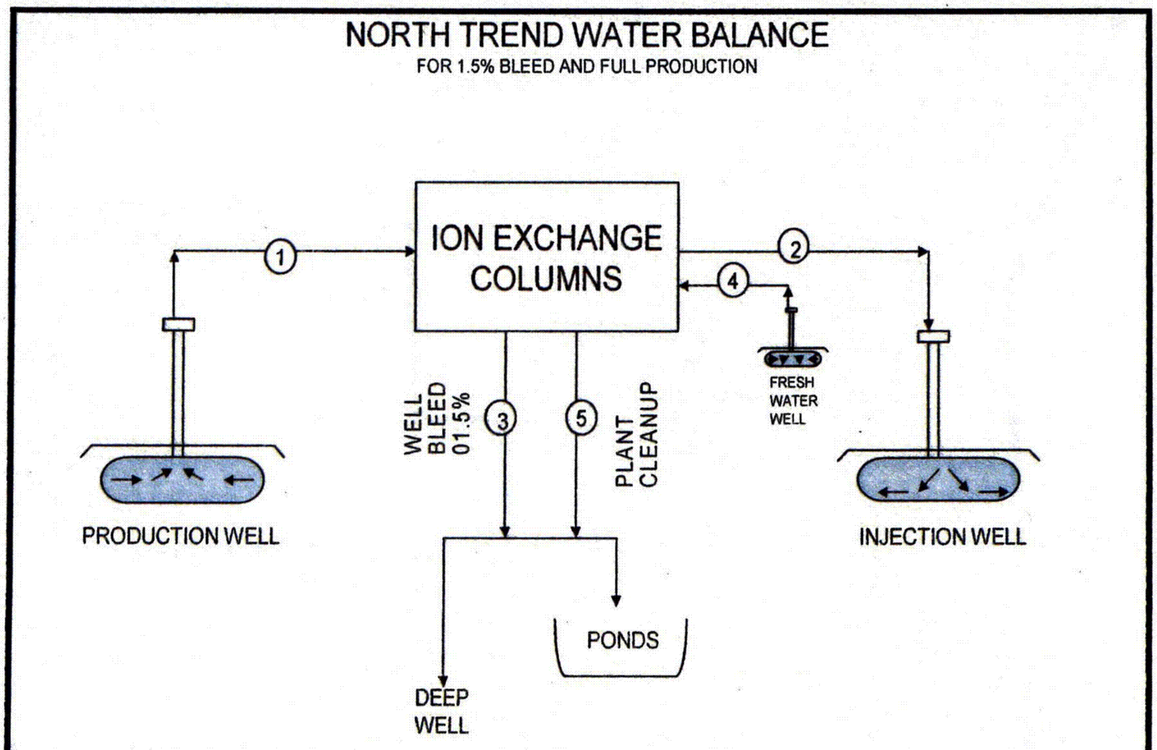


Figure 3.1-8: North Trend Water Balance



STREAM #	1	2	3	4	5
SOLUTION GPM*	4500	4432.5	67.5	2	2

*BALANCE IS NOMINAL FOR A 1.5% BLEED. ACTUAL BALANCE MAY VARY ACCORDINGLY.

A full and detailed analysis of the potential impacts of the mining operations at North Trend on surrounding water users will be provided in an Industrial Groundwater Use Permit application required by NDEQ. A similar permit application was submitted to NDEQ by Ferret Exploration of Nebraska (predecessor to Crow Butte Resources) in 1991, and that application provides a reasonable analogy between the current licensed area and North Trend. The application states that water levels in the City of Crawford (approximately three miles northwest of the mining area) could potentially be impacted by approximately 20 feet by consumptive withdrawal of water from the Basal Chadron Sandstone during mining and restoration operations (based on a 20-year operational period).

A similar order of magnitude impact (drawdown) likely exists for the North Trend operations. No impact to other users of groundwater is expected because (1) there is no documented existing use of the Basal Chadron in the proposed North Trend Permit Area, and (2) the potentiometric head of the Basal Chadron Sandstone in the North Trend Permit area ranges from approximately 10 to more than 50 feet above ground surface.

Because the Basal Chadron Sandstone (production zone) is a deep confined aquifer, no surface water impacts are expected. As discussed in Sections 2.6 and 2.7, the outcrop of the Basal Chadron Sandstone is more than 10 miles north of the North Trend Expansion Area. As discussed in Section 2.2, there is no use of the Basal Chadron Sandstone in the North Trend Expansion Area; in this regard, the nearest use of the Basal Chadron is outside the permit boundary in the southeast quarter of Section 34 (livestock and lawn watering). The only Basal Chadron well within a 2-mile radius of the permit boundary that potentially could be used for drinking water purposes is Well No. 61 (Anders). It is believed this residence has recently been supplied with City of Crawford water, and this well is located across the White River structural feature.

Further, the geologic and hydrologic data presented in Sections 2.6 and 2.7, respectively, demonstrate that (1) the occurrence of uranium mineralization is limited to the Basal Chadron Sandstone, and (2) the Basal Chadron is isolated from underlying and overlying sands. Hence, the mining operations are expected to impact water quality only in the Basal Chadron Sandstone, and restoration operations will be conducted in the Basal Chadron following completion of mining.

Based on a bleed of 0.5% to 1.5% which has been successfully applied in the current licensed area, the potential impact from consumptive use of groundwater is expected to be minimal. In this regard, the vast majority (e.g., on the order of 99%) of groundwater used in the mining process will be treated and re-injected (Figure 3.1-8). Potential impacts on groundwater quality due to consumptive use outside the license area are expected to be negligible.

In order to better understand the impact of the White River Structure on production, further investigations were conducted on the geometry and kinematics of the structure, as well as the hydrological affects of folding. A three-dimensional geologic model was developed based on an extensive review of available geophysical logging records. Results of the structural analyses indicate that the fault does not cut upsection into the Basal Chadron Sandstone (or younger geologic units). Instead, the fault terminates at depth as a "blind fault" that is manifested as a fault-propagation fold within the White River Group. Results of the structural analyses are discussed in more detail in Section 2.6.2.7.

Recent water levels collected from the Basal Chadron Sandstone indicate that steep folding of the Basal Chadron Sandstone associated with development of the monocline structure south of the North Trend Area does not appear to effect the overall hydraulic gradient direction. However, there is a noticeable increase in hydraulic gradient parallel to the fold axis along the length of the structure. This has been interpreted as a decrease in transmissivity. Reduced transmissivity was likely the result of structural thinning of Basal Chadron Sandstone along the northern limb of the monocline. Other explanations for the steepened gradient in the vicinity of the fold include possible heterogeneity within the Basal Chadron Sandstone, any spatial variation of leakage through the upper confining layers (though the rate of leakage required to produce the observed change in gradient would be minimal) and pressure-induced permeability reductions due to compressional stresses associated with folding.

To generally quantify the potential impact of drawdown due to mining and restoration operations, the following assumptions were used:

• Mining/restoration life:	20 years
• Average net consumptive use:	50 gpm
• Location of pumping centroid:	Center of Section 27 (Mine Unit NT-1)
• Observation radius:	2-3 miles radially from centroid of pumping
• Formation transmissivity	60 ft^2/d
• Formation thickness	26 feet
• Formation hydraulic conductivity	2.3 ft/d
• Formation storativity	5.3×10^{-5}

The data were evaluated using a Theis semi-steady state analytical solution, which includes the following assumptions:

- The aquifer is confined and has apparent infinite extent;
- The aquifer is homogeneous and isotropic, and of uniform effective thickness over the area influenced by pumping;
- The piezometric surface is horizontal prior to pumping;
- The well is pumped at a constant rate;

- No recharge to the aquifer occurs;
- The pumping well is fully penetrating; and,
- Well diameter is small, so well storage is negligible.

Based on these assumptions and results from the North Trend Pump Test, drawdown after 20 years of operation at 2- and 3-mile radial distances from the centroid of pumping were estimated to be 65 and 55 feet, respectively. This amount of drawdown is approximately 10 percent of the available drawdown in the Basal Chadron Sandstone. As discussed in Section 5.7 of this application, an extensive water-sampling program will be conducted prior to, during and following mining operations at the North Trend facility to identify any potential impacts to water resources of the area.

The groundwater monitoring program is designed to establish baseline water quality prior to mining; detect excursions of lixiviant either horizontally or vertically outside of the production zone; and determine when the production zone aquifer has been adequately restored following mining. The program will include sampling of monitoring wells and private wells within and surrounding the permit area to establish pre-mining baseline water quality. Water quality sampling will be continued throughout the operational phase of mining for detection of excursions. Water quality sampling will also be conducted during restoration, including stabilization monitoring at the end of restoration activities, to determine when baseline or otherwise acceptable water quality has been achieved.

During operation, the primary purpose of the wellfield monitoring program will be to detect and correct conditions that could lead to an excursion of lixiviant or detect such an excursion, should one occur. The techniques employed to achieve this objective include monitoring of production and injection rates and volumes, wellhead pressure, water levels and water quality.

Monitoring of production (extraction) and injection rates and volumes will enable an accurate assessment of water balance for the wellfields. A bleed system will be employed that will result in less leach solution being injected than the total volume of fluids (leach solution and native groundwater) being extracted. A bleed of 0.5% to 1.5% will be maintained during production. Maintenance of the bleed will cause an inflow of groundwater into the production area and prevent loss of leach solution.

Wellhead pressure will be monitored at all injection wells. Pressure gauges will be installed at each injection wellhead or on the injection manifold and monitored at least daily. Wellhead pressure will be restricted to less than 0.63 pounds per square inch (psi) per foot of well depth. Injection rates will be adjusted to maintain wellhead pressure below that level.

Each new production well (extraction and injection) will be pressure tested to confirm the integrity of the casing prior to being used for mining operations. Wells that fail pressure testing will be repaired or cemented and replaced as necessary.

Water level measurements will be routinely performed in the production zone and overlying aquifer. Sudden changes in water levels within the production zone may indicate that the wellfield flow system is out of balance. Flow rates would be adjusted to correct this situation. Increases in water levels in the overlying aquifer may be an indication of fluid migration from the production zone. Adjustments to well flow rates or complete shut down of individual wells may be required to correct this situation. Increases in water levels in the overlying aquifer may also be an indication of casing failure in a production, injection or monitor well. Isolation and shut down of individual wells can be used to determine the well causing the water level increases.

To ensure the leach solutions are contained within the designated area of the aquifer being mined, the production zone and overlying aquifer monitor wells will be sampled once every two weeks as discussed in section 5.7.

3.1.4 Process Description

Uranium solution mining is a process that takes place underground, or in-situ, by injecting lixiviant (leach) solutions into the ore body and then recovering these solutions when they are rich in uranium. The chemistry of solution mining involves an oxidation step to convert the uranium in the solid state to a form that is easily dissolved by the leach solution. Hydrogen peroxide (H_2O_2) or gaseous oxygen (O_2) is typically used as the oxidant because both revert to naturally occurring substances. Carbonate species are also added to the lixiviant solution in the injection stream to promote the dissolution of uranium as a uranyl carbonate complex.

The reactions representing these steps at a neutral or slightly alkaline pH are:

Oxidation:

$$UO_{2\,(solid)} + H_2O_{2\,(in\ solution)} \rightarrow UO_{3\,(at\ solid\ surface)} + H_2O$$

$$UO_{2\,(solid)} + \tfrac{1}{2}\,O_{2\,(in\ solution)} \rightarrow UO_{3\,(at\ solid\ surface)}$$

Dissolution:

$$UO_3 + 2\,HCO_3^{-1} \rightarrow UO_2(CO_3)_2^{-2} + H_2O$$

$$UO_3 + CO_3^{-2} + 2HCO_3^{-1} \rightarrow UO_2(CO_3)_3^{-4} + H_2O$$

The principal uranyl carbonate ions formed as shown above are uranyl dicarbonate, $UO_2(CO_3)_2^{-2}$, (UDC), and uranyl tricarbonate $UO_2(CO_3)_3^{-4}$, (UTC). The relative abundance of each is a function of pH and total carbonate strength.

Solutions resulting from the leaching of uranium underground will be recovered through the production wells and piped to the satellite plant for extraction. The uranium recovery process utilizes the following steps:

1. Loading of uranium complexes onto an ion exchange resin;

2. Reconstitution of the leach solution by addition of carbon dioxide and/or sodium bicarbonate and an oxidizer;

3. Elution of uranium complexes from the resin; and,

4. Precipitation of uranium.

The first two steps will be performed at the North Trend Satellite Plant. Steps 3 and 4 will be performed at the current Central Processing Plant. The process flow sheet for the above steps is shown in Figure 3.1-9. The left side of Figure 3.1-9 depicts the uranium extraction process that is completed at the satellite plant. The right side of the figure shows the uranium recovery steps that will be performed at the Central Processing Plant. Once the ion exchange resin at the satellite plant is loaded to capacity with uranium complexes, the resin will be transferred to the Central Processing Plant for the completion of uranium recovery.

3.1.4.1 Uranium Extraction

The recovery of uranium from the leach solution in the North Trend Expansion Facility will take place in the ion exchange columns. The uranium-bearing leach solution enters the pressurized downflow ion exchange column and passes through the resin bed. The uranium complexes in solution are loaded onto the IX resin in the column. This loading process is represented by the following chemical reaction:

$$2\,R\,HCO_3 + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + 2HCO_3^{-1}$$

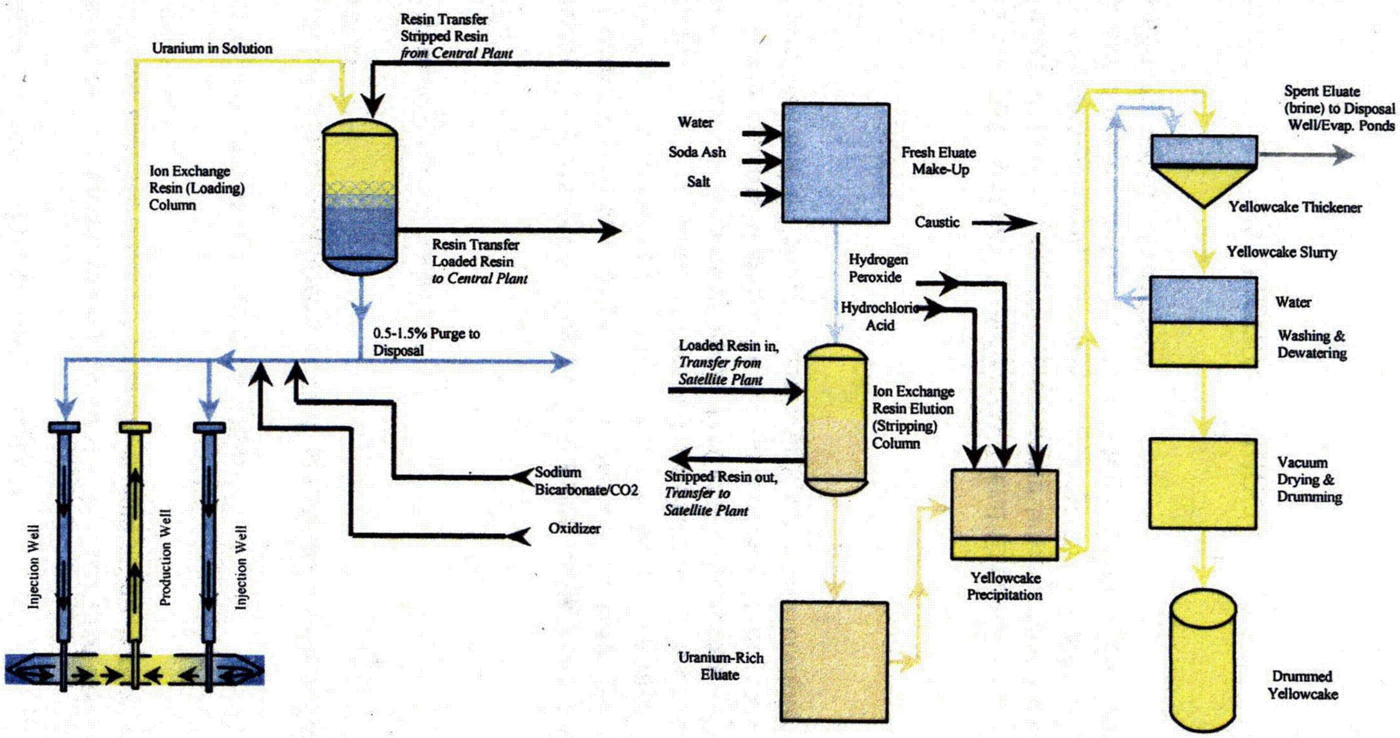
$$2\,RCl + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + 2Cl^{-}$$

$$R_2SO_4 + UO_2(CO_3)_2^{-2} \longrightarrow R_2UO_2(CO_3)_2 + SO_4^{-2}$$

Figure 3.1-9: Process Flow Diagram

Satellite Plant
(Uranium Extraction)

Central Plant
(Uranium Recovery)



As shown in the reaction, loading of the uranium complex results in simultaneous displacement of chloride, bicarbonate or sulfate ions.

The now barren leach solution passes from the IX columns to be reinjected into the formation. The solution is refortified with sodium and carbonate chemicals, as required, and pumped to the wellfield for reinjection into the formation. The expected lixiviant concentration and composition is shown in Table 3.1-1.

3.1.4.2 Resin Transport and Elution

Once the majority of the ion exchange sites on the resin in an IX column are filled with uranium, the column will be taken out of service. The resin loaded with uranium will be transferred to a tanker truck for transport to the Central Processing Plant for elution and final processing. Once the resin has been stripped of the uranium by the process of elution, the resin will be returned to the North Trend Satellite Plant for reuse in the ion exchange circuit.

At the Central Processing Plant, the loaded resin that has been transported from the satellite facility will be stripped of uranium by an elution process based on the following chemical reaction:

$$R_2UO_2(CO_3)_2 + 2Cl^- + CO_3^{-2} \longrightarrow 2\,RCl + UO_2(CO_3)_2^{-2}$$

After the uranium has been stripped from the resin, the resin is rinsed with a solution containing sodium bicarbonate. This rinse removes the high chloride eluant physically entrained in the resin and partially converts the resin to bicarbonate form. In this way, chloride ion buildup in the leach solution can be controlled.

3.1.4.3.Precipitation

When a sufficient volume of pregnant eluant is held in storage, it is acidified to destroy the uranyl carbonate complex ion. The solution is agitated to assist in removal of the resulting CO2. The decarbonization can be represented as follows:

$$UO_2(CO_3)_3^{-4} + 6H^+ \longrightarrow UO_2^{++} + 3\,CO_2\uparrow + 3H_2O$$

Table 3.1-1: Typical Lixiviant Concentrations

SPECIES	RANGE	
	Low	High
Na	≤ 400	6000
Ca	≤ 20	500
Mg	≤ 3	100
K	≤ 15	300
CO_3	≤ 0.5	2500
HCO_3	≤ 400	5000
Cl	≤ 200	5000
SO_4	≤ 400	5000
U_3O_8	≤ 0.01	500
V_2O_5	≤ 0.01	100
TDS	≤ 1650	12000
pH	≤ 6.5	10.5

* All values in mg/l except pH (units).

NOTE: The above values represent the concentration ranges that could be found in barren lixiviant or pregnant lixiviant and would include the concentration normally found in "injection fluid".

Sodium hydroxide (NaOH) is then added to raise the pH to a level conducive for precipitating pure crystals.

Hydrogen peroxide is then added to the solution to precipitate the uranium according to the following reaction:

$$UO_2^{++} + H_2O_2 + 2H_2O \longrightarrow UO_4 \bullet 2H_2O + 2H^+$$

The precipitated uranyl peroxide slurry is pH adjusted, allowed to settle, and the clear solution decanted. The decant solution is recirculated back to the barren makeup tank, sent to fresh salt brine makeup, or sent to waste. The thickened uranyl peroxide is further dewatered and washed. The solids discharge is either sent to the vacuum dryer for drying before shipping or is sent to storage for shipment as slurry to a licensed recovery or converting facility.

3.1.5 Wellfield and Process Wastes

All well development water will be captured in water trucks specifically labeled and dedicated for such purpose, and equipped with signage indicating that these trucks may only discharge their contents to the lined evaporation ponds.

The operation of the North Trend Satellite Plant will result in one source of liquid waste being generated at the satellite facility and an increase in the liquid waste at the Central Processing Plant. A production bleed stream is continuously withdrawn from the recovered lixiviant stream at a rate that is expected to be 0.5 to 1.5 percent of the total volume of recovered lixiviant. The production bleed stream is taken following the recovery of uranium by ion exchange and has the same chemical characteristics as the lixiviant. 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.

The other source of wastewater resulting from uranium mining activities in the North Trend Expansion Area is the eluant bleed stream at the Central Processing Plant. This is an existing source of wastewater at the Central Processing Plant that is currently produced at a rate of approximately 5 to 10 gpm. It is likely that the eluant bleed stream will increase by a maximum of 10 percent due to processing of ion exchange resin from the North Trend Satellite Plant. The eluant bleed waste stream will be managed by reuse in the plant or disposal in existing ponds and/or by deep disposal well injection at the Central Processing Plant.

All byproduct material produced as a result of the operation of the North Trend Satellite Plant will be disposed of at a licensed facility approved for disposal of 11e.(2) byproduct material, similar to provisions made for the byproduct material currently produced. All solid waste will be disposed of in an approved landfill in accordance with current practice. There will be no on-site disposal of these materials.

3.2 CENTRAL PROCESSING PLANT, SATELLITE PLANT, WELLFIELDS, AND CHEMICAL STORAGE FACILITIES – EQUIPMENT USED AND MATERIAL PROCESSED

The uranium recovery process described in the preceding section will be accomplished in two steps. The uranium recovery from the leach solution by ion exchange will be performed at the North Trend Satellite Plant. The subsequent processing of the loaded ion exchange resin to remove the uranium (elution), the precipitation of uranium, and the dewatering and packaging of solid uranium (yellowcake) will be performed at the existing Central Processing Plant. The capacity for resin handling and cleaning, elution, precipitation, dewatering and washing, and drying in the Central Processing Plant will be increased appropriately to handle the processing of material from the North Trend Expansion Area in addition to the material that will continue to be produced in the current license area. Depending upon the mining schedules for the existing wellfield and the North Trend Expansion Area, it is possible that the belt filter and dryer capacity may be increased.

