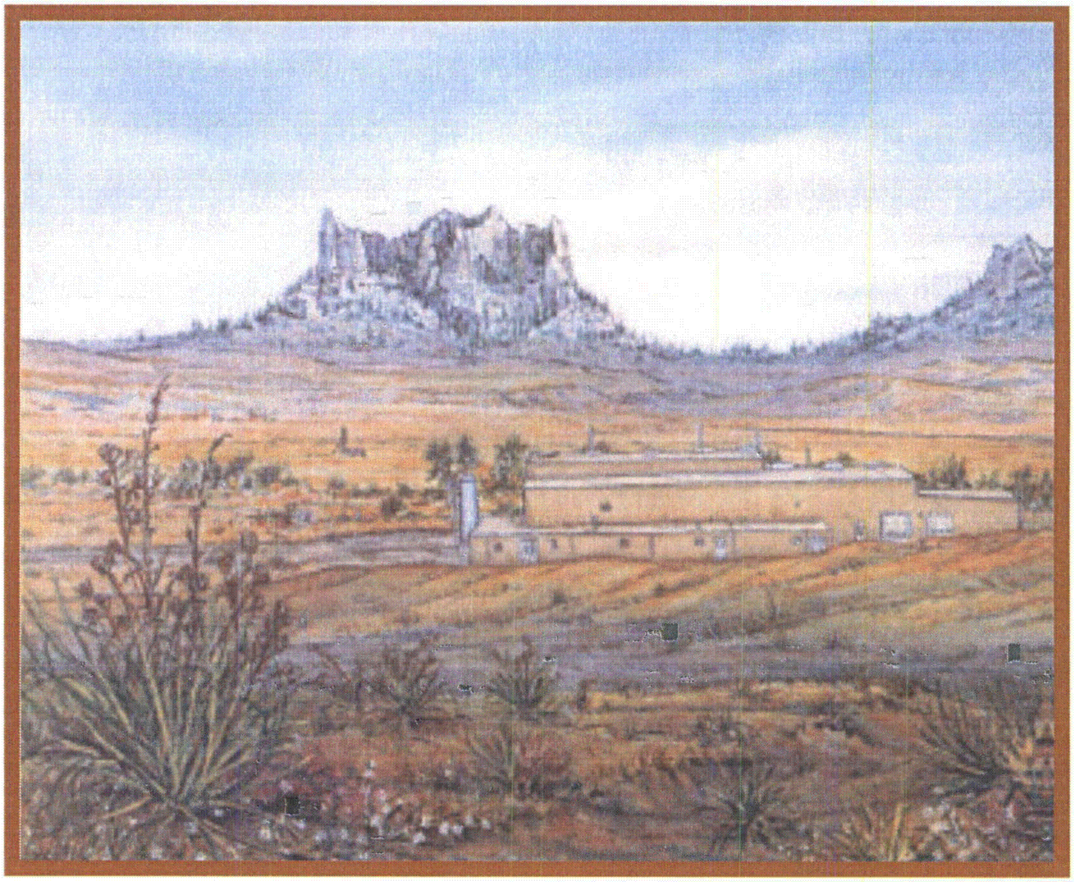
Updates to Application for Amendment of USNRC Source Materials License SUA-1534 Marsland Expansion Area Crawford, Nebraska

Volume I

Environmental Report



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Acronyms and Abbreviations

µCi/kg	microCuries per kilogram
µg/m³	