3.2.1 North Trend Satellite Plant Equipment

Only the equipment proposed for the North Trend Satellite Plant is described in this section. The equipment and processes in the Central Processing Plant are covered under the existing USNRC Source Materials License Number SUA-1534. A general arrangement for the satellite plant is shown on Figure 3.2-1. The North Trend Satellite Plant facilities will be housed in a building approximately 130 feet long by 100 feet wide. The satellite plant equipment includes the following systems:

- Ion exchange;
- Filtration;
- Resin transfer; and,
- Chemical addition.

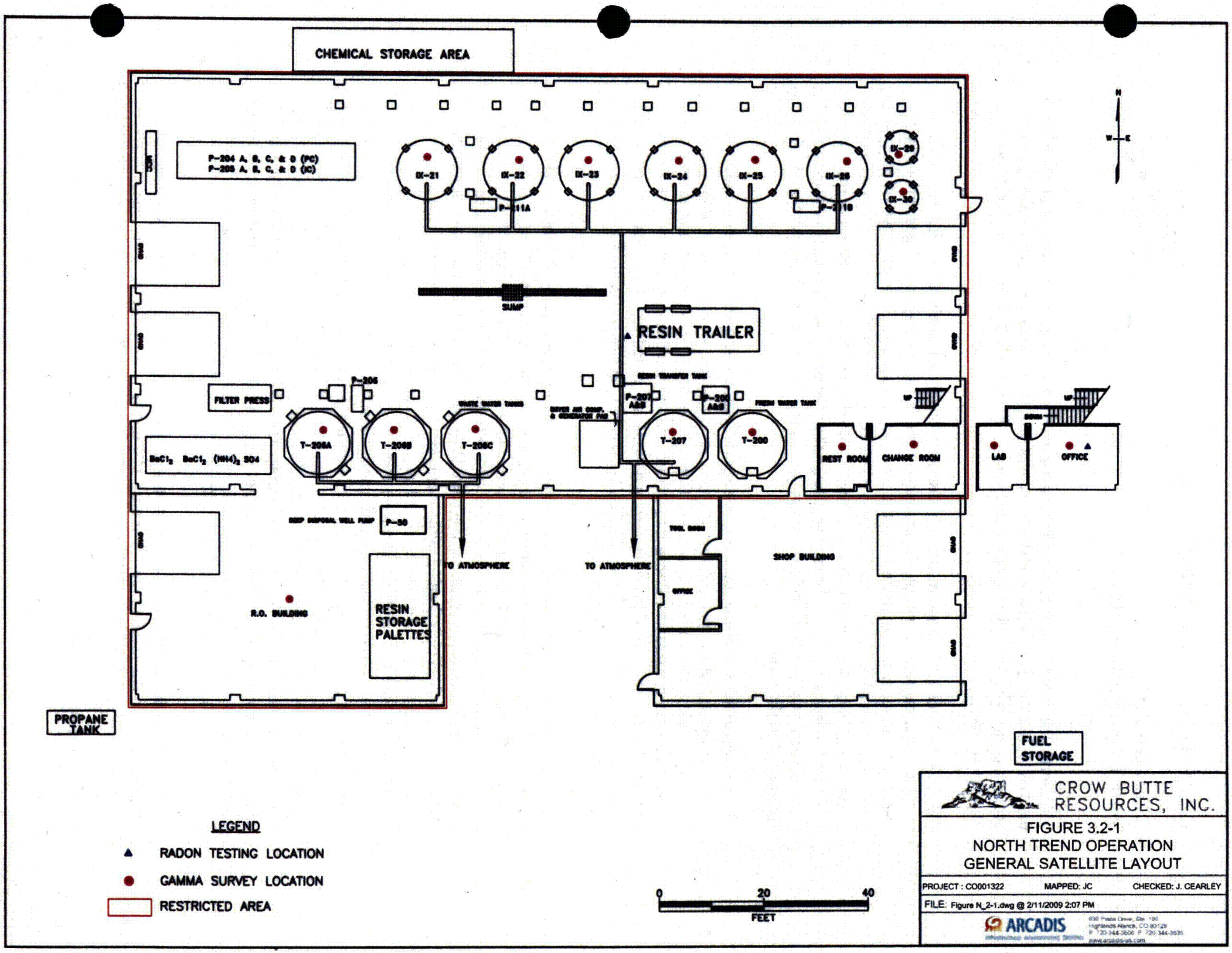


FIGURE 3.2-1
NORTH TREND OPERATION
GENERAL SATELLITE LAYOUT

The North Trend Satellite Plant will be located within a 30 acre fenced area in the E½ of the NW¼, Section 27, T32N, R52W. This area will also contain the evaporation ponds, deep disposal well, and chemical storage areas. Figure 3.2-2 shows the plan view of these facilities.

The in situ process of uranium mining associated with the satellite facility uses water, oxygen and a carbonate (simple bicarbonate of soda [soda ash] or the gaseous carbon dioxide) to dissolve the uranium from the sands in the aquifer. The presence of oxygen dissolves the uranium and the carbonate (i.e., sodium bicarbonate and/or carbon dioxide) complexes it as uranyl tricarbonate allowing the uranium to flow in solution in the water so that it can be recovered. The oxygen causes the uranium to settle out (precipitate) and the carbonate (e.g., carbon dioxide) keeps the uranium in solution and prevents it from coming out of the water.

The satellite plant will house the ion exchange (IX) columns, water treatment equipment, resin transfer facilities, pumps for injection of lixiviant, a small laboratory and an employee break room. Bulk soda ash and carbon dioxide and oxygen in compressed form and/or hydrogen peroxide will be stored adjacent to the satellite plant or in the wellfield. Sodium bicarbonate and/or gaseous carbon dioxide are added to the lixiviant as the fluid leaves the satellite plant for the wellfields. Gaseous oxygen is added to the injection line for each injection well at the wellhouses.

The ion exchange system consists of eight fixed-bed ion exchange columns. The ion exchange columns will be operated as three sets of two columns in series with two additional columns available for restoration. The ion exchange system is designed to process recovered leach solution at a rate of 4,500 gpm with each column sized at 11.5 foot diameter by 21 foot overall height with 500 cubic feet of resin operated downflow. Once a set of columns is loaded with uranium, the resin is transferred to a truck for transport to the Central Processing Plant at the Crow Butte facility. The downflow columns are pressurized, sealed systems so there is no overflow of water, oxygen stays in solution and radon emissions are contained. Radon releases from the pressurized downflow columns occur only when the individual columns are disconnected from the circuit and opened to remove the resin for elution. Upflow columns are not pressurized and the top is open, so there is the possibility of overflow of water, oxygen is lost out of solution and radon is emitted to the atmosphere, typically via a vent system when enclosed in a building. One disadvantage of the downflow column is that there must be good pressure control. Exposure pathways associated with downflow columns to be used at North Trend are discussed in Section 7.3.1 of Chapter 7.0.

After the ion exchange process, the barren leach solution recovered from the wellfield is replenished with an oxidant and leaching chemicals (i.e., sodium bicarbonate and/or carbon dioxide). The injection filtration system consists of optional backwashable filters,

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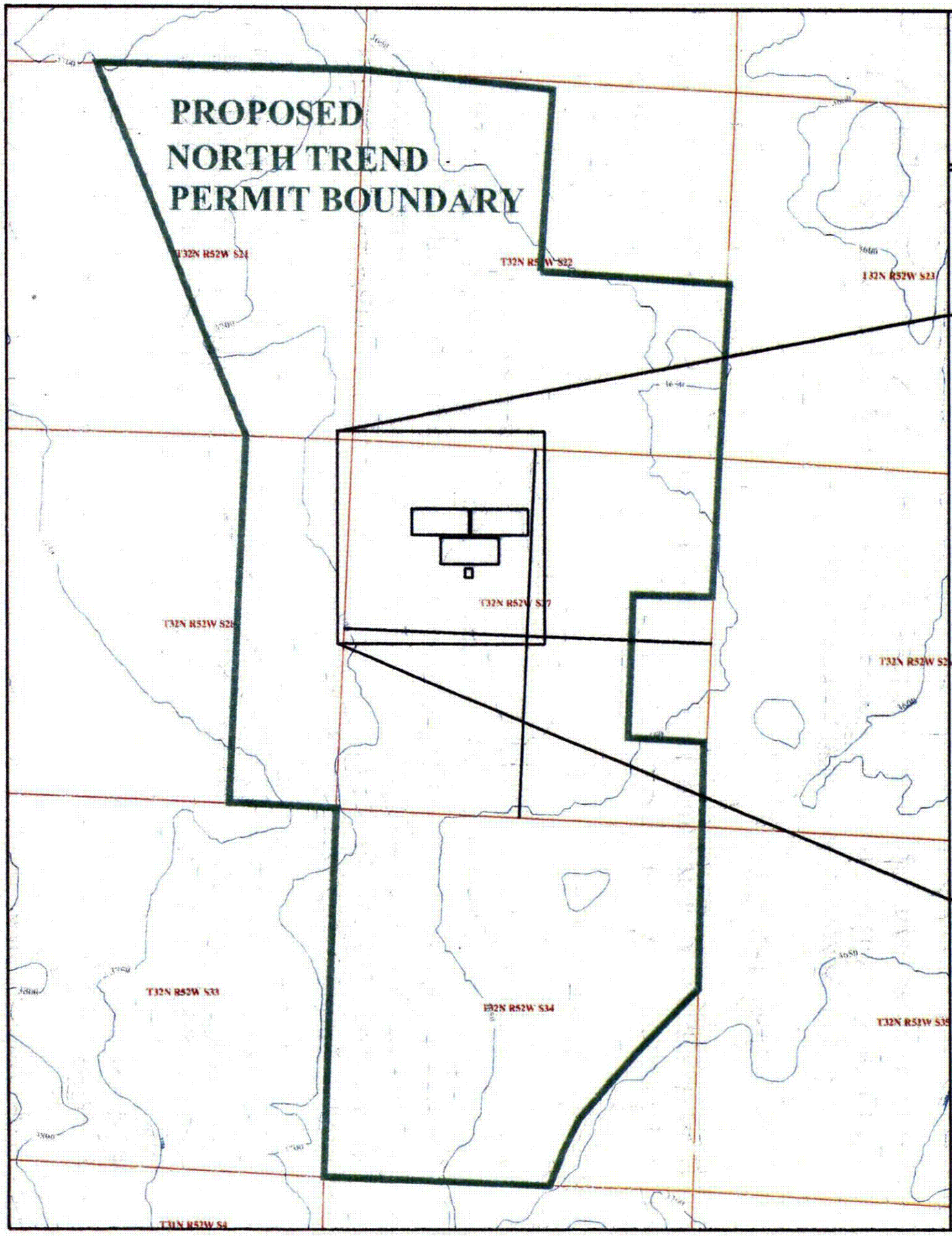
License Amendment Application
North Trend Expansion Area



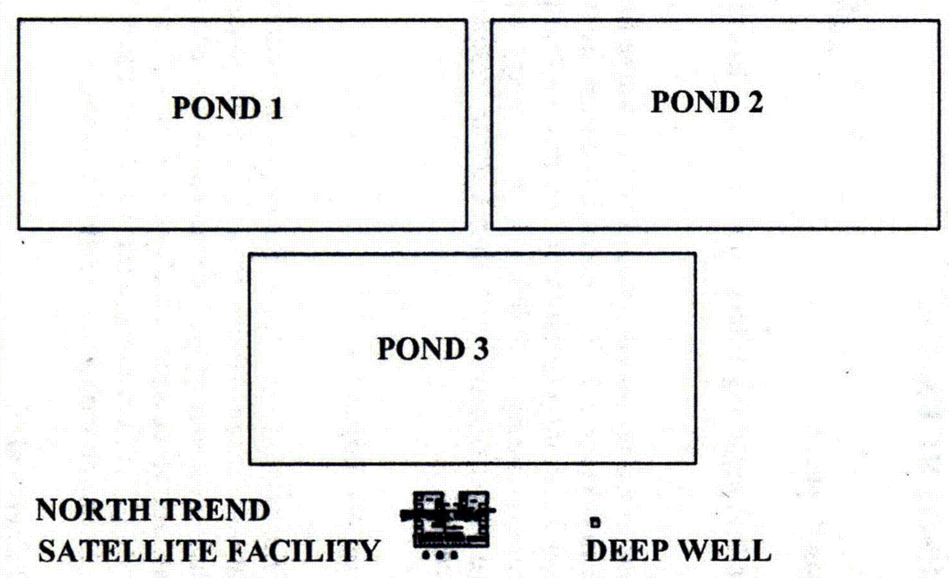


FIGURE 3.2-2

CROW BUTTE RESOURCES, INC.

General Arrangement
Satellite Plant
Plan View

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 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.

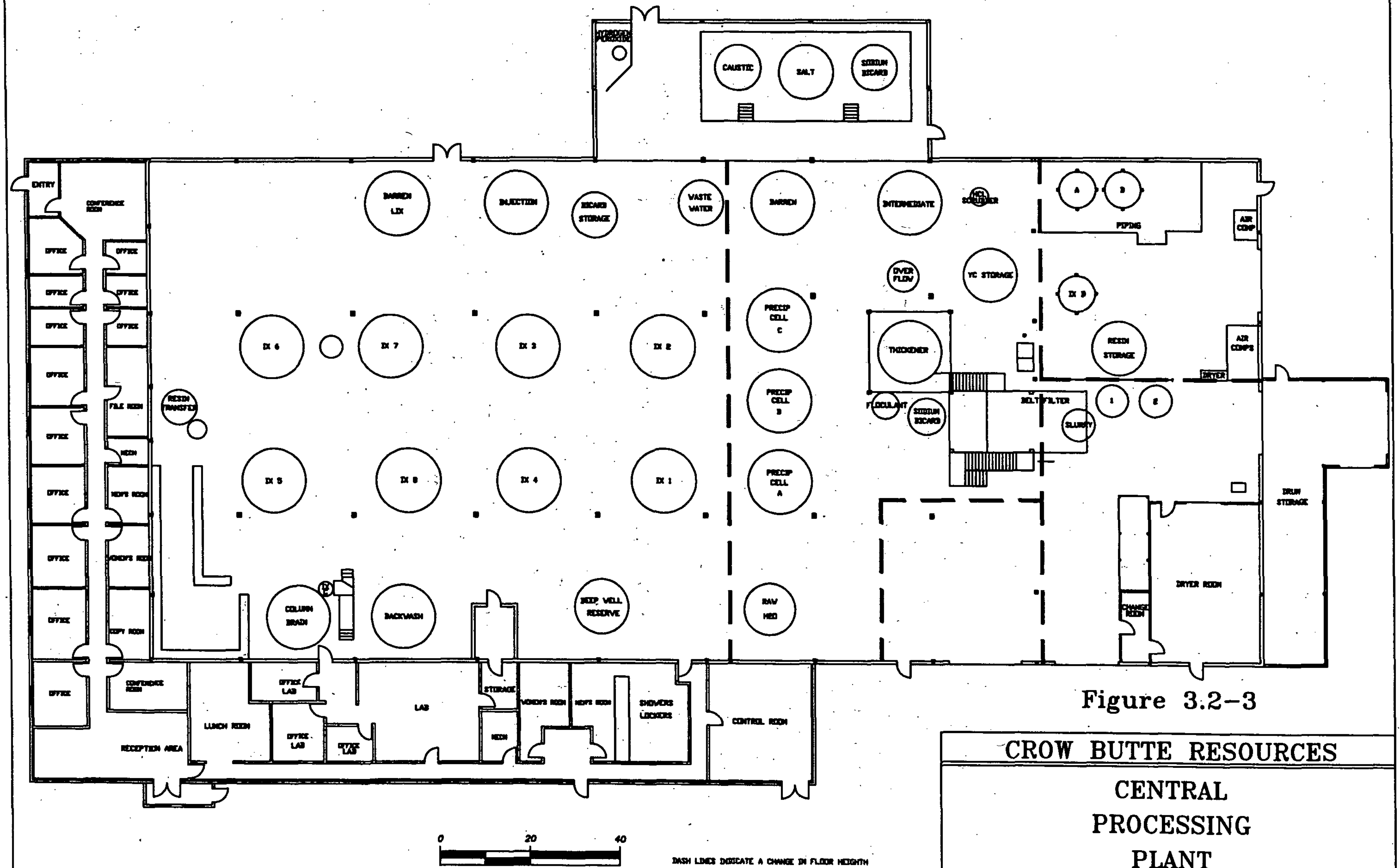


Figure 3.2-3

CROW BUTTE RESOURCES

CENTRAL
PROCESSING
PLANT

3.2.2.2 Non-Process Related Chemicals

Non-process related chemicals that will be stored at the North Trend Satellite Plant include petroleum (gasoline, diesel) and propane. Due to the flammable and/or combustible properties of these materials, all bulk quantities will be stored outside of process areas at the satellite plant. All gasoline and diesel storage tanks are located above ground and within secondary containment structures to meet EPA requirements.

3.3 INSTRUMENTATION AND CONTROL

The wellfield houses will be located remotely from the Satellite Facility building. A distribution system will be used to control the flow to and from each well in the wellfield. Wellfield instrumentation will be provided to measure total production and injection flow and to indicate the pressure that is being applied to the injection trunklines. Wellfield houses will be equipped with wet alarms to monitor the presence of liquids in the wellfield house sumps.

Instrumentation will be provided to monitor the total flow into the Satellite Facility, the total injection flow leaving the plant, and the total waste flow leaving the plant. Instrumentation will be provided on the plant injection manifold to record an alarm in the event of any pressure loss that might indicate a leak or rupture in the injection system. The instruments used for flow measurement will include, but are not limited to, turbine meters, ultrasonic meters, variable area meters, electromagnetic flow meters, differential pressure meters, positive displacement meters, piezoelectric and vortex flow meters. The injection pumps will be sized or equipped so that they are incapable of producing pressures high enough to exceed design pressure of the injection lines or the maximum pressure to be applied to the injection wells. Pressure gauges, pressure shutdown switches and pressure transducers will be used to monitor and control the trunkline pressures.

The basic control system at the Crow Butte site will be built around a Sequential Control and Data Acquisition (SCDA) network. At the heart of this network is a series of programmable logic controllers. This system allows for extensive monitoring and control of all waste flows, wellfield flows, and recovery plant operations.

The SCDA system will be interconnected throughout the facility via a Local Area Network (LAN) to many computer display screens. The software used to display plant processes and collect data incorporates a series of menus which allows the plant operators to monitor and control a variety of systems and parameters. Critical processes, pressures, and wellfield flows will have alarmed set-points that alert operators when any parameters are out of tolerance. In addition, each wellfield house will contain its own 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 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 *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 *Volume IV Health Physics Manual, Environmental, Health, and Safety Management System.*

3.4 REFERENCES

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[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 4.0
Effluent Control Systems

Replace Section 4.0, pages 4-1 through 4-18

4 EFFLUENT CONTROL SYSTEMS

This section describes the effluent control systems that will be used at the North Trend Satellite Facility. The effluents of concern at ISL operations include the release or potential release of radon gas (radon-222), radionuclides in liquid process streams, and dried yellowcake. Yellowcake processing and drying operations are conducted at the Central Plant. Loaded ion exchange resin from the North Trend Satellite Facility will be transported to the Central Plant for elution, precipitation, drying, and packaging.

The yellowcake drying facilities at the Central Plant are comprised of one vacuum dryer. The current license allows for the addition of a second dryer. By design, vacuum dryers do not discharge any uranium when operating. Effluent controls for yellowcake drying at the Crow Butte Central Plant have been reviewed by NRC and approved in the current license.

4.1 GASEOUS AND AIRBORNE PARTICULATES

The principal radioactive airborne gaseous radiological effluent at the North Trend Satellite Facility will be Radon-222 gas. Processing at the Satellite Facility will occur in the form of water based solutions (no yellowcake processing or drying); therefore, airborne uranium concentrations are expected to be at or near local background levels. Airborne releases from in situ leach facilities normally are Rn-222 and its daughters from process fluids and particulates from yellowcake drying and packaging operations[1]. One process area at the proposed NTEA where small quantities of airborne uranium particulates have the potential for occurring is the resin transfer station where minor spills may occur. The loaded ion exchange resin is transferred to a truck for transport to the current processing facility for completion of uranium recovery. Spills can occur during the transfer of this loaded resin to trucks, and this is where exposure to uranium particulates is possible. All spills will be cleaned up as soon as possible to avoid the wet materials from drying and creating the potential for airborne particulates. Spills associated with resin transfer would involve the impregnated resin itself. The uranium is still bound to the resin at this stage, reducing the potential of employee exposure.

There could also be maintenance activities on piping containing pregnant lixiviant that could result release of radon and uranium. Any spills or releases during maintenance of these potential sources would be cleaned up promptly to avoid drying of the material and creation of particulates subject to dispersion. All non-routine operations or maintenance activities where the potential exists for significant exposure to radioactive materials, and for which no Standard Operating Procedure (SOP) exists, require a Radiation Work Permit (RWP). The RWP ensures the applicable radiological safety measures are used by the workers and identifies the type personnel monitoring that would be required for determining radiation exposure (i.e., internal and external radiation).

One stationary sample point would be established near the resin transfer station and would be sampled monthly for potential airborne uranium particulates. Monitoring activities for routine operations, maintenance activities and spill cleanups are discussed in Section 5.7.

Radon-222 is found in the pregnant lixiviant that comes from the wellfield into the satellite facility for separation of uranium. The uranium will be separated from the groundwater by passing the solution through fixed bed ion exchange (IX) units operated in a pressurized downflow mode. Vessel vents from the individual IX vessels will be directed to a manifold that is exhausted to atmosphere outside the satellite building. Venting any released radon-222 gas to atmosphere outside the plant via high-volume exhaust fans minimizes employee exposure. Small amounts of radon-222 may be released via solution sampling and spills, filter changes, IX resin transfer, reverse osmosis (RO) system operation during groundwater restoration, and maintenance activities. These are minimal radon gas releases on an infrequent basis. The general building ventilation system in the satellite plant will further reduce employee exposure. The air in the plant is sampled for radon daughters (see Section 5.0) to assure that concentration levels of radon and radon daughters are maintained as low as reasonably achievable (ALARA).

Injection wells would generally be closed and pressurized, but periodically vented releasing radon to the atmosphere. Production wells will be continually vented to the surface, but water levels will typically be low and radon venting will be minimal. Some venting would also occur from the meter houses. All of the well releases would be outside of buildings and directly vented to the atmosphere. Wellhouses would be vented so as to remove any radon releases from the building to the surrounding atmosphere. Releases to the atmosphere from wells and wellhouses would result in radon emissions dispersing rapidly. Wellfield off gassing is not considered a significant source of radon or a safety issue. This statement is supported by MILDOS calculations (Section 7.3) and by monitoring at the current Crow Butte operations. Radon individual exposure levels from 1994 through 2006 for Crow Butte employees ranged from 5 to 16 % of the occupational exposure limit of 4 working level months (WLM). Exposure to radon is reported as WLM, a unit commonly used in occupational environments and refers to exposure to a set concentration of radon and its associated progeny. Exposures at the proposed North Trend operations would be expected to be less than for the current operations, due to lack of uranium recovery operation activities such as elution, precipitation, and drying. Discussions of radiological exposure pathways are presented in Chapter 7.3.

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 EHSMS. 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

Table 4.1-1 Monthly Summary of Radon Daughter Surveys (2008) at Current Crow Butte Processing Facility

Sample Point #	Sample Point Locations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Spt	Oct	Nov	Dec
							Working Level*						
1R	Between IX Columns & Precipitation Cells	0.013	0.011	0.013	0.013	0.024	0.037	0.009	0.008	0.012	0.011	0.011	0.015
2R	Between Precipitation Cells & Eluent Tanks	0.015	0.013	0.010	0.010	0.058	0.035	0.013	0.011	0.030	0.014	0.010	0.011
3R	Between IX Columns & Injection Tanks	0.019	0.020	0.016	0.021	0.016	0.036	0.024	0.016	0.036	0.014	0.007	0.011
4R	Between IX Columns & Resin Transfer Tank	0.024	0.028	0.014	0.020	0.021	0.022	0.021	0.017	0.024	0.017	0.008	0.010
5R	Between IX Columns & Column Drain Tank	0.015	0.005	0.013	0.016	0.017	0.027	0.019	0.012	0.014	0.016	0.005	0.007
6R	Between IX Column Trains	0.023	0.027	0.013	0.012	0.017	0.026	0.028	0.039	0.015	0.015	0.005	0.004
7R	Between Precipitation Cells & Raw Water Tk.	0.013	0.011	0.008	0.012	0.029	0.036	0.010	0.004	0.009	0.015	0.008	0.018
8R	Motor Control Room	0.002	0.005	0.003	0.001	0.003	0.004	0.005	0.001	0.002	0.001	0.003	0.001
9R	Lab	0.006	0.007	0.002	0.003	0.004	0.002	0.001	0.003	0.001	0.002	0.012	0.001
10R	Lunch Room	0.002	0.001	0.001	0.001	0.002	0.007	0.002	0.001	0.003	0.005	0.009	0.006
11R	Reverse Osmosis Building	0.005	0.004	0.003	0.002	0.004	0.008	0.002	0.003	0.002	0.002	0.006	0.002
12R	Restoration Room	0.014	0.011	0.009	0.027	0.030	0.037	0.018	0.006	0.028	0.020	0.009	0.008
	Plant Average (1R-8R & 12R)	0.015	0.015	0,.011	0.015	0.024	0.029	0.016	0.013	0.019	0.014	0.007	0.009
	Annual Plant Average	0.016											
	1R-8R & 12R												

**Working level* (WL) is any combination of short-lived radon daughters (for radon-222: polonium-218, lead-214, bismuth-214, and polonium-214; and for radon-220: polonium-216, lead-212, bismuth-212, and polonium-212) in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha particle energy.

Table 4.1-2 Monthly Airborne Uranium Sampling at Current Crow Butte Operations for 2008

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Spt	Oct	Nov	Dec
	µCi/ml											
Between IXD Trains	6.96E-13	2.65E-13	4.43E-13	2.46E-13	3.32E-13	1.80E-12	2.52E-13	6.44E-14	2.50E-13	1.05E-13	1.55E-13	3.65E-13
Under Thickener (yellowcake Storage)	9.53E-13	3.58E-13	4.13E-13	3.40E-13	9.49E-13	9.93E-13	6.66E-13	3.30E-13	1.56E-13	8.24E-14	1.30E-13	5.91E-13
Belt Filter Room	6.33E-12	2.90E-12	2.43E-13	8.18E-13	2.60E-13	2.66E-12	1.04E-12	2.69E-13	1.86E-12	1.98E-13	2.99E-13	8.37E-13
Precipitation Area-Catwalk by Precipitation B	8.07E-13	5.07E-13	1.01E-12	6.97E-13	5.87E-13	1.27E-12	6.77E-13	5.81E-13	5.62E-13	7.59E-14	1.95E-13	4.11E-13
White Slurry Storage Tanks	2.50E-12	4.34E-13	4.63E-13	6.56E-13	2.28E-13	3.45E-14	6.62E-13	2.68E-12	2.65E-13	3.87E-13	3.87E-13	3.07E-12
Outside of the Dryer Room	1.68E-12	2.37E-13	2.54E-13	3.16E-13	6.35E-13	7.88E-13	3.43E-13	3.36E-13	2.13E-13	9.29E-14	4.16E-13	3.85E-13
Laboratory	3.03E-14	1.91E-13	3.42E-13	3.48E-13	2.34E-13	3.17E-13	2.64E-13	2.96E-13	2.04E-13	4.85E-13	5.18E-13	2.65E-13

verify that radon daughters are maintained below the 25% DAC action level. Ongoing operations would ensure that the ventilation system would be operating satisfactorily and as designed through the use of Standard Operating Procedures (SOPs).

Other emissions to the air are limited to exhaust and dust from limited vehicular traffic. There are no significant amounts of process chemicals that will be used at the satellite plant. There are no significant combustion-related emissions from the process facility, as commercial electrical power is available at the site. The primary types of non-radiological pollutants that could occur during operations at the North Trend site are discussed in Section 7.2.1 (Air Quality Impacts of Operations). The North Trend Satellite operational building would not have combustion devices, except for the propane heaters used for heating the building as needed.

Occupational and public exposures to radon emitted from the mine units and from the satellite processing facility were analyzed using the MILDOS computer model to ensure the discharged amount would be within regulatory dose limits. The results of this modeling are presented in Section 7.3.

4.2 LIQUIDS AND SOLIDS

4.2.1 Liquid Waste

As a result of in-situ leach mining, there are several sources of liquid waste. The potential wastewater sources that exist at the North Trend Satellite Facility include the following:

- Water Generated During Well Development

This water is recovered groundwater and has not been exposed to any mining process or chemicals. However, the water may contain elevated concentrations of naturally-occurring radioactive material if the development water is collected from the mineralized zone. The water will be discharged directly to the solar evaporation pond and silt, fines and other natural suspended matter collected during well development will settle out in the pond. Well development water may also be treated with filtration and/or reverse osmosis and used as plant make-up water or disposed of in the deep disposal well.

- Liquid Process Waste

The operation of the satellite facility results in one primary source of liquid waste, a production bleed, as previously discussed in Section 3.0. This bleed will be routed to either the deep disposal well or an evaporation pond.

- Aquifer Restoration Waste

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
4. Wellfield Circulation

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 by site conditions. 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 will be used to reduce the total dissolved solids (TDS) of the groundwater. The RO unit produces clean water (permeate) and brine. The permeate is either injected into the formation or disposed of in the waste disposal system. The brine is sent to the wastewater disposal system.

- Stormwater Runoff

Stormwater may be contaminated by contact with industrial materials. Stormwater management is controlled under permits issued by the NDEQ. CBR is subject to stormwater National Pollutant Discharge Elimination System (NPDES) permitting requirements for industrial facilities and construction activities. The NDEQ NPDES regulatory program contained in Title 119[3] requires that procedural and engineering controls be implemented such that runoff will not pose a potential source of pollution.

- Domestic Liquid 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. These systems are in common use throughout the United States and the effect of the system on the environment is known to be minimal when the systems are designed, maintained, and operated properly. CBR currently maintains a Class V UIC Permit issued by the NDEQ for operation of the septic system at the current license area. A similar permit will be required for the North Trend Satellite Facility.

- Laboratory Waste

Liquid waste from the laboratory will be disposed of in either the evaporation pond or the deep disposal well.

4.2.1.1 Liquid Waste Disposal

Two methods of disposal are proposed for the North Trend Satellite Facility and are already permitted for use at the Crow Butte Central Plant:

- Deep disposal well injection; and
- Evaporation via evaporation ponds.

In addition to these two disposal methods, the NDEQ has issued CBR a NPDES Permit for the current licensed area that allows land application of treated wastewater. CBR has not used this waste disposal method at the current operation. At this time, CBR does not intend to apply for an NPDES permit to allow land application at the North Trend Satellite Facility. It is expected that liquid waste generated in the North Trend Expansion Area will be managed in the same manner as at the existing Crow Butte Central Plant (i.e., by evaporation and deep well injection).

4.2.1.1.1 Deep Disposal Well

CBR currently operates a non-hazardous Class I injection well in the current license area for disposal of wastewater. The well is permitted under NDEQ regulations in Title 122[4] and operated under a Class I UIC Permit. CBR has operated the deep disposal well at the current license area for over ten years with excellent results and no serious compliance issues. CBR expects that the liquid waste stream at the North Trend Satellite Facility will be chemically and radiologically similar to the waste disposed of in the current deep disposal well.

CBR plans to install a deep disposal well at the North Trend Satellite Facility as the primary liquid waste disposal method. CBR has found that permanent deep disposal is preferable to evaporation in evaporation ponds. All compatible liquid wastes at the North Trend Satellite Facility will be disposed of in the planned deep disposal well. At the time of preparation of this amendment request, an application is under preparation for submittal to the NDEQ for a Class I UIC Permit for the North Trend Satellite Facility.

4.2.1.1.2 Evaporation Pond

Evaporation pond design, installation and operation criteria are those found in USNRC Regulatory Guide 3.11[5]. The evaporation pond configuration at the North Trend Satellite Facility will be similar to the existing ponds at the current CBR license area. 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. This information is currently not available due to the stage of project development. A license amendment application with pond design and specifications, which meet the requirements of the most current pond design and construction Regulatory Guides, will be submitted to the NRC prior to pond construction. In addition, plans for monitor wells used to demonstrate compliance with 10 CFR 40, Appendix A, Criterion 7a, will be submitted as part of the license amendment.

Each pond will have the capability of being pumped to a water treatment plant before disposal. 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 treat the water to a quality that falls well within NPDES criteria.

CBR maintains three commercial and two R & D evaporation ponds in the current license area. The ponds are constructed with a primary and secondary liner system. An underdrain system consisting of perforated piping between the primary and secondary liners is installed to monitor for leaks. The underdrain slopes gradually to the ends of the ponds where they are connected to a surface monitor pipe. Checking for an increase in measurable moisture inside the leak detection system and/or analyzing the water in the pipe can discover a leak in the pond liner. The design of the North Trend evaporation pond will include similar features.

The current pond inspection program is based on NRC recommendations in Regulatory Guide 3.11.1[6] and is approved in SUA-1534. Routine inspections are required as follows:

- 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 Environmental, Health, and Safety Management System (EHSMS) 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 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 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 driver could begin the containment of any spilled material. Because the uranium adheres to the resin and the resin is wet when transferred, the radiological and environmental impacts of a spill due to an accident will be minimal. Finally, each resin transfer vehicle will be equipped with a radio for communications with the Central Plant. This allows quick response and implementation of the emergency response plan for transportation accidents.

4.2.1.2.6 Spills

Spills can take two forms within an in-situ facility. These are surface spills (such as pond leaks, piping ruptures etc.) and subsurface releases such as a well casing failure, or a pond liner leak resulting in a release of waste solutions.

Engineering and administrative controls are in place at the Central Plant and will be implemented at the satellite facility to prevent both surface and subsurface releases to the environment, and to mitigate the effects should an accident occur. The most common form of surface release from in-situ mining operations occurs from breaks, leaks, or separations within the piping that transfers mining fluids from the process plant to the wellfield and back. With the current CBR monitoring system, these are generally small releases and are quickly discovered and mitigated.

In general, piping from the plant, to and within the wellfield, will be constructed of high density polyethylene pipe (HDPE) with butt welded joints or the equivalent. All pipelines will be pressure tested before final 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 a major cause of potential failure, which is vehicles driving over the lines causing breaks. Typically, the only exposed pipes will be at the satellite plant, at the wellheads, and in the wellhouses in the wellfield. Trunkline flows and manifold pressures will be monitored for spill detection and process control.

4.2.2 Solid Waste

Any facility or process with the potential to generate industrial waste should practice good housekeeping. This activity generally consists of keeping facilities, equipment, and process areas clean and free of industrial waste or other debris. Good housekeeping includes promptly cleaning any spillage or process residues that are on floors or other areas that could be spread and collecting solid wastes in designated containers or area until proper disposal.

Solid waste generated at the North Trend Satellite Facility is expected to include spent resin, resin fines, empty reagent containers, miscellaneous pipe and fittings, and domestic trash. The solid waste will be segregated based on whether it is clean or has the potential for contamination with 11(e).2 byproduct materials.

4.2.2.1 Non-contaminated Solid Waste

Non-contaminated solid waste is waste which is not contaminated with 11(e).2 byproduct material or which can be decontaminated and re-classified as non-contaminated waste. This type of waste may include trash, piping, valves, instrumentation, equipment and any other items which are not contaminated or which may be successfully decontaminated. Release of contaminated equipment and materials is discussed in further detail in Section 5.

CBR has recently estimated that the current licensed site produces approximately 1,055 cubic yards (yd^3) of non-contaminated solid waste per year. This estimate is based on the number of collection containers on site and the experience of the contract waste hauler. CBR estimates that the proposed North Trend Satellite Facility would produce approximately 700 yd^3 of non-contaminated solid waste per year. Non-contaminated solid waste will be collected on the site in designated areas and disposed of in the nearest permitted sanitary landfill.

4.2.2.2 11(e).2 Byproduct Material

Solid 11e.(2) byproduct waste consists of solid waste contaminated with 11e.(2) byproduct material that cannot be decontaminated.

11(e).2 byproduct material generated at ISL facilities consists of filters, Personal Protective Equipment (PPE), spent resin, piping, etc. CBR has recently estimated that the current licensed site produces approximately 60 to 90 cubic yards (yd^3) of 11(e).2 byproduct material waste per year. This estimate is based on the number of historical number of shipments to the licensed disposal facilities. CBR estimates that the proposed North Trend Satellite Facility would produce approximately 60 yd^3 of 11(e).2 byproduct materials per year. These materials will be stored on site until such time that a full shipment can be shipped to a licensed waste disposal site or licensed mill tailings facility. CBR currently maintains an agreement for waste disposal at a properly licensed facility as a License Condition for SUA-1534. CBR is required to notify NRC in writing within 7 days if the disposal agreement expires or is terminated, and to submit a new agreement for NRC approval within 90 days of the expiration or termination.

If decontamination is possible, records of the surveys for residual surface contamination will be made prior to releasing the material. Decontaminated materials have activity 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 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 5.0 Operations

Replace Section 5.0, pages 5-1 through 5-61

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 CBR's 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).

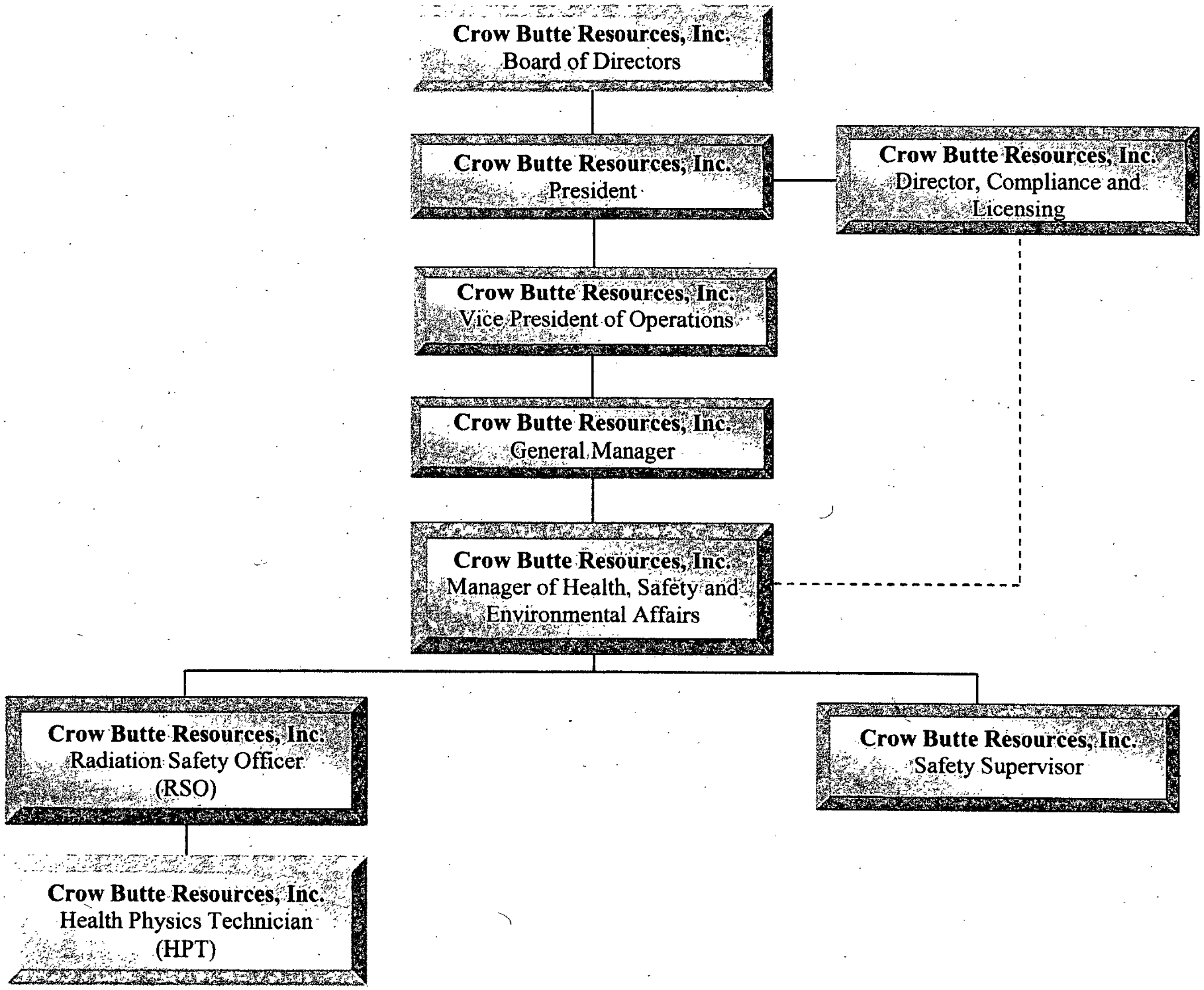
5.1 CORPORATE ORGANIZATION AND ADMINISTRATIVE PROCEDURES

CBR will maintain a performance-based approach to the management of the environment and employee health and safety, including radiation safety. The Environmental, Health, and Safety Management System (EHSMS) 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 EHSMS program 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 EHSMS Program. 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 and Director, Compliance 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 and Director, Compliance 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 EMS Management System Program. 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 as indicated in reports from the Manager of Health, Safety, and Environmental Affairs or the RSO. 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 Director, Compliance and Licensing, the Manager of Health, Safety and Environmental Affairs, or the RSO. The General Manager reports directly to the Vice President of Operations.

5.1.5 Director, Compliance and Licensing

The Director, Compliance and Licensing 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 EHS Management System. The Director, Compliance and Licensing is also responsible for company compliance with all regulatory license conditions/stipulations, regulations and reporting requirements. The Director, Compliance and Licensing 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 Manager of Health, Safety and Environmental Affairs or the RSO. The Director, Compliance and Licensing may also serve as Corporate Radiation Safety Officer (CRSO) and if doing so, shall meet the qualifications described in Regulatory Guide 8.31.

5.1.6 Manager of Health, Safety, and Environmental Affairs

The Manager of Health, Safety, and Environmental Affairs is responsible for all radiation protection, health and safety, and environmental programs as stated in the EHSMS Program and for ensuring that CBR complies with all applicable regulatory requirements. This manger is responsible for the drafting, approving and updating EHSMS procedures on an annual basis. The Manager of Health, Safety, and Environmental Affairs reports directly to the General Manager and supervises the RSO to ensure that the radiation safety and environmental monitoring and protection programs are conducted in a manner consistent with regulatory requirements. 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 Manager of Health, Safety, and Environmental Affairs 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 Manager of Health, Safety and Environmental Affairs has a secondary reporting requirement to the Director, Compliance and Licensing. The Manager of Health, Safety, and Environmental Affairs 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 Manager of Health, Safety, and Environmental Affairs. The RSO, as a direct report to the Manager of Health, Safety and Environmental Affairs, 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.

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. The HPT may delegate radiation survey requirements to properly trained 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).

5.1.9 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 Manager of Health, Safety and Environmental Affairs.

5.1.10 ALARA Program Responsibilities

The purpose of the ALARA (As Low As Reasonably Achievable) 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 EHSMS Program;
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 EHSMS Program;
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 EHSMS Program, 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 EHSMS Program;
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 Environmental, Health, and Safety Management System (EHSMS) Program formalizes the Company's approach to environmental, health, and safety management to ensure a consistency across its operations. The EHSMS Program 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 Environmental, Health, and Safety (EH&S) Policy and regulatory requirements. The Manager of Health, Safety and Environmental Affairs, with assistance from the RSO and Safety Supervisor, is responsible for drafting, approving, and updating (as needed) the EHSMS procedures on an annual basis. More frequent updates may be made if site activities and/or conditions warrant such actions.

The CBR EHS Management System:

- 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 EHSMS Program 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 EHSMS Program 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 EHSMS Program 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 EHSMS Program 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 (SERP)

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 Radiation Safety Officer (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 EHSMS Program 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 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 EHSMS Program 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 North Trend Expansion Area 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 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 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 Manager of Health, Safety, and Environmental Affairs 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, Manager of Health, Safety and Environmental Affairs, 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 EHS Management System covering radiation safety, radioactive material handling, and radiological emergency procedures. The CBR Training Program in EHSMS Program 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:

Fundamentals of health protection

- 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 EHSMS Program 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 Manager of Health, Safety, and Environmental Affairs.

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 Volume *IV Health Physics Manual, Environmental, Health, and Safety Management Plan*, 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 Manager of Health, Safety and Environmental Affairs, as applicable.

- Surface Releases

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 EHSMS Program 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 EHSMS Program 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.

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 EHSMS Program 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 EHSMS Program 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 EHSMS Program Volume IV, *Health Physics Manual.*

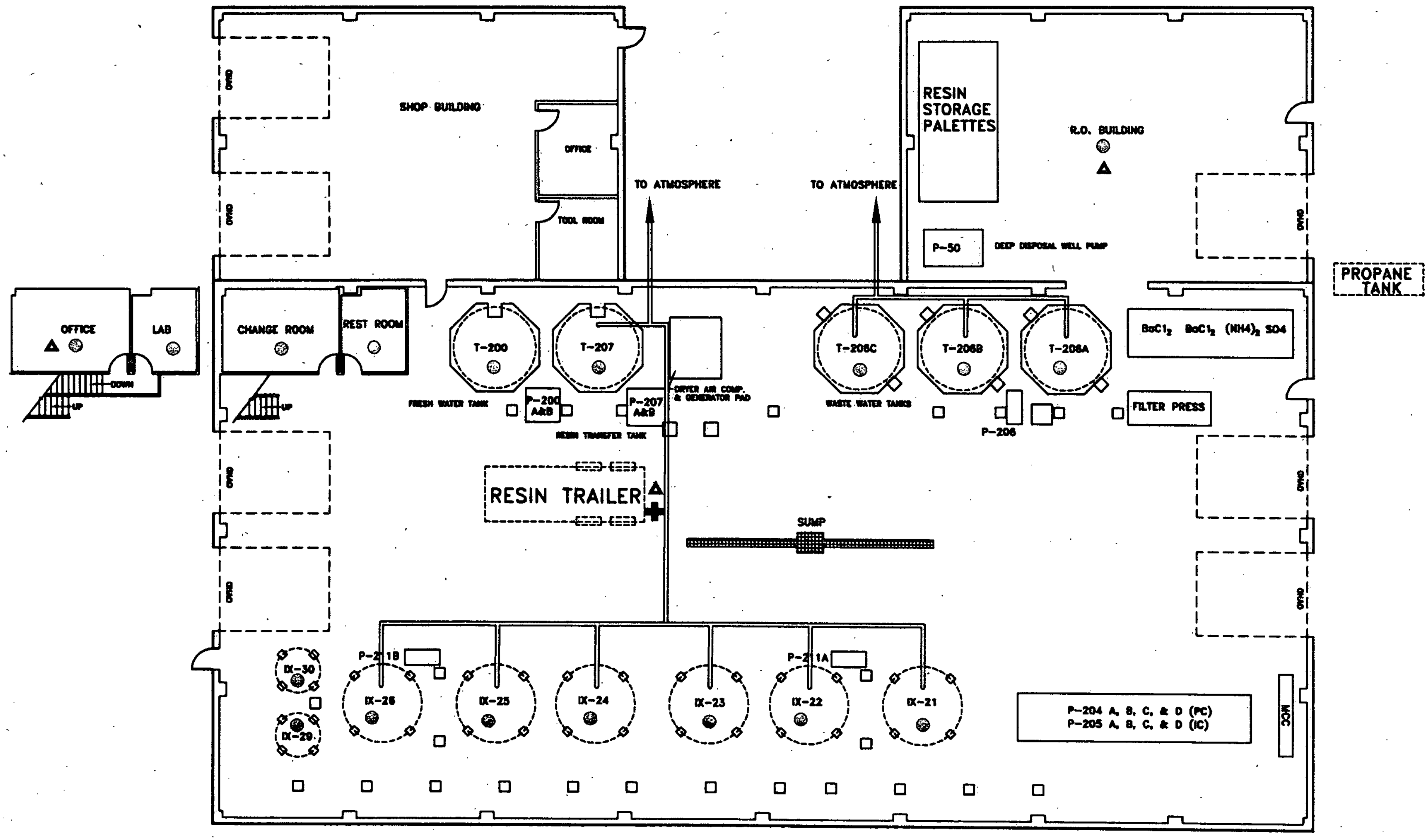
CBR has data for other external dose parameters such as Shallow Dose Equivalent (SDE) and Lens Dose Equivalent (LDE) for the existing site. As with the Deep Dose Equivalent (DDE) it can be shown that the external doses are all less than 10% of the applicable limits. Extremity monitoring is required when 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 North Trend Satellite Plant Survey and Sampling Locations 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.



LEGEND

- RADON TESTING LOCATIONS
- GAMMA SURVEY LOCATIONS
- AIRBORNE URANIUM SURVEY LOCATIONS

0 20 40

Figure 5.7-2

CROW BUTTE RESOURCES

NORTH TREND OPERATION
PROPOSED MONITORING
LOCATIONS

The NTEA would be subject to requirements of CBR's Volume III Operating Manual, Environmental, Health and Safety Management System (EHSMS), 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 EHSMS Program 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 EHSMS Program 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 EHSMS.

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 EHSMS Program 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 EHSMS Program 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 x 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 EHSMS Program 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 EHSMS

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 EHSMS Program 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 (5×10^{-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:

$$H_{iE} = 5*0.5*6.77\text{ E-}7/2 = 8.5\text{ E-}7\text{ rem}$$

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:

$$I_r = \frac{1}{170} \sum_{i=1}^{n} \frac{W_i \times t_i}{PF}$$

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:

<u>Time of Exposure Determination</u>

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 EHSMS Program 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 EHSMS Program 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.

The RSO, the radiation safety staff, or properly trained employees 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 is officed, it would be more efficient to have properly trained full-time personnel at the North Trend site available to perform surveys for releasing items from the restricted area. Such a person would be the Lead Operator or a plant/wellfield operator trained by the RSO or radiation staff in the use of applicable radiation survey instruments and procedures. These staff members would have received training as operators and received radiation safety training that all employees are required to take. In addition, they would also be subject to additional hands-on training as to the survey instruments and procedures. The release limits are set by *"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 EHSMS Program Volume IV, *Health Physics Manual.*

5.7.7 AIRBORNE EFFLUENT AND ENVIRONMENTAL MONITORING PROGRAMS

Radon

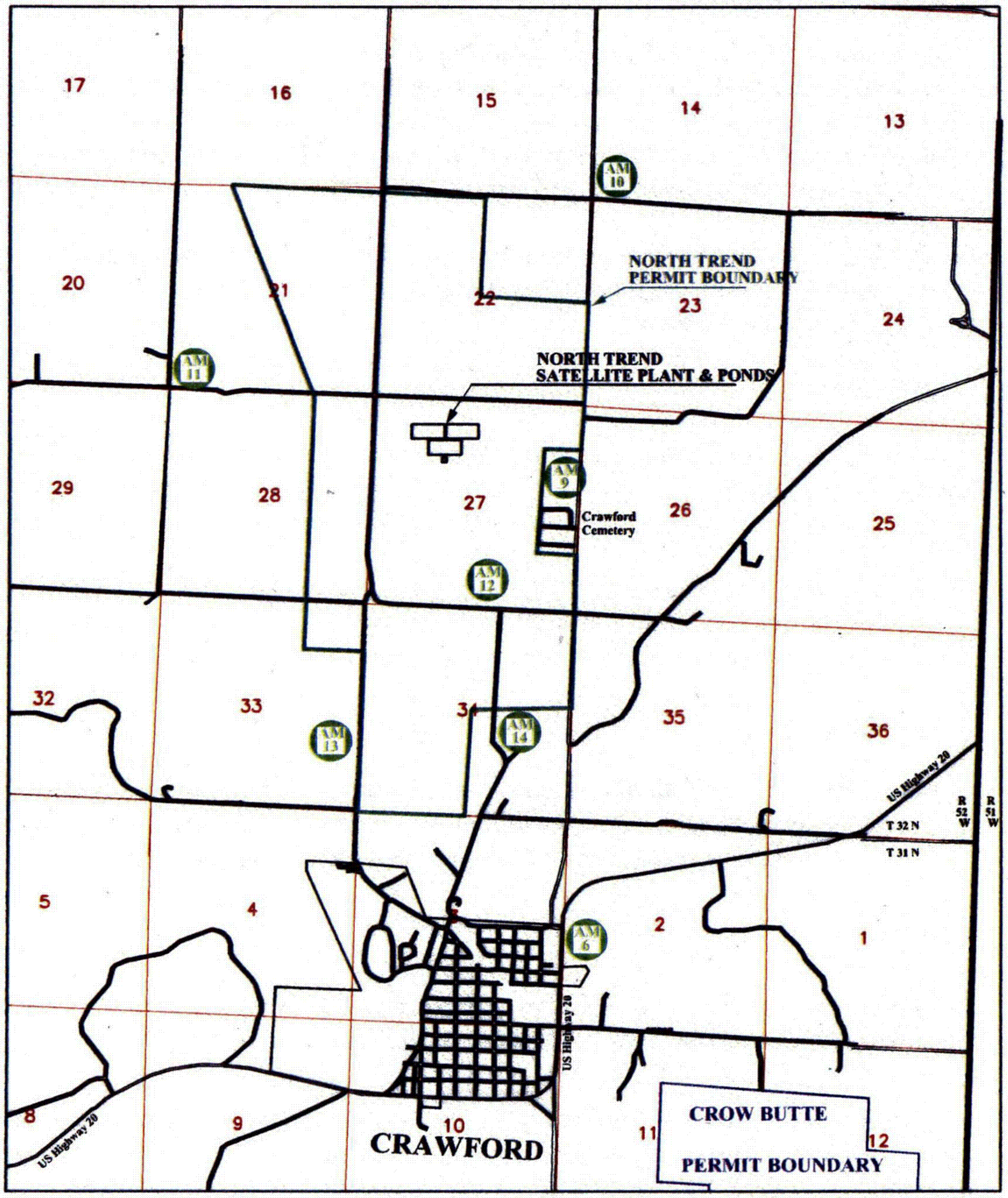
The radon gas effluent released to the environment from North Trend operations will be monitored at the same air monitoring locations (AM-9 through AM-14) that were used for baseline determination of radon concentrations as described in Section 2.9.2. Sampling locations are shown on Figure 5.7-3. Monitoring 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). EHSMS 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

FIGURE 5.7-3
PROPOSED AIR MONITORING LOCATIONS



AM 13 Air Monitoring Stations

AM-6 - Radon, Gamma, Air Particulates
AM-9 - Radon, Gamma
AM-10 - Radon, Gamma, Air Particulates
AM-11 - Radon, Gamma
AM-12 - Radon, Gamma
AM-13 - Radon, Gamma
AM-14 - Radon, Gamma

SCALE 0 ½ 1 1½ 2 MILES

N

FIGURE 5.7-3

CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

Proposed Air Monitoring Stations
& Permit Boundary

Prepared By : WB

Drawn By: WB

Date: 1/07

concentration did not result in significant public dose. 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.

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.

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.

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

Upstream and downstream sediment samples from the White River will be collected annually. Samples will be analyzed for natural uranium, radium-226, and lead-210.

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 EHSMS Program 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 EHSMS Program 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 thirty (30) 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

Pre-operational surface water quality monitoring was performed as discussed in Section 2.9. The proposed license area does not contain surface water features. However, the proximity of the White River to the southern boundary of the license area required CBR to collect upstream and downstream samples. Surface water samples are taken in accordance with the instructions contained in EHSMS Program Volume VI, *Environmental Manual.* Upstream and downstream samples from all locations will be obtained quarterly. Surface water samples are analyzed for the parameters given in Section 2.9, Table 2.9-2. Surface monitoring results are submitted in the semi-annual environmental and effluent reports submitted to NRC.

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 EHSMS Program 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).

Replacement Pages for Section 6.0

Replace Section 6, pages 6-1 through 6-35

6 GROUNDWATER QUALITY RESTORATION, SURFACE RECLAMATION, AND FACILITY DECOMMISSIONING

6.1 PLANS AND SCHEDULES FOR GROUNDWATER RESTORATION

The objective of the Restoration and Reclamation Plan is to return the affected ground water and land surface to conditions suitable for the uses for which they were suitable before mining. The methods to achieve this objective for both the affected ground water and the surface are described in the following sections. Before discussing restoration methodologies, a discussion of the ore body genesis and chemical and physical interactions between the ore body and the lixiviant is provided.

6.1.1 Ore Body Genesis

The uranium deposit in the North Trend Expansion Area (NTEA) is similar to that found in the current license area. It is a roll front deposit in fluvial sandstone and is similar to those in the Wyoming basins such as the Gas Hills, Shirley Basin and the Powder River Basin. The origin of the uranium in the deposit could lie within the host rock itself either from the feldspar or volcanic ash content of the Chadron Sandstone. The source of the uranium could also be volcanic ash of the Chadron Formation which overlays the Chadron Sandstone. Regardless of the source of the uranium, it has precipitated in several long sinuous roll fronts. The individual roll fronts are developed within subunits of the Chadron Sandstone. The Chadron Sandstone is divided into local subunits by thin clay beds that confined the uranium bearing waters to several distinct hydrological subunits of the sandstone. These clay beds are laterally continuous for hundreds of feet but control the deposition of the uranium over greater distances as other clay beds exert vertical control when the locally controlling beds pinch out. Precipitation of the uranium resulted when the oxidizing water containing the uranium entered reducing conditions. These reducing agents are likely hydrogen sulfide (H_2S) and, to a lesser degree, organic matter and pyrite. More detailed discussions of the geochemical description of the mineralized zone are presented in Section 2.6.2.3.1.

Solution mining of the deposit is accomplished by reversing the natural processes that deposited the uranium. Oxidizing solution is injected into the mineralized portion of the Chadron Sandstone to oxidize the reduced uranium and to complex it with bicarbonates. Pumping from recovery wells draws the uranium bearing solution through the mineralized portion of the sandstone. The presence of reducing agents will increase oxidant requirements over that necessary to only oxidize the uranium.

Since the deposition of the uranium was controlled between clay beds within the Chadron Sandstone, the mining solutions will be largely confined to this portion of the sandstone by selectively screening these intervals. This will limit the contamination and thus the required restoration of unmineralized portions of the sandstone.

6.1.2 Chemical and Physical Interactions of Lixiviant with the Ore Body

The following discussion is based on a range of lixiviant conditions from 0.5 to 3.0 grams per liter total carbonate and a pH from 6.5 to 9.0 standard units (S.U.). This represents the normal range of operating conditions for the NTEA in-situ mining operations.

6.1.2.1 Ion Exchange

The principal ion exchange reaction is the exchange of sodium from the lixiviant onto exchangeable sites on ore minerals with the release into solution of calcium, magnesium and potassium. This reaction can be shown as follows:

$$Ca_{clay} + 2\,Na^{+}_{solution} = 2\,Na_{clay} + Ca^{++}_{solution}$$

Similar reactions can be written for magnesium and potassium. Due to higher solubility of their sulfate and carbonate compounds and their low concentrations in Chadron Sandstone and the ore, magnesium and potassium in solution have no impact. The limited solubility of calcium carbonate ($CaCO_3$), and to a lesser degree, calcium sulfate, may lead to the potential for calcium precipitation.

Laboratory tests have indicated that the maximum calcium ion exchange capacity of the ore in a sodium lixiviant with 3.0 g/L total carbonate strength is 1.21 milliequivalents of calcium per 100 grams of ore. This equates roughly to ½ pound of calcium or about 1.2 pounds of calcium carbonate per ton of ore that could potentially precipitate. Not all of this calcium, however, will be realized since laboratory testing is run in such a way as to indicate the maximum amount of calcium that can be exchanged. Somewhat less than this amount will be released and only a portion of that precipitated. There is no way to directly control the buildup of calcium in the lixiviant circuit. In practice, the lixiviant carbonate concentration and the lixiviant pH is controlled. The formation characteristics dictate an equilibrium calcium concentration in the lixiviant system and ion exchange and/or precipitation will occur until the equilibrium is satisfied. The production bleed represents a departure from this equilibrium and as such has some effect on the amount of calcium exchanged. If the bleed is kept generally small, on the order of 0.5 percent, the effect of the bleed on the ion exchange is small.

6.1.2.2 Precipitation

In the presence of carbonate ions and bicarbonate ions in the lixiviant system, calcium ions will precipitate provided the limit of saturation has been reached. Calcium precipitation is a function of total carbonate, pH and temperature. For example, at 15° C, a pH of 7.5 S.U., and 1 g/L carbonate in lixiviant, the equilibrium solubility of calcium is approximately 40 to 100 ppm. Some uncertainty is seen in these numbers due to the effect of ionic strength and supersaturation considerations. However, these figures illustrate the effect of carbonate concentration and pH on the equilibrium solubility of calcium.

The amount of calcium produced depends on the ion exchange that is taking place, while the precipitation of calcium is a function of the lixiviant chemistry, and the degree of supersaturation that is observed in the system. As a first approximation, the proportion of calcium precipitation occurring above ground and underground will occur in the ratio of the residence times. In other words, if the residence time is much longer underground than it is above ground, as is the case for most in-situ leach operations including those projected for the NTEA, then more of the calcium will precipitate underground than above ground. The calcium precipitation is a function of turbulence in the solution, changes in dissolved carbon dioxide (CO_2) partial pressure or pH, and the presence of surface area. The most likely places for calcium to precipitate are underground where the ore provides abundant surface area for precipitation, at or near the injection or production wellbore where changes in pressure, turbulence and CO_2 partial pressure are all observed, and on the surface in the filters, in pipes, and in tanks. If all the calcium were to precipitate (based on 1.2 pounds of $CaCO_3$ per ton of ore) the precipitate would occupy about 0.15% of the void space in that ton of ore.

Calcium may be removed from the system in two ways:

- Filters will be routinely backwashed to the evaporation ponds and periodically acid cleaned, if necessary, to remove precipitated calcium carbonate from the filter housing or filter media; and

- The solution bleed (approximately 0.5 to 1.0 percent) taken to create overproduction and a hydrologic sink in the mining area serves to eliminate some calcium from the system.

Should precipitation of calcium carbonate at or near the wellbore of the wellfield wells become a problem, these wells may be air lifted, surged, water jetted, or acidified to remove the precipitated calcium. Any water recovered from these wells containing dissolved calcium carbonate or particulate calcium carbonate is collected and placed into the waste disposal system. A liquid seal is maintained on any calcium carbonate in the evaporation ponds. Upon decommissioning, calcium carbonate from the plant equipment and pond residues will be disposed of in either a licensed tailings pond or a commercial disposal site.

The other possible precipitating species that has been identified is iron, which could precipitate as either the hydroxide or the carbonate, causing some fouling. Such fouling is usually evidenced by a reduction in the ion exchange capacity of the resin in the extraction circuit. Should this fouling become a serious problem, the resin can be washed and the wash solution disposed of in the waste disposal system. Due to the small amount of iron present in the Chadron Sandstone, iron precipitation has not been a problem in mining operations to date.

6.1.2.3 Hydrolysis

Hydrolysis reactions, which involve minerals and hydrogen or hydroxide ions, do not play an important role in the ore/lixiviant interaction. In the pH range of 6.5 to 9.0 S.U., the concentration of hydrogen and hydroxide ions is so small that these types of reactions do not occur to any great degree. The only potential impact would be a small increase in the dissolved silica content of the lixiviant system and a possible small increase in the cations associated with the siliceous minerals. The hydrolysis reaction does not have a significant effect on operations.

6.1.2.4 Oxidation

The oxidant consumers in the Chadron Sandstone are hydrogen sulfide in the groundwater, uranium, vanadium, iron pyrite, and other trace and heavy metals. The impact of these oxidant consumers on the operation of the plant is a general increase in the oxidant consumption over that which would be required for uranium alone. The second effect is a release of iron and sulfate into solution from the oxidation of pyrite. A third effect is an increase in the levels of some trace metals such as arsenic, vanadium and selenium into solution. As mentioned previously, the iron solubilized will most likely be precipitated as the hydroxide or carbonate, depending on its oxidation state. Any vanadium that is oxidized along with the uranium will be solubilized by the lixiviant, recovered with the uranium and could potentially contaminate the precipitated yellowcake product. Hydrogen peroxide precipitation of uranium is used to reduce the amount of vanadium precipitated in the product. Oxidation will also solubilize arsenic and selenium. The restoration program will return these substances to acceptable levels. A final potential oxidation reaction is the partial oxidation of sulfur species, increasing the concentrations of compounds such as polythionates, which can foul ion exchange resins. In in-situ operations with chemistries similar to the North Trend Expansion Area, these sulfur species are completely oxidized to sulfate, which poses no problems.

6.1.2.5 Organics

Organic materials are generally not present in the North Trend Expansion Area ore body at levels greater than 0.1 to 0.2 percent. Where present organic materials effectively increase the oxidant consumption and reduce uranium leaching. On longer flow paths, organic material could potentially re-precipitate uranium should all of the oxidant be consumed and conditions become reducing. Another potential impact of mobilized organics could be the coloring and fouling of leach solutions. As the aquifer is maintained in the pH range of 6.5 to 9.0 S.U., mobilization of the organics and coloring of the leach solution is avoided.

6.1.3 Basis of Restoration Goals

The primary goal of the groundwater restoration program is to return groundwater affected by mining operations to pre-injection baseline values on a mine unit average as determined by the baseline water quality sampling program. This sampling program is performed for each mine unit before mining operations commence. Should restoration efforts be unable to achieve baseline conditions after diligent application of the best practicable technology (BPT) available, CBR commits, in accordance with the Nebraska Environmental Quality Act and NDEQ regulations, to return the groundwater to the restoration values set by the NDEQ in the Class III UIC Permit. These secondary restoration values ensure that the groundwater is returned to a quality consistent with the use, or uses, for which the water was suitable prior to ISL mining. These secondary restoration values are approved by the NDEQ in the individual Notice of Intent (NOI) for each mine unit based on the permit requirements and the results of the baseline monitoring program.

EPA groundwater protection standards issued under the authority of the Uranium Mill Tailings Radiation Control Act (UMTRCA) are required to be followed by ISL licenses of the NRC and its Agreement States. The EPA regulations issued under UMTRCA authority provide the principal standards for uranium ISL operations and groundwater protection, while the UIC regulations are considered additional requirements for ISL operations. CBR is required to restore groundwater quality to the standards listed in Criterion 5B(5) of 10 CFR Part 40, Appendix A as required by the UMTRCA, as amended. Under EPA requirements, groundwater restoration at ISL facilities must meet the UMTRCA standards and not those associated with the Safe Drinking Water Act or analogous state regulations.

Under Criterion 5B (5) of 10 CFR Part 40, Appendix A of UMTRCA, at the point of compliance (mining zone after restoration), the concentration of hazardous constituent must not exceed:

a. The Commission approved background concentration of that constituent in the groundwater;

b. The respective value given in Table 6.1-1_for the UMTRCA values if the constituent is listed in the table and of the background level of the constituent is below the value listed; or

c. Alternate concentration limit established by the Commission.

CBR will comply with these provisions as to groundwater restoration limits. The NRC is currently developing rulemaking on groundwater protection standards in an effort to eliminate dual jurisdiction and interactions with the EPA. Such new rulemaking could affect the groundwater restoration limits, but the new language will emphasize that UMTRCA would govern.

6.1.3.1 Establishment of Baseline Water Quality

Before mining in each mine unit, the baseline groundwater quality is determined. The data are established in each mine unit by assigning and evaluating groundwater quality in "baseline restoration wells". A minimum of one baseline restoration well for each four acres is sampled to establish the mine unit baseline water quality. A minimum of three samples is collected from each well. The samples are collected at least 14 days apart. The samples are analyzed for the parameters listed in Table 6.1-1.

Attachment 6.1(A) contains the restoration tables for Mine Units 1 through 9 in the current commercial license area. These tables provide the baseline average and the range for all restoration parameters as well as the NDEQ restoration standard approved for that mine unit in the NOI.

6.1.3.2 Establishment of Restoration Goals

The baseline data are used to establish the restoration standards for each mine unit. As previously noted, the primary goal of restoration is to return the mine unit to preoperational water quality condition on a mine unit average. Since ISL operations alter the groundwater geochemistry, it is unlikely that restoration efforts will return the groundwater to the precise water quality that existed before operations.

Restoration goals are established by NDEQ to ensure that, if baseline water quality is not achievable after diligent application of best practicable technology (BPT), the groundwater is suitable for any use for which it was suitable before mining. USNRC considers these NDEQ restoration goals as the secondary goals. The NDEQ restoration values are established for each mine unit and are approved with the Notice of Intent to Operate submittals according to the following analysis:

- For parameters that have numerical groundwater standards established in Title 118[1], the restoration goal is based on the Title 118 maximum contaminant level (MCL).
- If the baseline concentration exceeds the applicable MCL, the standard is set as the mine unit baseline average plus two standard deviations.
- If there is no MCL for an element (e.g., vanadium), the restoration value is based a wellfield average of the preoperational sampling data. Normal statistical procedures will be used to obtain the average.
- The restoration values for the major cations (Ca, Mg, K, Na) allow the concentrations of these cations to vary by as much as one order of magnitude as long as the TDS restoration value is met. The total carbonate restoration criterion allows for the total carbonate to be less than 50 percent of the TDS. The TDS restoration value is set at the baseline mine unit average plus one standard deviation.

The current NDEQ restoration standards are listed in Table 6.1-1.

Table 6.1-1: NDEQ Groundwater Restoration Standards

Parameter	NDEQ Title 118 Groundwater Standard	NDEQ Restoration Standard[1]	NRC UMTRCA Groundwater Protection Standards
Ammonium (mg/l)	Not Listed	10.0	--
Arsenic (mg/l)	0.010	0.010	0.05
Barium (mg/l)	2.0	2.0	1.0
Cadmium (mg/l)	0.005	0.005	0.01
Chloride (mg/l)	250	250	--
Chromium *mg/l)	--	--	0.05
Copper (mg/l)	1.3	1.3	--
Fluoride (mg/l)	4.0	4.0	--
Iron (mg/l)	0.3	0.3	--
Mercury (mg/l)	0.002	0.002	0.002
Manganese (mg/l)	0.05	0.05	--
Molybdenum (mg/l)	(Reserved)	1.0	--
Nickel (mg/l)	(Reserved)	0.15	--
Nitrate (mg/l)	10.0	10.0	--

Table 6.1-1: NDEQ Groundwater Restoration Standards

Parameter	NDEQ Title 118 Groundwater Standard	NDEQ Restoration Standard[1]	NRC UMTRCA Groundwater Protection Standards
Lead (mg/l)	0.015	0.015	0.05
Radium (pCi/L)	5.0	5.0	--
Selenium (mg/l)	0.05	0.05	0.01
Sodium (mg/l)	N/A	Note 2	--
Sulfate (mg/l)	250	250	--
Uranium (mg/l)	0.030	0.030	
Ra-226 & Ra-228 (pCi/l)	--	--	5
Vanadium (mg/l)	(Reserved)	0.2	--
Zinc (mg/l)	5.0	5.0	--
pH (Std. Units)	6.5 - 8.5	6.5 – 8.5	--
Calcium (mg/l)	N/A	Note 2	--
Total Carbonate (mg/l)	N/A	Note 3	--
Potassium (mg/l)	N/A	Note 2	--
Magnesium (mg/l)	N/A	Note 2	--
TDS (mg/l)	N/A	Note 4	--

Notes:

1. NDEQ Restoration Standard based on groundwater standard (MCL) from Title 118. For parameters where the baseline concentration exceeds the applicable MCL, the standard is set as the mine unit baseline average plus two standard deviations.

2. One order of magnitude above baseline is used as the restoration value for some parameters due to the ability of some major ions to vary one order of magnitude depending on pH.

3. Total carbonate shall not exceed 50% of the total dissolved solids value.

4. The restoration value for Total Dissolved Solids (TDS) shall be the baseline mean plus one standard deviation.

Source: NDEQ Class III UIC Permit Number NE0122611 (except for NRC UMTRCA Groundwater Protection Standards)
Source: NRC UMTRCA Groundwater Protection Standards (Criterion 5B (5) of 10 CFR Part 40, Appendix A of UMTRCA

It is anticipated that the Class III UIC Permit issued for the NTEA will have similar requirements. Under the provisions of the performance-based license, the CBR Safety and Environmental Review Panel (SERP) reviews and approves the establishment of restoration standards using the review procedures discussed in Section 5. Table 6.1-1 lists the 27 parameters used at the Crow Butte Project to determine groundwater quality. The current MCLs from Title 118 are listed as well as the restoration standards from the Class III UIC Permit. The restoration value for each mine unit is based on the current Title 118 standard at the time the Notice of Intent is approved by the NDEQ.

6.1.4 Groundwater Restoration Methods

6.1.4.1 Introduction

Restoration activities in the current license area have proven that the groundwater can be restored to the appropriate standards following commercial mining activities. As shown in Table 1.7-1, Mine Units 2 through 4 are currently undergoing restoration, with Mine Unit 2 undergoing extended stability monitoring following active restoration. Mine Unit 1 groundwater restoration has been approved by the NDEQ and the USNRC. On February 12, 2003, the NRC issued the final approval of groundwater restoration in Mine Unit 1 at Crow Butte. This approval was the culmination of three years of agency reviews including a license amendment to accept the NDEQ restoration standards as the approved secondary goals. Mine Unit 1 consisted of 40 patterns installed in 9.3 acres immediately adjacent to the Central Plant. Included within the boundaries of Mine Unit 1 were five wells that were originally mined beginning in 1986 as part of the research and development (R & D) pilot plant operation. Commercial mining activities began in 1991 and were completed in 1994. Mine Unit 1 was successfully restored to the approved primary or secondary restoration standards for all parameters.

CBR's approved restoration plan consists of four steps:

- Groundwater transfer
- Groundwater sweep
- Groundwater treatment
- Wellfield Recirculation

A reductant may be added at anytime during the restoration stage to lower the oxidation potential of the mining zone. A sulfide or sulfite compound will be added to the injection stream in concentrations sufficient to reduce the mobilized species. Safety and handling issues associated with the use of sodium sulfide are discussed in Section 3.2.2.2 (Process Related Chemicals). Instructions and safety precautions on the use of sodium sulfide are included in Crow Butte's *Environmental, Health, and Safety Management System, Volume III Operating Manual* (Restoration Reductant [Sodium Sulfide]).

Crow Butte Resources' Class III UIC Permit requires a minimum of a six month period for stability monitoring of a Mine Unit to demonstrate the success of restoration activities (stabilization). As shown by historical Mine Unit 1 restoration data, six months may not be sufficient to assure stability for all monitored constituents. Stability monitoring may continue beyond the six month period as necessary. Stability monitoring will conclude, instead, when stabilization samples show that restoration goals on a mine unit average for monitored constituents are met and there is an absence of significant increasing trends. At the end of the stabilization period, when restoration parameters have been achieved and there is absence of significant increasing trends for any of the restoration parameters, a request would be made to the NDEQ for acceptance of restoration completion for the mine unit. The NDEQ would either accept the restoration of the mine unit, or extend the stabilization period or require further restoration.

During mining and until restoration is complete, a hydrologic bleed will be maintained in each Mine Unit to prevent lateral migration of mining lixiviant. If a proper hydrologic bleed is not maintained, it is possible for water with chemistry similar to that in Table 2.7-15 column "Typical Water Quality During Mining at CSA" to begin migrating toward the monitor well ring. The mobile ions such as chloride and carbonate would be detected at the monitor well ring and adjustments would be made to reverse the trend. The maintenance of a hydrologic bleed and the close proximity of the monitor well ring, less than 300 feet from the mining patterns, will ensure there is negligible migration of mining fluid. Vertical migration of fluids is less of a concern than lateral migration due to the underlying and overlying aquitards. The ubiquitous Chadron Formation clays, which cap the Lower Chadron Formation ore body, have hydraulic conductivities on the order of 10-11 cm/sec as outlined in section 2.7.2.2 of this application. Likewise, the underlying Pierre Shale is over 1,200 feet thick and acts as a significant aquitard. The vastly different piezometric heads between the Lower and Middle Chadron as well as the results of the pumping test support the conclusion that the Lower Chadron is vertically isolated.

Crow Butte is currently starting a pilot study using bioremediation to complete restoration of Mine Unit 4 at the existing production facility. This bioremediation test was initiated on December 17, 2008. Based on the results of a one-year study, bioremediation may or may not be used at the NTEA. If the tests are successful, and use at the NTEA appears to be a viable restoration alternative, a request for a license amendment will be submitted to the NRC.

6.1.4.2 Restoration Process

Restoration activities include four steps that are designed to optimize restoration equipment used in treating groundwater and to minimize the number of pore volumes circulated during the restoration stage. The number of pore volumes that would be displaced during groundwater restoration would be as follows: 3 pore volumes through IX treatment; 6 pore volumes through the Reverse Osmosis (RO); and 2 pore volumes of recirculation. There were 9 pore volumes used for Mine Unit 1 at the current CBR operations. CBR will monitor the quality of selected wells during restoration to determine the efficiency of the operations and to determine if additional or alternate techniques are necessary.

The calculated pore volume for the entire North Trend Wellfield would be 133,268,000 gallons. This is based on a calculated square footage (30,636,400 ft^2) of the potential wellfield area, an average under-ream interval of 15 feet and a 29% open pore space value.

- Groundwater Transfer

During the groundwater transfer step, water may be transferred between the mine unit commencing restoration and a mine unit commencing mining operations. Baseline quality water from the mine unit starting mining may be pumped and injected into the mine unit in restoration. The higher TDS water from the mine unit in restoration is recovered and injected into the mine unit commencing mining. The direct transfer of water will act to lower the TDS in the mine unit being restored by displacing water affected by the mining with baseline quality water.

The goal of the groundwater transfer step is to blend the water in the two mine units until they become similar in conductivity. The recovered water may be passed through ion exchange columns and filtration during this step if suspended solids are sufficient in concentration to present a problem with blocking the injection well screens.

For the groundwater transfer step to occur, a newly constructed mine unit must be ready to commence mining. If a mine unit is not available to accept transferred water, groundwater sweep or other activity will be utilized as the first step of restoration. The advantage of using the groundwater transfer technique is that it reduces the amount of water that must ultimately be sent to the wastewater disposal system during restoration activities.

- Groundwater Sweep

During groundwater sweep, water is pumped without injection from the wellfield, causing an influx of baseline quality water from the perimeter of the mining unit, which sweeps the affected portion of the aquifer. The cleaner baseline quality water has lower ion concentrations that act to strip off the cations that have attached to the clays during mining. The affected water near the edge patterns of the wellfield is also drawn into the boundaries of the mine unit. The number of pore volumes transferred during groundwater sweep, if any, is dependent upon the presence of other active mine units along the mine unit boundary, the capacity of the wastewater disposal system, and the success of the groundwater transfer step in lowering TDS.

- Groundwater Treatment

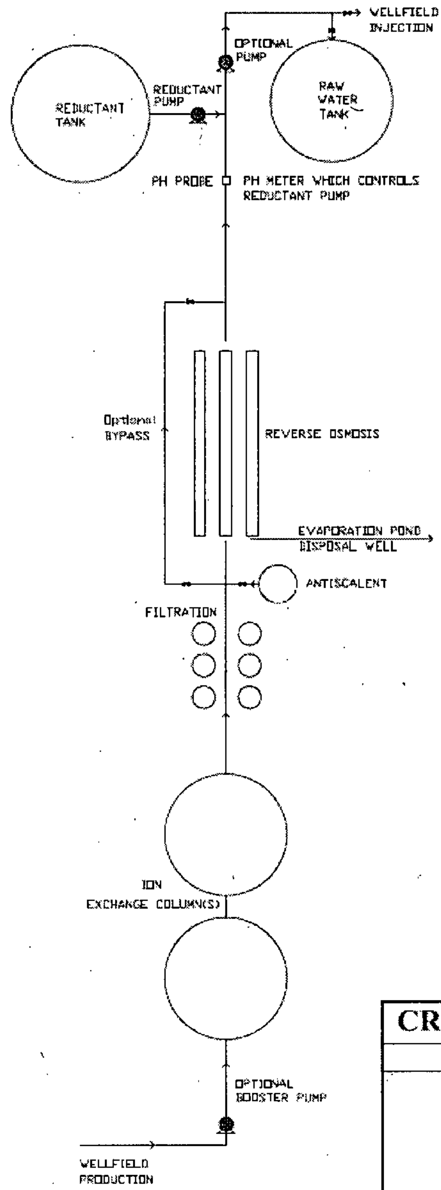
Following the groundwater sweep step, water will be pumped from production wells to treatment equipment and then re-injected into the wellfield. Ion exchange (IX), reverse osmosis (RO), and/or Electro Dialysis Reversal (EDR) treatment equipment is generally used during this stage as shown on the generalized restoration flow sheet on Figure 6.1-1.

Water recovered from restoration that contains a significant amount of uranium is passed through the IX system. The IX columns exchange the majority of the contained soluble uranium for chloride or sulfate. Once the solubilized uranium is removed, a small amount of reductant may be metered into the restoration wellfield injection to reduce any pre-oxidized minerals. The concentration of reductant injected into the formation is determined by the concentration and type of trace elements encountered. The goal of reductant addition is to reduce those minerals that are solubilized by carbonate complexes to prevent the buildup of dissolved solids, which would increase the time for restoration to be completed.

A portion of the restoration recovery water can be sent to the reverse osmosis (RO) unit. The use of a RO unit 1) reduces the total dissolved solids in the contaminated groundwater, 2) reduces the quantity of water that must be removed from the aquifer to meet restoration limits, 3) concentrates the dissolved contaminates in a smaller volume of brine to facilitate waste disposal, and 4) enhances the exchange of ions from the formation due to the large difference in ion concentration.

Before the water can be processed by the RO, soluble uranium can be removed by the IX system. The RO unit contains membranes that pass about 60 to 75 percent of the water through, leaving 60 to 90 percent of the dissolved salts in the water that will not pass the membranes. Table 6.1-2 shows typical RO manufacturers specification data for removal of ion constituents. The clean water, called "permeate", will be re-injected, sent to storage for use in the mining process, or to the wastewater disposal system. The 25 to 40 percent of water that is rejected, called "brine", contains the majority of dissolved salts that contaminate the groundwater and is sent for disposal in the waste system. Make-up

FIGURE 6.1-1
Restoration Process Flow Diagram



CROW BUTTE RESOURCES	
DAWES COUNTY, NEBRASKA	
Restoration Process Flow Diagram	
Prepared By : JD	
Drawn By: JD	Date: 3/30

water may be added to the wellfield injection stream to control the amount of "bleed" in the restoration areas.

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The reductant (either biological or chemical) added to the injection stream during the groundwater treatment stage will scavenge any oxygen and reduce the oxidation-reduction potential (Eh) of the aquifer. During mining operations, certain trace elements are oxidized. By adding a reductant, the Eh of the aquifer is lowered, thereby decreasing the solubility of these elements. Hydrogen sulfide (H_2S), sodium sulfide (Na_2S), or a similar compound will be added as a reductant. CBR typically uses sodium sulfide due to the chemical safety issues associated with proper handling of hydrogen sulfide. A comprehensive safety plan regarding reductant use is implemented.

The number of pore volumes treated and re-injected during the groundwater treatment stage will depend on the efficiency of the RO in removing total dissolved solids (TDS) and the reductant in lowering the uranium and trace element concentrations.

- Wellfield Recirculation

At the completion of the Groundwater Treatment Stage, wellfield recirculation may be initiated. In order to homogenize the aquifer, pumping from the production wells and re-injecting the recovered solution into injection wells may be performed to recirculate solutions.

The sequence of the activities will be determined by CBR based on operating experience and waste water system capacity. Not all phases of the restoration stage will be used if deemed unnecessary by CBR.

Once the restoration activities are completed, CBR will sample the restoration wells and determine if the mining unit has achieved the restoration values, on a mine unit average basis. If so, CBR will notify the regulatory agencies that it is initiating the Stabilization

Table 6.1-2: Typical Reverse Osmosis Membrane Rejection

NAME	SYMBOL	PERCENT REJECTION
	Cations	
Aluminum	Al^{+3}	99+
Ammonium	NH_4^{+1}	88-95
Cadmium	Cd^{+2}	96-98
Calcium	Ca^{+2}	96-98
Copper	Cu^{+2}	98-99
Hardness	Ca and Mg	96-98
Iron	Fe^{+2}	98-99
Magnesium	Mg^{+2}	96-98
Manganese	Mn^{+2}	98-99
Mercury	Hg^{+2}	96-98
Nickel	Ni^{+2}	98-99
Potassium	K^{+1}	94-96
Silver	Ag^{+1}	94-96
Sodium	Na^{+}	94-96
Strontium	Sr^{+2}	96-99
Zinc	Zn^{+2}	98-99
	Anions	
Bicarbonate	HCO_3^{-1}	95-96
Borate	$B_4O_7^{-2}$	35-70
Bromide	Br^{-1}	94-96
Chloride	Cl^{-1}	94-95
Chromate	CrO_4^{-2}	90-98
Cyanide	CN^{-1}	90-95
Ferrocyanide	$Fe(CN)_6^{-3}$	99+
Fluoride	F^{-1}	94-96
Nitrate	NO_3^{-1}	95
Phosphate	PO_4^{-3}	99+
Silicate	SiO_2^{-1}	80-95
Sulfate	SO_4^{-2}	99+
Sulfite	SO_3^{-2}	98-99
Thiosulfate	$S_7O_3^{-2}$	99+

Source: Osmonics, Inc.

Stage and will submit supporting documentation that the restoration parameters are at or below the restoration standards. If at the end of restoration activities the parameters are not at or below the approved values, CBR will either re-initiate certain steps of the restoration plan or submit documentation to the agencies that the best practical technology has been used in restoration. The documentation will include a justification for alternate parameter value(s) including available water quality data and a narrative of the restoration techniques used.

6.1.5 Stabilization Phase

Upon completion of restoration, a groundwater stabilization monitoring program will begin in which the restoration wells and any monitor wells on excursion status during mining operations will be sampled and analyzed for the restoration parameters listed in Table 6.1-1. The sampling frequency will be one sample per month for a period of 6 months, and if the six samples show that the restoration values for all wells are maintained during the stabilization period with no significant increasing trends, restoration shall be deemed complete.

6.1.6 Reporting

During the restoration process CBR will perform daily, weekly, and monthly analyses as needed to track restoration progress. These analyses will be summarized and discussed in the Semiannual Radiological Effluent and Environmental Monitoring Report submitted to USNRC. This information will also be included in the final report on restoration.

Upon completion of restoration activities and before stabilization, all designated restoration wells in the mine unit will be sampled for the constituents listed in Table 6.1-1. If restoration activities have returned the wellfield average of restoration parameters to concentrations at or below those approved by the USNRC and the NDEQ, CBR will proceed with the stabilization phase of restoration.

During stabilization, all designated restoration wells will be sampled monthly for the constituents listed in Table 6.1-1. At the end of a six-month stabilization period, CBR will compile all water quality data obtained during restoration and stabilization and submit a final report to the regulatory agencies. If the analytical results continue to meet the appropriate standards for the mine unit and do not exhibit significant increasing trends, CBR would request the mine unit be declared restored. Following agency approval, wellfield reclamation and plugging and abandonment of wells will be performed as described in Section 6.2.

6.2 PLANS FOR RECLAIMING DISTURBED LANDS

The following section addresses the final decommissioning methods of disturbed lands including wellfields, plant areas, evaporation ponds, and diversion ditches that will be used on the Crow Butte Project sites. The section discusses general procedures to be used during final decommissioning as well as the decommissioning of a particular phase or production unit area.

Decommissioning of wellfields and process facilities, once their usefulness has been completed in an area, will be scheduled after agency approval of groundwater restoration and stability. Decommissioning will be accomplished in accordance with an approved decommissioning plan and the most current applicable NDEQ and USNRC rules and regulations, permit and license stipulations and amendments in effect at the time of the decommissioning activity.

The following is a list of general decommissioning activities:

- Plug and abandon all wells as detailed in Section 6.2.4.
- Determination of appropriate cleanup criteria for structures (Section 6.3) and soils (Section 6.4).
- Radiological surveys and sampling of all facilities, process related equipment and materials on site to determine their degree of contamination and identify the potential for personnel exposure during decommissioning.
- Removal from the site of all contaminated equipment and materials to an approved licensed facility for disposal or reuse, or relocation to an operational portion of the mining operation as discussed in Section 6.3.
- Decontamination of items to be released for unrestricted use to levels consistent with the requirements of NRC.
- Survey excavated areas for contamination and remove contaminated materials to a licensed disposal facility.
- Perform final site soil radiation surveys.
- Backfill and recontour all disturbed areas.
- Establish permanent revegetation on all disturbed areas.

The following sections describe in general terms the planned decommissioning activities and procedures for the Crow Butte facilities. These activities and procedures will apply to the NTEA facilities as well as the current facilities. CBR will, prior to final decommissioning of an area, submit to the USNRC and NDEQ a detailed Decommissioning Plan for their review and approval at least 12 months before planned commencement of final decommissioning. As required by 10 CFR 40.36 (f), records of information important to NTEA decommissioning will be maintained in the office of the onsite Radiation Safety Officer. Such information shall meet the criteria of 10 CFR 40.42 (g) (4) and (5).

6.2.1 General Surface Reclamation Procedures

The primary surface disturbances associated with solution mining are the sites containing the Central Processing Facility and associated facilities, Satellite Facilities, and evaporation ponds. Surface disturbances also occur during the well drilling program, pipeline installation, and road construction. These more superficial disturbances, however, involve relatively small areas or have short-term impacts.

The principal objective of the surface reclamation plan is to return disturbed lands to production compatible with the post mining land use of equal or better quality than the premining condition. For the Crow Butte area, the reclaimed lands should be capable of supporting livestock grazing and providing stable habitat for native wildlife species. Soils, vegetation, wildlife and radiological baseline data will be used as guidelines for the design, completion and evaluation of surface reclamation. Final surface reclamation will blend affected areas with adjacent undisturbed lands so as to re-establish original slope and topography and present a natural appearance. Surface reclamation efforts will strive to limit soil erosion by wind and water, sedimentation and re-establish natural trough drainage patterns.

The following sections provide procedural techniques for surface reclamation of all disturbances contained in the Crow Butte Resources mine plan. Provided are reclamation procedures for the facility sites, wellfield production units, evaporation ponds, and access and haul roads. Reclamation techniques and procedures for the North Trend Satellite Facilities, ponds, and wellfields will follow these same concepts. Reclamation schedules for wellfield production units will be discussed separately because they are dependent upon the progress of mining and the successful completion of groundwater restoration. Cost estimates for bonding calculations are discussed in Section 6.6 and include all activities that are anticipated to complete groundwater restoration, decontamination, decommissioning, and surface reclamation of wellfield and satellite plant facilities installed. These cost estimates are updated annually to cover work projected for the next year of mining activity.

6.2.1.1 Topsoil Handling and Replacement

In accordance with NDEQ requirements, topsoil is salvaged from building sites (including the satellite buildings) and pond areas. Conventional rubber-tired, scraper-type earth moving equipment is typically used to accomplish such topsoil salvage operations. The exact location of topsoil salvage operations is determined by wellfield pattern emplacement and designated wellfield access roads within the wellfields, which are determined during final wellfield construction activities.

As described in Section 2.6, topsoil thickness varies within the NTEA. Topsoil thickness is usually greatest in and along drainages where material has been deposited and deep soils have developed. Therefore, topsoil stripping depths may vary in depth, depending on location and the type of structure being constructed. In cases where it is necessary to strip topsoil in relatively large areas, such as a major road or building site, field mapping and Soil Conservation Service Soil Surveys will be utilized to determine approximate topsoil depths.

Salvaged topsoil is stored in designated topsoil stockpiles. These stockpiles are generally located on the leeward side of hills to minimize wind erosion. Stockpiles are not located in drainage channels. The perimeter of large topsoil stockpiles may be bermed to control sediment runoff. Topsoil stockpiles are seeded as soon as possible after construction with the permanent seed mix.

During mud pit excavation associated with well construction, exploration drilling and delineation drilling activities, topsoil is separated from subsoil with a backhoe. When use of the mud pit is complete, all subsoil is replaced and topsoil is applied. Mud pits generally remain open a short time. The success of revegetation efforts at the current site show that these procedures adequately protect topsoil and result in vigorous vegetation growth.

6.2.1.2 Contouring of Affected Areas

Due to the relatively minor nature of disturbances created by in-situ mining, there are only a few areas disturbed to the extent to which subsoil and geologic materials are removed, causing significant topographic changes that need backfilling and recontouring. Generally speaking, solar evaporation pond construction results in redistribution of sufficient amounts of subsurface materials, which requires replacement and contour blending during reclamation. The existing contours will only be interrupted in small, localized areas. Because approximate original contours will be achieved during final surface reclamation, no post mining contour maps have been included in this application.

Changes in the surface configuration caused by construction and installation of operating facilities will be only temporary, during the operating period. These changes will be caused by topsoil removal and storage along with the relocation of subsoil materials used for construction purposes. Restoration of the original land surface, which is consistent with the pre- and post-mining land use, the blending of affected areas with adjacent topography to approximate original contours and the reestablishment of drainage patterns will be accomplished by returning the earthen materials moved during construction to their approximate original locations.

Drainage channels that have been modified by the mine plan for operational purposes such as road crossings will be reestablished by removing fill materials, culverts and reshaping to as close to pre-operational conditions as practical. Surface drainage of disturbed areas that have been located on terrain with varying degrees of slope will be accomplished by final grading and contouring appropriate to each location so as to allow for controlled surface run off and eliminate depressions where water could accumulate.

6.2.1.3 Revegetation Practices

Revegetation practices are conducted in accordance with NDEQ requirements. During mining operations the topsoil stockpiles, and as much as practical of the disturbed wellfield and pond areas, will be seeded with vegetation to minimize wind and water erosion. After placement of topsoil and contouring for final reclamation, an area will normally be seeded with a seed mixture developed in consultation with the Natural Resource Conservation Service as required by the NDEQ.

6.2.2 Process Facility Site Reclamation

Following removal of structures as discussed in Section 6.3, subsoil and stockpiled topsoil will be replaced on the disturbances from which they were removed during construction, within practical limits. Areas to be backfilled will be scarified or ripped prior to backfilling to create an uneven surface for application of backfill. This will provide a more cohesive surface to eliminate slipping and slumping. The less suitable subsoil and unsuitable topsoil, if any, will be backfilled first so as to place them in the deepest part of the excavation to be covered with more suitable reclamation materials. Subsoils will be replaced using paddle wheel scrapers, bulldozers or other appropriate equipment to transfer the earth from stockpile locations or areas of use and to spread it evenly on the ripped disturbances. Grader blades may be used to even the spread of backfill materials. Topsoil replacement will commence as soon as practical after a given disturbed surface has been prepared. Topsoil will be picked up from storage locations by paddle wheel scrapers or other appropriate equipment and distributed evenly over the disturbed areas. The final grading of topsoil materials will be done so as to establish adequate drainage and the final prepared surface will be left in a roughened condition.

6.2.3 Evaporation Pond Decommissioning

6.2.3.1 Disposal of Pond Water

The volume of water remaining in the lined evaporation ponds after restoration as well as its chemical and radiological characteristics will be considered to determine the most practical disposal program. Disposal options for the pond liquid include evaporation (e.g., sprinklers), treatment and disposal in the deep well, or transportation to another licensed facility or disposal site. There are currently no plans for treating and discharging the pond water to public waters under an NPDES permit.

6.2.3.2 Pond Sludge and Sediments

Pond sludges and sediments will contain mining process chemicals and radionuclides. Wind blown sand grains and dust blown into the ponds during their active life also add to the bulk of sludges. This material will be contained within the pond bottom and kept in a dampened condition at all times, especially during handling and removal operation to prevent the spread of airborne contamination and potential worker exposure through inhalation. Dust abatement techniques will be used as necessary. The sludge will be removed from the ponds and loaded into roll off containers, dump trucks or drums and transported to a USNRC licensed disposal facility.

6.2.3.3 Disposal of Pond Liners and Leak Detection Systems

Pond liners will be kept washed down and intact as much as practical during sludge removal so as to confine sludges and sediments to the pond bottom. Pond liners will be cut into strips and transported to a USNRC licensed disposal facility or will be decontaminated for release to an unrestricted area. After removal of the pond liners, the pond leak detection system piping will be removed. Materials involved in the leak detection system will be surveyed and released for unrestricted use if not contaminated or transported to a USNRC licensed facility for disposal. The earthen material in the pond bottom and leak detection system trenches will be surveyed for soil contamination. Any contaminated soil in excess of the cleanup criteria discussed in Section 6.4 will be removed and disposed at a USNRC licensed disposal facility.

Following the removal of all pond materials and the disposal of any contaminated soils, surface preparation will take place prior to reclamation.

6.2.3.4 On Site Burial

At the present time, on site burial of contaminants is not anticipated. However, depending upon the availability of a USNRC licensed disposal site at the time of decommissioning, on site burial may become a potential alternative. Should this occur, pond locations would be considered initially as the on site disposal locations for contaminated materials. Appropriate licensing with the regulatory agencies would be obtained prior to any on site disposal of contaminated wastes.

6.2.4 Wellfield Decommissioning

Surface reclamation in the wellfield production units will vary in accordance with the development sequence and the mining/reclamation timetable. Final surface reclamation of each wellfield production unit will be completed after approval of groundwater restoration stability and the completion of well abandonment activities discussed below. Surface preparation will be accomplished as needed so as to blend any disturbed areas into the contour of the surrounding landscape.

Wellfield decommissioning will consist of the following steps:

- The first step of the wellfield decommissioning process will involve the removal of surface equipment. Surface equipment primarily consists of the injection and production feed lines, wellhouses, electrical and control distribution systems, well boxes, and wellhead equipment. Wellhead equipment such as valves, meters or control fixtures will be salvaged.

- Removal of buried well field piping.

- Wells will be plugged and abandoned according to the procedures described below.

- The wellfield area may be recontoured, if necessary, and a final background gamma survey conducted over the entire wellfield area to identify any contaminated earthen materials requiring removal to disposal.

- Final revegetation of the wellfield areas will be conducted according to the revegetation plan.

- All piping, equipment, buildings, and wellhead equipment will be surveyed for contamination prior to release in accordance with the NRC guidelines for decommissioning.

It is estimated that a significant portion of the equipment will meet release limits, which will allow disposal at an unrestricted area landfill. Other materials that are contaminated will be acid washed or decontaminated with other methods until they are releasable. If the equipment cannot be decontaminated to meet release limits, it will be disposed of at a USNRC licensed disposal facility.

Wellfield decommissioning will be an independent ongoing operation throughout the mining sequence at the Central Processing Facility and at the NTEA. Once a production unit has been mined out and groundwater restoration and stability have been accepted by the regulatory agencies, the wellfield will be scheduled for decommissioning and surface reclamation.

6.2.4.1 Well Plugging and Abandonment

All wells no longer useful to continue mining or restoration operations will be abandoned. These include all injection and production wells, monitor wells, and any other wells within the production unit used for the collection of hydrologic or water quality data or incidental monitoring purposes. The only known exception at this time may be a shallow well that could be transferred to the landowner for domestic or livestock use.

The objective of the Crow Butte well abandonment program is to seal and abandon all wells in such a manner as to assure the groundwater supply is protected and to eliminate any potential physical hazard.

Prior to abandoning a well, data will be gathered (static water level, under-ream interval, casing depth) for use in a well abandonment spreadsheet that accounts for formation pressures, mining injection pressures, static water level, casing depth, materials used and weight of material used. Based on that information, adjustments can be made to the amount of bentonite chips to be used to plug the well screens, and also to calculate the minimum weight (lbs/gallon) of abandonment mud to be used to fill the hole to the surface and keep formation and mining pressures from allowing water to rise in the borehole. A prepackaged bentonite filled tube is currently used for plugging of the well screens. These tubes are placed into the screens by filling the well to the surface with water from a water truck, and then dropping the bentonite tubes down the well. The water is allowed to run while the tubes make their descent into the screens. The drill rig then trips drill pipe into the well and tags the bentonite to make sure it has reached the targeted depths. The drill stem is raised approximately 10 feet and a Plug-gel abandonment mud is mixed. If the weight of the abandonment mud needs to be increased, an amount of barite may be added to increase the weight. Likewise, a drilling additive (Dris-pac) to improve the ability of the abandonment mud to carry the barite may be added. In situations where it appears that the operating pressure and formation pressure are great enough to make it difficult to mix heavy mud, cement slurry may be substituted to fill the casing to the surface. All abandoned wells will remain above the surface until the wellfield is reclaimed. This will allow for the continuation of monitoring and observation of the integrity of the abandonment fluid. If needed, additional abandonment fluids will be added.

The plugging method is approved by the NDEQ and is generally as summarized below:

- A mechanical plug may be placed above the screened interval.
- Thirty to fifty feet of coarse bentonite chips will be added to provide a grout seal.
- A plug gel or cement grout will be placed by tremie pipe from the chips to the top of the casing. The weight of the gel or grout plus the weight of the bentonite chips will be enough to exceed the local Chadron formation pressure plus the maximum injection pressure allowed (100 psi).
- The tremie pipe will be removed (when possible) and the casing will be filled to the surface.
- An approved hole plug will be installed.
- The well casing will be cut off below ground level, capped with cement, and the surface disturbance will be smoothed and contoured.
- The hole will be backfilled and the area revegetated.

Records of abandoned wells will be tabulated and reported to the appropriate agencies after decommissioning. CBR must submit a notarized affidavit to the NDEQ detailing the significant data and the procedure used in connection with each well plugged. The Nebraska Department of Natural Resources (DNR) also requires filing a well abandonment notice for all registered wells.

6.2.4.2 Buried Trunklines, Pipes and Equipment

Buried process related piping such as injection and production lines will be removed from the mine unit undergoing decommissioning. Salvageable lines will be held for use in ongoing mining operations. Lines that are not reusable may either be assumed to be contaminated and disposed of at a licensed disposal site or may be surveyed and, if suitable for release to an unrestricted area, may be sent to a sanitary landfill.

6.3 REMOVAL AND DISPOSAL OF STRUCTURES, WASTE MATERIALS, AND EQUIPMENT

CBR would submit a final and detailed decommissioning plan for structures and equipment to the NRC for review and approval at least 12 months before the planned commencement of decommissioning of such structures and equipment. This final decommissioning plan would include a description of structures and equipment to be decommissioned, a description of planned decommissioning activities, a description of methods to be used to ensure protection of workers and the environment against radiation hazards, a description of the planned final radiation survey, and an updated detailed cost estimate.

The procedures to be used for removing and disposing of structures, waste materials and equipment would meet the following criteria:

- A written program is in place to control residual contamination on structures and equipment.
- Measurements of radioactivity on the interior surface of pipes, drain lines, and duct work would be determined by conducting measurements at all traps and other appropriate access points, provided that such contamination is likely to be representative of contamination on the interior of the pipes, drain lines and ductwork.
- Any surfaces of premises, equipment or scrap that would likely be contaminated, but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement, would be presumed to be contaminated in excess of the limits.
- Prior to the release of structures for unrestricted use, a comprehensive radiation survey would be made to establish that contamination is within the limits specified in NRC *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material*[2] and NRC approval would be obtained.
- A contract between CBR and a waste disposal operator would be in place to dispose of 11e.(2) byproduct material.

6.3.1 Preliminary Radiological Surveys and Contamination Control

Prior to process plant decommissioning, a preliminary radiological survey will be conducted to characterize the levels of contamination on structures and equipment and to identify any potential hazards. The survey will support the development of procedures for dealing with such hazards prior to commencement of decommissioning activities. In general, the contamination control program used during mining operations (as discussed in Section 5.7) will be appropriate for use during decommissioning of structures.

Based on the results of the preliminary radiological surveys, gross decontamination techniques will be employed to remove loose contamination before decommissioning activities proceed. This gross decontamination will generally consist of washing all accessible surfaces with high-pressure water. In areas where contamination is not readily removed by high-pressure water, a decontamination solution (e.g., dilute acid) may be used.

6.3.2 Removal of Process Buildings and Equipment

The majority of the process equipment in the process building will be reusable, as well as the building itself. Alternatives for the disposition of the building and equipment are discussed in this section.

All process or potentially contaminated equipment and materials at the process facility including tanks, filters, pumps, piping, etc., will be inventoried, listed and designated for one of the following removal alternatives:

- Removal to a new location within the Crow Butte site for further use or storage;
- Removal to another licensed facility for either use or permanent disposal; or
- Decontamination to meet unrestricted use criteria for release, sale or other non-restricted use by others.

It is most likely that process buildings will be decontaminated, dismantled and released for use at another location. If decontamination efforts were unsuccessful, the material would be sent to a permanent licensed disposal facility. Cement foundation pads and footings will be broken up and trucked to a licensed disposal site or properly licensed facility if contaminated.

6.3.2.1 Building Materials, Equipment and Piping to be Released for Unrestricted Use

Salvageable building materials, equipment, pipe and other materials to be released for unrestricted use will be surveyed for alpha contamination in accordance with license conditions contained in SUA-1534 and NRC guidance.

The CBR release limits for alpha radiation are as follows:

- Removable of 1,000 dpm/100cm^2
- Average total of 5,000 dpm/100 cm^2 over an area no greater than one square meter
- Maximum total of 15,000 dpm/100 cm^2 over an area no greater than 100 cm^2

Monitoring for beta contamination is a current license requirement. This requirement has been eliminated in subsequent ANSI standards, including ANSI/HPS N13.12[3]. In addition, CBR has routinely made these measurements but has never found them limiting.

Decontamination of surfaces will comply with CBR's ALARA policy, to reduce surface contamination as far below the limits as practical.

Non-salvageable contaminated equipment, materials, and dismantled structural sections will be sent to an NRC-licensed facility for disposal. In most cases, the byproduct material will be shipped as Low Specific Activity (LSA-I) material, UN2912, pursuant to 49 CFR 173.427

6.3.2.2 Disposal at a Licensed Facility

If facilities or equipment are to be moved to a facility licensed for disposal of 11e.(2) byproduct material, the following procedures may be used.

- Flush inside of tanks, pumps, pipes, etc., with water or acid to reduce interior contamination as necessary for safe handling.
- The exterior surfaces of process equipment will be surveyed for contamination. If the surfaces are found to be contaminated the equipment will be washed down and decontaminated to permit safe handling.
- The equipment will be disassembled only to the degree necessary for transportation. All openings, pipe fittings, vents, etc., will be plugged or covered prior to moving equipment from the plant building.
- Equipment in the building, such as large tanks, may be transported on flatbed trailers. Smaller items, such as links of pipe and ducting material, may be placed in lined roll off containers or covered dump trucks or drummed in barrels for delivery to the receiving facility.
- Contaminated buried process trunk lines and sump drain lines will be excavated and removed for transportation to a licensed disposal facility.
- All other miscellaneous contaminated material will be transported to a licensed disposal facility.

6.3.2.3 Release for Unrestricted Use

If a piece of equipment or structure is to be released for unrestricted use, it will be appropriately surveyed before leaving the licensed area. Both interior and exterior surfaces will be surveyed to detect potential contamination. Radioactivity levels would be determined on the interior surfaces of pipes, drain lines, or duct work by making measurements in all traps and other appropriate access points, provided that contamination at these locations would be expected to be representative of contamination on the interior of the pipes, drain lines or duct work. If the shape, size, or presence of inaccessible surfaces prevents an accurate and representative survey, the material will be assumed contaminated and properly disposed of. Appropriate decontamination procedures will be used to clean any contaminated areas and the equipment resurveyed and documentation of the final survey retained to show that unrestricted use criteria were met prior to releasing the equipment or materials from the site. The current release criteria are based on USNRC guidelines. The criteria to be used for release to unrestricted use will be the appropriate USNRC guidelines at that time. Release surveys will be based on the release methods discussed in Section 5.7.

If a process building is left on site for unrestricted use by a landowner, the following basic decontamination procedures will be used. Actual corrective procedures will be determined by field requirements as defined by radiological surveys.

After the building has been emptied, the interior floors, ceiling and walls of the building and exterior surfaces at vent and stack locations will be checked for contamination. Any remaining removable contamination will be removed by washing. Areas where contamination was noted will be resurveyed to ensure removal of all contamination to appropriate levels.

Process floor sumps and drains will be washed out and decontaminated using water and, if necessary, acid solutions. If the appropriate decontamination levels cannot be achieved, it may be necessary to remove portions of the sump and floor to disposal.

Excavations necessary to remove trunklines or drains will be surveyed for contaminated earthen material. Earthen material that is found to be contaminated will be removed to a licensed disposal facility prior to backfilling the excavated areas.

The parking and storage areas around the building will be surveyed for surface contamination after all equipment has been removed.

Decontamination of these areas will be conducted as necessary to meet the standards for unrestricted use.

6.3.3 Waste Transportation and Disposal

Materials, equipment, and structures that cannot be decontaminated to meet the appropriate release criteria will be disposed of at a disposal site licensed by the NRC or an Agreement State to receive 11e.(2) byproduct material. CBR currently maintains agreements with two such facilities located in the states of Utah and Wyoming for disposal of 11e.(2) byproduct materials generated by mining operations. A contract for disposal at a minimum of one facility will be maintained current as required in USNRC License SUA-1534.

Transportation of all contaminated waste materials and equipment from the site to the approved licensed disposal facility or other licensed sites will be handled in accordance with the Department of Transportation (DOT) Hazardous Materials Regulations (49 CFR Part 173) and the USNRC transportation regulations (10 CFR 71).

6.4 METHODOLOGIES FOR CONDUCTING POST-RECLAMATION AND DECOMMISSIONING RADIOLOGICAL SURVEYS

6.4.1 Cleanup Criteria

Surface soils will be cleaned up in accordance with the requirements of 10 CFR Part 40, Appendix A, including a consideration of ALARA goals and the chemical toxicity of uranium.

The proposed limits and ALARA goals for cleanup of soils are summarized in Table 6.4-1 and described below.

Table 6.4-1
Soil Cleanup Criteria and Goals

	Radium-226 (pCi/gm)		**Natural Uranium (pCi/gm)**	
Layer Depth	*Limit*	*Goal*	*Limit*	*Goal*
Surface (0-15 cm)	5	5	230	150
Subsurface (15 cm layers)	15	10	230	230

The existing radium-226 criterion in 10 CFR Part 40, Appendix A, was used to derive a dose criterion (Benchmark Approach) for the cleanup of byproduct materials. The Benchmark Dose was modeled using the RESRAD code (Version 6.22). The results show that a concentration of 537 pCi/g for natural uranium in the top 15 cm layer of soil for the resident farmer scenario is equivalent to the Benchmark Dose derived from a concentration of 5 pCi/g of radium-226.

ALARA considerations require that an effort be made to reduce contaminants to as low as reasonably achievable levels. The ALARA goals are normally based on a cost-benefit analysis. For the cleanup of gamma-emitting radionuclides, the cost of cleanup becomes excessively high as soil concentrations and/or gamma emission rates become indistinguishable from background.

Cleanup of uranium mill sites has demonstrated that conservatively derived gamma action levels along with appropriate field survey and sampling procedures result in near background radium-226 concentrations for the site. In addition, the presence of a mixture of radium-226 and uranium will tend to drive the cleanup to even lower radium-226 concentrations. It is therefore believed that no specific ALARA goal is required for surface radium-226.

CBR proposes an ALARA goal of limiting the natural uranium concentration in the top 15 cm soil layer to 150 pCi/g, averaged over 100 m^2. According to the RESRAD runs shown in Appendix D, the ratio of Radium-226 dose rate per pCi/g to the uranium dose rate per pCi/g is 120. It is also shown by calculation that the ratio of Radium-226 to uranium emission rates is 30. Therefore, if the action level for pure radium-226 results in cleanup of the site to less than 5 pCi/g, the action level should result in the cleanup of pure uranium to 30 times 5 or 150 pCi/g.

The uranium concentration should be limited to at most 230 pCi/g for all soil depths because of chemical toxicity concerns. Using the most conservative daily limit corresponding to the National Primary Drinking Water Standard, a soil limit of 230 pCi/g corresponds to the EPA intake limit from drinking water with a uranium concentration of 0.06 mg/day.

CBR desires to reduce subsurface concentrations to a maximum of two-thirds of the proposed limit of 15 pCi/g Radium-226. The subsurface uranium goal has not been reduced since it has not been demonstrated that these levels can be detected with readily available field instruments.

Section 2.5 of Appendix E to the Environmental Report supporting this license amendment application Wellfield Decommissioning Plan for Crow Butte Uranium Project" demonstrates that spills of process solutions at the Crow Butte Uranium Project are not likely to contain substantial amounts of Thorium-230. CBR believes that development of soil cleanup criteria for Thorium-230 is not appropriate at this time. In the unlikely event that a situation exists where Thorium-230 is present in significant quantities, cleanup criteria will be developed using the Radium-226 Benchmark approach and submitted to the NRC for approval prior to final site decommissioning.

6.4.2 Excavation Control Monitoring

CBR will use 17,900 cpm as its gamma action level, as determined with a Ludlum Model 44-10/2221 NaI detection system or equivalent held at 18 inches above ground surface. The gamma action level, defined as the gamma count rate corresponding to the soil cleanup criterion, will be used in the interpretation of the data. This action level will be used with caution, or until a new action level is developed.

Hand-held and GPS-based gamma surveys will be used to guide soil remediation efforts. Field personnel will monitor excavations with hand-held detection systems to guide the removal of contaminated material to the point where there is high probability that an area meets the cleanup criteria. Support will be provided by GPS-based gamma surveys periodically to more accurately assess the progress of excavation.

The 17,900 cpm action level was based on an evaluation of the correlation between gamma count rates and Ra-226 concentration in soil using data from the few spill-related contaminated areas that existed at the main plant area. CBR believes that 17,900 cpm is a conservative value since the contaminated areas were small in size. The measured gamma emission rate per unit Ra-226 concentration from small areas is normally lower than that which would be measured using large areas, such as 100- m^2 area. Therefore cleanup to 17,900 cpm should ensure that each 100- m^2 area meets the radium-226 soil cleanup standard.

Section 6.3 of Appendix E to the Environmental Report supporting this license amendment application " Wellfield Decommission Plan for Crow Butte Uranium Project" discusses the development of the 17,900 counts per minute (cpm) action level. It does however allow for a revision of the number should it later be determined not appropriate.

6.4.3 Surface Soil Cleanup Verification and Sampling Plan

Cleanup of surface soils will be restricted to a few areas where there are known spills and, potentially, small spills near wellheads. Final GPS-based gamma surveys will be conducted in potentially contaminated areas, including 10 m buffer zones.

CBR will divide the area systematically into 100 m^2 grid blocks and sample all grid blocks containing gamma count rates exceeding the gamma action level. The samples will be five-point composites, and analyzed at an offsite laboratory for Radium-226 and natural uranium.

CBR will sample the remaining grid blocks with average gamma count rates ranking in the top 10 percent.

If any grid blocks within the top 10 percent fail the cleanup criteria, CBR will sample the second ten percent of grid blocks. This will continue until all grid blocks pass within a 10 percent grouping. To meet the cleanup criterion, each of the sampled grid blocks must satisfy the following inequality,

$$\sum \frac{C_i}{Cc} < 1$$

where C_i is the concentration of the constituent and C_c is the concentration of the constituent that is equivalent to the Benchmark Dose.

CBR will remediate the grid blocks failing this inequality or propose alternatives consistent with Appendix A of 10 CFR 40.

After all sampled grids have met the inequality, an EPA-recommended statistical test will be done to determine whether the mean of the equality defined above for all grid blocks is 1 or less at the 95 percent confidence level, using Equation 8-13 of draft NUREG/CR-5849[4]. If the mean of the sample concentrations is less than the criterion but the data fail the statistical test, CBR will follow procedures similar to those recommended in Section 8.6 of draft NUREG/CR-5849 (USNRC 1992).

6.4.4 Subsurface Soil Cleanup Verification and Sampling Plan

For subsurfaces, CBR will adopt different survey and sample protocols, depending on the type and size of excavation. CBR will rely more on sampling and Radium-226 and natural uranium analysis over surveying, to verify cleanup of subsurface excavations. The protocols are summarized in site procedures.

6.4.5 Temporary Ditches and Impoundments Cleanup Verification and Sampling Plan

CBR will adopt survey and sample protocols for temporary ditches and surface impoundments on a case-by-case basis. Ditches and impoundments can extend from the surface to the subsurface. For the purpose of decommissioning, the surfaces will be considered as part of adjacent soil surfaces. The subsurfaces will be surveyed and sampled systematically, based on their size and geometry. As with other subsurfaces, CBR will rely more on sampling and Radium-226 and uranium analysis over surveying to verify cleanup of ditches and impoundments. Surveying is applicable in larger impoundments, however, wherein the effects of geometry are not as pronounced, particularly in areas not influenced by adjacent walls.

6.4.6 Quality Assurance

Verification soil samples will be sent to a commercial laboratory for analysis of radium-226 and natural uranium. The criteria that CBR will use to select the commercial laboratory will follow the guidance published in the Multi-Agency Radiological Laboratory Analytical Protocols Manual[5] The commercial laboratory will adhere to a well-defined quality assurance program that addresses the laboratory's organization and management, personal qualifications, physical facilities, equipment and instrumentation, reference materials, measurement traceability and calibration, analytical method validation, standard operating procedures (SOPs), sample receipt, handing, storage, records, and appropriate licenses.

The analytical work performed by the commercial laboratory will adhere to CBR-defined Data Quality Objectives (DQOs). Part of the DQO process is specific analytical sensitivities required by CBR. The minimum sensitivity required for each sample will be 0.5 pCi/g dry weight for each analyte, with an estimated overall error of $\pm$ 0.5 pCi/g.

CBR will expect the reporting equivalent of an EPA Contract Laboratory Program Level 3 data package from the commercial laboratory.

CBR will maintain a laboratory QA file that will include, at a minimum, the laboratory's Quality Assurance Manual (QAM) and audit reports.

6.5 DECOMMISSIONING HEALTH PHYSICS AND RADIATION SAFETY

The health physics and radiation safety program for decommissioning will ensure that occupational radiation exposure levels are kept as low as reasonably achievable during decommissioning. This program will ensure that contamination and any use of the premises, equipment or scrap will not result in an unacceptable risk to the health and safety of the public or the environment. The Radiation Safety Officer, Health Physics Technician or designee will be on site during any decommissioning activities where a potential radiation exposure hazard exists. In general, the radiation safety program discussed in Section 5 will be used as the basis for development of the decommissioning health physics program. Health physics surveys conducted during decommissioning will be guided by applicable sections of Regulatory Guide 8.30[6] or other applicable standards at the time.

6.5.1 Records and Reporting Procedures

At the conclusion of site decommissioning and surface reclamation, a report containing all applicable documentation will be submitted to the NRC and NDEQ. Records of all contaminated materials transported to a licensed disposal site will be maintained for a period of five years or as otherwise required by applicable regulations at the time of decommissioning.

6.6 FINANCIAL ASSURANCE

6.6.1 Bond Calculations

Cost estimates for the purpose of bond calculations are made annually for the Crow Butte Project site. The cost assessment includes groundwater restoration, decontamination and decommissioning and surface reclamation costs for all areas to be affected by the installation and operation of the proposed mine plan. The detailed calculations utilized in determining the bonding requirements for the Crow Butte Project are submitted annually.

6.6.2 Financial Surety Arrangements

Crow Butte Resources maintains an NRC-approved financial surety arrangement consistent with 10 CFR 40, Appendix A, Criterion 9 to cover the estimated costs of reclamation activities. Crow Butte maintains an Irrevocable Standby Letter of Credit issued by the Royal Bank of Canada (New York Branch) in favor of the State of Nebraska in the present (2007) amount of $22,980,913. The surety amount is revised annually in accordance with the requirements of SUA-1534. The surety amount will be revised to reflect the estimated costs of reclamation activities for the North Trend Expansion Area as development activities proceed.

6.7 REFERENCES

[1]Nebraska Department of Environmental Quality. (NDEQ). 2006. *Title 118 – Ground Water Quality Standards and Use Classification*, March 27, 2006.

[2]U.S. Nuclear Regulatory Commission. (USNRC). 1993. *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material.* April 1993.

[3]American National Standards Institute. (ANSI). 1999. ANSI/HPS N13.12, *Surface and Volume Radioactivity Standards for Clearance.*

[4]U.S. Nuclear Regulatory Commission. (USNRC). 1992. NUREG/CR-5849, *Manual for Conducting Radiological Surveys in Support of License Termination, Draft Report for Comment.* June 1992.

[5]U.S. Nuclear Regulatory Commission. (USNRC). Multi-Agency Radiological Laboratory Analytical Protocols Manual. NUREG-1576. July 2004.

[6]U.S. Nuclear Regulatory Commission. (USNRC). 2002. Regulatory Guide No. 8.30, *Health Physics Surveys in Uranium Recovery Facilities*, May 2002.

Replacement Pages for Section 7.4 Non-Radiological Effects

Replace pages 7-36 through 7-52

Table 7.3-2
Dose to the Population Bronchial Epithelium and Increased Continental Dose from One Year's Operation at the Crow Butte Facility

Criteria	Dose (person rem/yr)
Dose received by population within 80 km of the facility	171
Natural background by population within 80 km of the facility	24025
Dose received by population beyond 80 km of the facility	224
Total continental dose	394
Natural background for the continental population	$1.73 \times 10^{+8}$
Fraction increase in continental dose	$2.27 \text{ X } 10^{-6}$

7.4 NON-RADIOLOGICAL EFFECTS

Nonradiological effects of site preparation and construction activities are discussed in Section 7.1, including impacts on air quality, land use, surface water, population, social and economic, and noise impacts. Impacts on operational activities are discussed in Section 7.2, including air quality, land use, soil, groundwater, surface water, ecology and noise impacts.

As discussed in Sections 7.1 and 7.2, overall emissions associated with equipment and facility operations during site preparation, construction and operations would be expected to be minimal and should not affect the local ambient air quality. Nonradiological emissions include NO_x, CO, SO_2, VOC and particulate matter (operating equipment and fugitive dust due to traffic on unpaved areas). During operations, a gaseous and airborne effluent will consist of air ventilated from the plant building ventilation system and vented from process vessels and tanks. This gaseous effluent would primarily contain radon gas as previously discussed in Sections 4 and 7.3. The gaseous and airborne effluent will not contain any significant non-radiological emissions.

In addition to gaseous and airborne effluents, there would be three types of wastes generated at the proposed NTEA Satellite Facility: liquid, solid and sanitary. The operational-generated liquid wastes would be disposed of through a deep disposal well and evaporation ponds. Such liquid wastes would consist of: wellfield bleed streams; plant washdown water; groundwater restoration water; laboratory wastewaters; liquids resulting from rainwater/snow fall and spills within the curbed process areas. Accumulations of rainfall/snowmelt and any spills within the curbed bulk chemical, lubricant storage facility and the fuel diked area will be removed and disposed of as per the site's Spill Prevention, Containment and Countermeasure Plan. Well development water in the wellfields will be collected in dedicated tanker trucks and transported to the main satellite processing facility for disposal in the deep disposal well or evaporation ponds.

There would be no discharge from the evaporation ponds. The deep disposal well will permanently dispose of liquid wastes and will be permitted under a Class I UIC Permit issued by the NDEQ. The current Class I UIC Permit for the deep disposal well located at the Central Plant implements injection limits and requires monthly monitoring for RCRA Metals to ensure that hazardous waste is not injected. Based on the monitoring for the current deep disposal well, there is no non-radiological impact expected due to the liquid effluents from the North Trend Satellite Facility.

Solid wastes generated would consist of waste such as spent resin, resin fines, filters, miscellaneous pipe and fittings, and domestic waste. These wastes are classified as contaminated or noncontaminated waste according to radiological survey results. Contaminated byproduct waste that cannot be decontaminated is packaged and stored until it can be shipped to a licensed waste disposal site or licensed mill tailings facility. Non-contaminated solid waste is collected on the site on a regular basis and disposed of in a sanitary landfill permitted by the NDEQ. CBR's estimate of annual quantities of non-contaminated generated solid waste for North Trend is presented in Section 4.2.2.1. No significant non-radiological impacts associated with management of relative small quantities of solid wastes would be expected.

The estimates of hazardous waste generation at the proposed NTEA operations, and the site's expected waste generation status (i.e., Conditionally Exempt Small Quantity Generator), are discussed in Section 4.2.2.4. The potential for any adverse impacts due to the handling and disposal of hazardous waste would be minimal due to the small quantities handled and operational procedures in CBR's *EHSMS Program Volume VI, Environmental Manual.* The EHSMS document is reviewed annually and the sections updated as required.

Sanitary liquid waste will be disposed of in an on-site wastewater treatment system (i.e., septic) permitted by the NDEQ under the Class V Underground Injection Control (UIC) Regulations. Periodic removal of septic tank solids will be performed by companies or individuals licensed for such activities by the State of Nebraska. There have been no problems associated with operating a similar sanitary system at the current commercial operating facility, and no problems would be expected for the North trend operations.

For any spill, the free liquids would be recovered and any contaminated soils would be removed and placed in an offsite disposal site approved for the type of waste generated. Spills are also discussed in Section 4.2.1.3.4.

In summary, the design and construction of the North Trend Satellite Facilities will concentrate on minimizing the potential for releases of nonradiological waste materials.

For example, CBR would use spillage control through the use of diking or by flow cut-off and flow isolation procedures and equipment for radiological and nonradiological materials. A quality assurance and quality control system will be used, which would involve pre-operational testing of equipment, periodic testing and regular inspection of equipment (e.g., pipelines, manifolds), and associated monitoring on line flows and pressures with automatic shutdowns in response to flow or pressure changes. Consequently, any spills should be small with little impacts on the environment. For any spill, the free liquids would be recovered and disposed of in the deep disposal well or evaporation ponds and any contaminated soils would be removed and placed in an offsite disposal site approved for the type of waste generated.

7.5 EFFECTS OF ACCIDENTS

Accidents involving human safety associated with the in-situ uranium mining technology typically have far less severe consequences than accidents associated with underground and open pit mining methods. In-situ mining provides a higher level of safety for personnel and neighboring communities when compared to conventional mining methods or other energy-related industries. Accidents that may occur would generally be quite minor when compared to other industries, such as an explosion at an oil refinery or chemical plant. Radiological accidents that might occur would typically manifest themselves slowly and are therefore easily detected and mitigated. The remote location of the facility and the low level of radioactivity associated with the process both decrease the potential hazard of an accident to the general public.

NRC has previously evaluated the effects of accidents at uranium milling facilities in NUREG–0706[1] and specifically at in situ leach facilities in NUREG/CR-6733[2]. These analyses demonstrate that, for most credible potential accidents, consequences are minor so long as effective emergency procedures and properly trained personnel are used. The CBR emergency management procedures contained in EHSMS Program Volume VIII, *Emergency Manual,* have been developed to implement the recommendations contained in the NRC analyses. Training programs contained in EHSMS Volume VII, *Training Manual,* have been developed to ensure that CBR personnel have been adequately trained to respond to all potential emergencies. EHSMS Program Volume II, *Management Procedures,* requires periodic testing of emergency procedures and training by conducting drills.

NUREG-0706 considered the environmental effects of accidents at single and multiple uranium milling facilities. Analyses were performed on incidents involving radioactivity and classified these incidents as trivial, small, and large. NUREG-0706 also considered transportation accidents. Some of the analyses in NUREG-0706 are applicable to ISL facilities, such as transportation accidents; however, much of the analyses do not apply due to the significantly different mining and processing methods. ISL facilities do not handle large quantities of radioactive materials such as crushed ore and tailings, so the quantity of material that could be affected by an incident is significantly less than at a mill site.

NUREG/CR-6733 specifically addressed risks at ISL facilities and identified the following "risk insights".

7.5.1 Chemical Risk

NUREG/CR-6733 noted that the scope of the NRC mission includes hazardous chemicals to the extent that mishaps with these chemicals could affect releases of radioactive materials. The use of hazardous chemicals at Crow Butte is regulated by the Occupational Health and Safety Administration (OSHA). Crow Butte is subject to the Process Safety Management of Highly Hazardous Chemicals standard contained in 29 CFR §1910.119. Of the highly hazardous chemicals, toxics, and reactives listed in Appendix A to 29 CFR §1910.119, none will be used at the North Trend Satellite Plant. As a satellite plant, North Trend will use oxygen, carbon dioxide, and sodium carbonate for addition to the injection solution. Sodium sulfide may be used as a reductant during groundwater restoration activities. All other operations requiring process chemicals described in NUREG/CR-6733 will be performed at the Central Plant.

Crow Butte construction, operating, and emergency procedures have been developed to implement the codes and standards that regulate hazardous chemical use.

7.5.1.1 Oxygen

Oxygen presents a substantial fire and explosion hazard. The design and installation of the oxygen storage facility is typically performed by the oxygen supplier and meets applicable industry standards. As currently practiced at the Central Plant, CBR will install wellfield oxygen distribution systems at North Trend. Combustibles such as oil and grease will burn in oxygen if ignited. CBR ensures that all oxygen service components are cleaned to remove all oil, grease, and other combustible material before putting them into service. Acceptable cleaning methods are described in CGA G-4.1[3]. Construction of oxygen systems in the wellfield are covered by procedures contained in EHSMS Program Volume III, *Operations Manual.* Emergency response instructions for a spill or fire involving oxygen systems are contained in EHSMS Program Volume VIII, *Emergency Manual.*

7.5.1.2 Carbon Dioxide

The primary hazard associated with the use of carbon dioxide is concentration in confined spaces, presenting an asphyxiation hazard. Bulk carbon dioxide facilities are typically located outdoors and are subject to industry design standards. Floor level ventilation and carbon dioxide monitoring at low points is currently performed at the central plant to protect workers from undetected leaks of carbon dioxide. Operation of carbon dioxide systems is currently covered by procedures contained in EHSMS Program Volume III, *Operations Manual*. Emergency response instructions for a leak involving carbon dioxide are contained in EHSMS Program Volume VIII, *Emergency Manual*.

7.5.1.3 Sodium Carbonate

Sodium carbonate is primarily an inhalation hazard. CBR typically uses soda ash and carbon dioxide to prepare sodium carbonate for injection in the wellfield. Soda ash storage and handling systems are designed to industry standards to control the discharge of dry material. Operation of sodium carbonate systems is currently covered by procedures contained in EHSMS Program Volume III, *Operations Manual*. Emergency response instructions for a spill involving sodium carbonate or soda ash are contained in EHSMS Program Volume VIII, *Emergency Manual*.

7.5.2 Radiological Risk

7.5.2.1 Tank Failure

A spill of the materials contained in the process tanks at the North Trend Satellite Facility will present a minimal radiological risk. Process fluids will be contained in vessels and piping circuits within the process plant or in outside storage tanks. The tanks at the North Trend Satellite will contain injection and production solutions and ion exchange resin. Elution, precipitation, and drying will be performed at the central plant. The satellite plant will be designed to control and confine liquid spills from tanks should they occur. The plant building structure and concrete curb will contain the liquid spills from the leakage or rupture of a process vessel and will direct any spilled solution to a floor sump. The floor sump system will direct any spilled solutions back into the plant process circuit or to the waste disposal system. Bermed areas, tank containments, or double-walled tanks will perform a similar function for process vessels located outside the satellite building.

All tanks will be constructed of fiberglass or steel. Instantaneous failure of a tank is unlikely. Tank failure would more likely occur as a small leak in the tank. In this case, the tank would be emptied to at least a level below the leaking area and repairs or replacement made as necessary.

7.5.2.2 Plant Pipe Failure

The rupture of a pipeline within the process plant is easily visible and can be repaired quickly. Spilled solution will be contained and removed in the same fashion as for a tank failure.

Response procedures for the radiological risk from releases are currently contained in EHSMS Volume VIII, *Emergency Manual.* These procedures also provide instructions for emergency notification including notification to NRC in compliance with the requirements of 10 CFR 20.2202 and 20.2203.

7.5.3 Groundwater Contamination Risk

7.5.3.1 Lixiviant Excursion

Excursions of lixiviant at ISL facilities have the potential to contaminate adjacent aquifers with radioactive and trace elements that have been mobilized by the mining process. These excursions are typically classified as horizontal or vertical. A horizontal excursion is a lateral movement of mining solutions outside the exempted portion of the ore-body aquifer. A vertical excursion is a movement of ISL fluids into overlying or underlying aquifers.

CBR controls lateral movement of lixiviant by maintaining wellfield production flow at a rate slightly greater than the injection flow. This difference between production and injection flow is referred to as process bleed. The bleed solution is either recycled in the plant or is sent to the liquid waste disposal system. When process bleed is properly distributed among the many mining patterns within the Mine Unit, the wellfield is said to be balanced.

CBR monitors for lateral movement of lixiviant using a horizontal excursion monitoring system. This system consists of a ring of monitor wells completed in the same aquifer and zone as the injection and production wells. The current NRC License and NDEQ Class III UIC Permit require that Chadron aquifer monitor wells be located no more than 300 feet from the nearest mineral production wells and no more than 400 feet each other. These spacing requirements have proven effective for monitoring horizontal excursions at Crow Butte and will be employed at the North Trend Satellite. Monitor wells are sampled biweekly for approved excursion indicators. CBR proposes to implement the current approved excursion monitoring program at the North Trend Satellite. The program was discussed in detail in section 5.7.8.

Section 7.2.5 provided a discussion of horizontal excursions reported at the current Crow Butte operation. The historical experience indicates that the selected indicator parameters and UCLs allow detection of horizontal excursions early enough that corrective action can be taken before water quality outside the exempted aquifer boundary is significantly degraded. As noted in NUREG/CR-6733, significant risk from a horizontal excursion would occur only if it persisted for a long period without being detected.

Vertical excursions can be caused by improperly cemented well casings, well casing failures, improperly abandoned exploration wells, or leaky or discontinuous confining layers. CBR controls vertical excursions through aquifer testing programs and rigorous well construction, abandonment, and testing requirements. Aquifer testing is conducted before mining wells are installed to detect any leaks in the confining layers. Aquifer test reports are submitted to the NDEQ for review and approval before well construction activities may proceed. Well construction and integrity testing is conducted in accordance with NDEQ regulations contained in Title 122[4] and methods approved by NRC and NDEQ. Construction and integrity testing methods were discussed in detail in section 3.1. Well abandonment is conducted in accordance with methods approved and monitored by the NDEQ and discussed in detail in section 6.2. Procedures for these activities are contained in EHSMS Program Volume III, *Operating Manual.*

CBR monitors for vertical excursions in the overlying aquifers using shallow monitor wells. These wells are located within the wellfield boundary at a density of one well per five acres. Shallow monitor wells are sampled biweekly for approved excursion indicators. CBR proposes to implement the current approved excursion monitoring program at the North Trend Satellite. The program was discussed in detail in section 5.7.8.

7.5.3.2 Pond Failure

An accident involving a leak in a pond is detectable either from the regular visual inspections or through monitoring the leak detection system. The current pond operation and inspection program is contained in EHSMS Program Volume VI, *Environmental Manual,* and consists of daily, weekly, monthly and quarterly inspections in conjunction with an annual technical evaluation of the pond system. The CBR monitoring program was developed to meet the guidance contained in USNRC Regulatory Guides 3.11[5] and 3.11.1[6]. Any time six inches or more of fluid is detected in the standpipes, it is analyzed for specific conductance. If the water quality is degraded beyond the action level, it is sampled again and analyzed for chloride, alkalinity, sodium, and sulfate. In addition, monitor wells are installed downgradient of the pond in the first water bearing zone. These monitor wells are sampled and analyzed for the excursion parameters on a quarterly basis. The pond operation and monitoring program was discussed in detail in Section 4.2.

In the event of a leak, the contents of any one pond can be transferred to another pond cell while repairs are made. Freeboard requirements may be waived during this period.

Catastrophic failure of a pond embankment is unlikely given the design and inspection requirements of the pond and the freeboard limitations.

7.5.4 Wellfield Spill Risk

The rupture of an injection or recovery line in a wellfield, or a trunkline between a wellfield and the North Trend Satellite plant would result in either a release of barren or pregnant lixiviant solution, which would contaminate the ground in the area of the break. All piping from the plant, to and within the wellfield will be buried for frost protection. Pipelines are constructed of PVC, high density polyethylene (HDPE) with butt welded joints, or equivalent. All pipelines are pressure tested at operating pressures prior to final burial and production flow and following maintenance activities that may affect the integrity of the system.

Each mine unit will have a number of wellhouses where injection and production wells will be continuously monitored for pressure and flow. With the control system currently employed at Crow Butte, individual wells may have high and low flow alarm limits set. All monitored parameters and alarms will be observed in the satellite control room via the computer system. In addition, each wellfield building will have a "wet building" alarm to detect the presence of any liquids in the building sump. High and low flow alarms have been proven effective at the current operation in detection of significant piping failures (e.g., failed fusion weld).

Occasionally, small leaks at pipe joints and fittings in the wellhouses or at the wellheads may occur. Until remedied, these leaks may drip process solutions onto the underlying soil. CBR currently implements a program of continuous wellfield monitoring by roving wellfield operators and required periodic inspections of each well that is in service. Based on experience from the current operation, small leaks in wellfield piping typically occur in the injection system due to the higher system pressures. These leaks seldom result in soil contamination based on monitoring using field survey instruments and soil samples for radium-226 and uranium. Following repair of a leak, CBR procedures require that the affected soil be surveyed for contamination and the area of the spill documented. If contamination is detected, the soil is sampled and analyzed for the appropriate radionuclides. Contamination may be removed as appropriate.

7.5.5 Transportation Accident Risk

Transportation of materials to and from the North Trend Satellite Plant can be classified as follows:

- Shipments of process chemicals or fuel from suppliers to the site.

- Shipment of radioactive waste from the site to a licensed disposal facility.
- Shipments of uranium-laden resin from the satellite plant to the central plant and return shipments of barren, eluted resin from the central plant back to the satellite plant.

The first two types of transportation risks do not present an increase over the risks associated with operation of the current Crow Butte facility since production from North Trend is planned to replace declining production at the current facility. The shipment of loaded ion exchange resin from North Trend and the return of barren, eluted resin represent an additional transportation risk that was not considered for the current operation.

NUREG-0706 concluded that the probability of a truck accident in any year is 11 percent for each uranium extraction facility or mill. This calculation used average accident probabilities (4.0×10^{-7}/km for rural interstate, 1.4×10^{-6}/km for rural two-lane road, and 1.4×10^{-6}/km for urban interstate) that NUREG/CR-6733 determined were conservative with respect to probability distributions used in a later NRC transportation risk assessment[7]. For North Trend, uranium-loaded and barren resin will be routinely transported by tank truck from the satellite plant to the Central Plant. For the Crown Point site, NRC determined that the probability of an accident involving such a truck was 0.009 in any year[8].

Accident risks involving potential transportation occurrences and mitigating measures are discussed below:

7.5.5.1 Accidents Involving Shipments of Process Chemicals

Based on the current production schedule and material balance, it is estimated that approximately 150 bulk chemical deliveries per year will be made to the North Trend Satellite. This averages about one truck per working day for delivery of chemicals throughout the operational life of the project. Types of deliveries include carbon dioxide, oxygen, and soda ash.

7.5.5.2 Accidents Involving Radioactive Wastes

Low level radioactive 11e.(2) by-product material or unusable contaminated equipment generated during operations will be transported to a licensed disposal site. Because of the low levels of radioactive concentration involved, these shipments are considered to have minimal potential impact in the event of an accident.

7.5.5.3 Accidents Involving Resin Transfers

One of the potential additional risks associated with operation of a satellite plant is the transfer of the ion exchange resin to and from the satellite plant.

Resin will be transported to and from the North Trend Satellite Plant in a 4,000 gallon capacity tanker trailer. It is currently anticipated that one load of uranium-laden resin will be transported to the Crow Butte central plant for elution and one load of barren eluted resin will be returned to the North Trend Satellite Plant on a daily basis. The transfer of resin between the two sites will occur on county and private roads. The planned transport route has been designed to avoid travel on U.S. Highway 20 and Nebraska State Highway 2/71. The planned transport route will cross these two highways.

Resin or eluate shipments will be treated similarly to yellowcake shipments in regards to Department of Transportation (DOT) and USNRC regulations. Shipments will be handled as Low Specific Activity (LSA) material for both uranium-laden and barren eluted resin. Pertinent procedures, which Crow Butte will follow for a resin shipment, are listed as follows:

- The resin, either loaded or eluted, will be shipped as "Exclusive Use Only". This will require the outside of each container or tank to be marked "Radioactive LSA" and placarded on four sides of the transport vehicle with "Radioactive" diamond signs.

- A bill of lading will be included for each shipment (including eluted resin). The bill of lading will indicate that a hazardous cargo is present. Other items identified shall be the shipping name, ID number of the shipped material, quantity of material, the estimated activity of the cargo, the transport index and the package identification number.

- Before each shipment of loaded or barren eluted resin, the exterior surfaces of the tanker will be surveyed for alpha contamination. In addition, gamma exposure rates will be obtained from the surface of the tanker and inside the cab of the tractor. All of the survey results will appear on the bill of lading.

- Trained CBR drivers will transport the resin between the North Trend Satellite Plant and the central plant.

- Crow Butte's current emergency response plan for yellowcake and other transportation accidents to or from the Crow Butte site is contained in EHSMS Program Volume VIII, *Emergency Manual*. This plan will be expanded to include an emergency resin transfer accident procedure. Personnel at both the satellite plant and the central plant will receive training for responding to a resin transfer transportation accident.

Currently, Crow Butte Resources intends to treat the eluted resin the same as the uranium loaded resin. It is possible that the eluted resin may be clean enough to be transported as non-radioactive material, as defined by DOT regulations. Operating experience will aid in the determination of the most practical and efficient way of dealing with the shipment of barren resin. Regardless, compliance with all applicable DOT and USNRC regulations will be the primary determining factor.

The worst case accident scenario involving resin transfer transportation would be an accident involving the transport truck and tanker trailer when carrying uranium laden resin where all of the tanker contents were spilled. Because the uranium is ionically-bonded to the resin and the resin is in a wet condition during shipment, the radiological and environmental impacts of such a spill are minimal. The radiological or environmental impact of a similar accident with barren, eluted resin would be very minor. The primary environmental impact associated with either accident would be the salvage of soils impacted by the spill area and the subsequent damage to the topsoil and vegetation structure. Areas impacted by the removal of soil would be revegetated.

In the event of a transportation accident involving the resin transfer operation, CBR will institute its emergency response plan for transportation accidents. To minimize the impacts from such an accident, the following procedures will be followed:

- Each resin hauling truck will be equipped with a radio which can communicate with either the Crow Butte central plant or the North Trend Satellite plant. In the event of an accident and spill, the driver can radio to both sites to obtain help.

- A check-in and check-out procedure will be instituted where the driver will call the receiving facility prior to departure from his location. If the resin shipment fails to appear within a set time, a crew would respond and search for this vehicle. This system will assure reasonably quick response time in the case that the driver is incapacitated in the accident.

- Each resin transport vehicle will be equipped with an emergency spill kit which the driver can use to begin containment of any spilled material.

- Both the satellite and central process facilities will be equipped with emergency response packages to quickly respond to a transportation accident.

- Personnel at the satellite and central process facilities as well as the designated truck drivers will have specialized training to handle an emergency response to a transportation accident.

7.5.6 Natural Disaster Risk

NUREG/CR-6733 considered the potential risks to an ISL facility from natural disasters. Specifically, the risk from an earthquake and a tornado strike were analyzed. NRC determined that the primary hazard from these natural events was from dispersal of yellowcake from a tornado strike and failure of chemical storage facilities and the possible reaction of process chemicals during either event. NUREG/CR-6733 recommended that licensees follow industry best practices during design and construction of chemical facilities. CBR is committed to following these standards.

The project area along with most of Nebraska is in seismic risk Zone 1. Most of the central United States is within seismic risk Zone 1 and only minor damage is expected from earthquakes that occur within this area. Seismology was discussed in detail in section 2.6.

The Crow Butte operation is located in an area that is subject to tornadoes. CBR emergency procedures currently contained in EHSMS Program Volume VIII, *Emergency Manual,* provide instructions for response and mitigation of natural disasters and spills or radioactive materials.

7.6 ECONOMIC AND SOCIAL EFFECTS OF CONSTRUCTION AND OPERATION

The preliminary evaluation of socioeconomic impacts of the commercial facility was completed in 1987 as reported in the original commercial license application. The preliminary evaluation was divided into two phases – construction and operation. The evaluation concluded that the construction phase would cause a moderate impact to the local economy, resulting from the purchases of goods and services directly related to construction activities. Impacts to community services such as roads, housing, schools, and energy costs would be minor or non-existent and temporary.

Since the inception of the operational phase, the overall effect of the current commercial facility operations on the local and regional economy has been beneficial. Purchases of goods and services by the mine and mine employees contribute directly to the economy. Local, state, and the federal governments benefit from taxes paid by the mine and its employees. Indirect impacts, resulting from the circulation and recirculation of direct payments through the economy, are also beneficial. These economic effects further stimulate the economy, resulting in the creation of additional jobs. Beneficial impacts to the local and regional economy provided by the current operation would continue for the life of the mine, estimated to be an additional twelve years as of January 2007. However, the positive impacts from the current operation will begin to decline as reserves are depleted in the next five years.

The current mine operation has not resulted in any significant impact to the community infrastructure (including schools, roads, water and sewage facilities, law enforcement, medical facilities, and any other public facility) in the town of Crawford or in Dawes County. As discussed in further detail below, the mine employs a workforce of approximately 52 employees and 20 contractors. The majority of these employees are hired from the surrounding communities.

In summary, monetary benefits accrue to the community from the presence of the Crow Butte Project. Against these monetary benefits are the monetary costs to the communities involved, such as those for new or expanded schools and other community services. While it is not possible to arrive at an exact numerical balance between these benefits and costs for any one community, or for the project, because of the ability of the community and possibly the project to alter the benefits and costs, this section summarizes the economic impact of the project to date and projects the incremental impacts from operation of the proposed North Trend Satellite Facility.

7.6.1 Tax Revenues

The following table summarizes the recent tax revenues from the Crow Butte project.

	2006	2005	2004	2003
Property Taxes	627,000	351,000	144,000	65,000
Sales and Use Taxes	238,000	185,000	161,000	153,000
Severance Taxes	545,000	338,000	180,000	73,000
Total	**1,410,000**	**874,000**	**485,000**	**291,000**

Future tax revenues are dependent on uranium prices which cannot be forecast with any accuracy; however, these taxes are also somewhat dependent on the number of pounds of uranium produced by CBR. To the extent that uranium prices remain at current levels (spot market of around $80 per pound U_3O_8 in mid-March 2007), the increased production from the satellite plants should contribute to higher tax revenues as well.

The present taxes are based on a relatively consistent production rate of 800,000 pounds per year. The additional production from the satellite plants should be about 600,000 pounds per year. This additional production will eventually be offset by declining production from the original plant; however, the incremental contribution to taxes would be on the order of $1.0 million to $1.2 million per year in combined taxes.

7.6.2 Temporary and Permanent Jobs

7.6.2.1 Current Staffing Levels

CBR currently employs approximately 52 employees and 20 contractors on a full-time basis. Short-term contractors and part time employees are also used for specific projects and/or during the summer months and may add up to 10 percent to the total staffing. This level of employment is significant to the local economies. The private employment in Dawes County in 2006 was 2,189 out of a total labor force of 3,401[9]. Based on these statistics, CBR currently provides approximately 2.3 percent of the private employment in Dawes County. In 2006, CBR's total payroll was over $2,543,000. Of the total Dawes County wage and salary payments of $76,006,000 in 2006, the CBR payroll represented about 3.4 percent.

Total CBR payroll for the past four years was:

2003:	$2,102,000
2004:	$2,213,000
2005:	$2,382,000
2006:	$2,543,000

The average annual wage for all workers in Dawes County was $22,350 for 2006. By way of comparison, the average wage for CBR was about $51,000. Entry-level workers for CBR earn a minimum of $15.53 per hour or $32,300 per year, not including bonus or benefits.

7.6.2.2 Projected Short-Term and Long-Term Staffing Levels

CBR expects that construction of future satellite plant(s) will provide approximately ten to fifteen temporary construction jobs for a period of up to one year for each satellite. It is likely that the majority of these jobs will be filled by skilled construction labor brought into the area by a construction contractor, although some positions could be filled by local hires. Permanent CBR employees will perform all other facility construction (e.g., wells and wellfields).

CBR actively pursues a policy of hiring and training local residents to fill all possible positions. Due to the technical skills required for some positions, a small percentage of the current mine staff (less than five percent) have been hired elsewhere and relocated to the area. Because of the small number of people who have needed to move into the area to support this project, the impact on the community in terms of expanded services has been minimal. CBR expects that the types of positions required at the current facility and those that will be created by any future expansion will be filled with individuals from the local workforce and that there will be no significant impact on services and resources such as housing, schools, hospitals, recreational facilities, or other public facilities. In 2006, total unemployment in Dawes County was 137 individuals, or 2.9 percent of the total work force of 4,799. CBR expects that any new positions will be filled from this pool of available labor.

CBR projects that the current staffing level will increase by ten to twelve full-time CBR employees for each active satellite plant. These new employees will be needed for satellite plant and wellfield operator and maintenance positions. Contractor employees (i.e., drilling rigs) may also increase by four to seven employees depending on the desired production rate. The majority if not all of these new positions will be filled with local hires.

These additional positions should increase payroll by about $40,000 per month, or $400,000 to $480,000 per year.

7.6.3 Impact on the Local Economy

In addition to providing a significant number of well-paid jobs in the local communities of Crawford, Harrison, and Chadron, Nebraska, CBR actively supports the local economies through purchasing procedures that emphasize obtaining all possible supplies and services that are available in the local area.

Total CBR payments made to Nebraska businesses for the past four years were:

2003:	$3,602,000
2004:	$3,597,000
2005:	$4,570,000
2006 (est):	$5,000,000

The vast majority of these purchases were made in Crawford and Dawes County.

This level of business is expected to continue and should increase somewhat with the addition of expanded production from the satellite plant, although not in strict proportion to production. While there are some savings due to some fixed costs (central plant utilities for instance), there are additional expenses that are expected to be higher (wellfield development for the satellites is expected to be more expensive). Therefore, it can be estimated that the overall effect on local purchases will be proportional to the number of pounds produced. In addition, mineral royalty payments accrue to local landowners. This should translate to additional purchases of $3.65 to $4.35 million per year.

7.6.4 Economic Impact Summary

As discussed in this section, the Crow Butte Project currently provides a significant economic impact to the local Dawes County economy. Approval of this license amendment request would have a positive impact on the local economy as summarized in Table 7.6-1.

Table 7.6-1
Current Economic Impact of Crow Butte Uranium Project and Projected Impact from North Trend Expansion Area

	Current Crow Butte Operation	Estimated Economic Impact due to North Trend Expansion Area
Employment		
Full Time Employees	52	+ 10 to 12
Full Time Contractor employees	20	+ 4 to 7
Part Time Employees and Short Term Contractors	7	+ 10 to 15 (Satellite Construction)
CBR Payroll, 2006	$2,543,000	+ $400,000 to $480,000
Taxes		
Property Taxes	$627,000	-
Sales and Use Taxes	$238,000	-
Severance Taxes	$545,000	-
Total Taxes	$1,410,000	+ $1,000,000 to $1,200,000
Local Purchases		
Local Purchases, 2006 (est.)	$5,000,000	+ $3,650,000 to $4,350,000
Total Direct Economic Impacts		
	$8,953,000	**+ $5,050,000 to $6,030,000**

7.7 REFERENCES

[1] U.S. Nuclear Regulatory Commission, NUREG–0706, *Final Generic Environmental Impact Statement on Uranium Milling—Project M–25*, September 1980.

[2] Center for Nuclear Waste Regulatory Analyses, NUREG/CR–6733, *A Baseline Risk-Informed, Performance-Based Approach for In Situ Leach Uranium Extraction Licenses*, 2001.

[3] Compressed Gas Association, Inc., CGA-G-4.1, *Cleaning Equipment for Oxygen Service*, 1996.

[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 for Uranium Mills* (Revision 2, December 1977).

[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, NUREG/CR—6672, *Reexamination of Spent Fuel Shipment Risk Estimates*, SAND2000—0234, 2000.

[8] U.S. Nuclear Regulatory Commission, NUREG—1508, *Final Environmental Impact Statement to Construct and Operate the Crown Point Uranium Solution Mining Project, Crown Point, New Mexico*, 1997.

[9] US Department of Labor, Bureau of Labor Statistics, as of March 5, 2007.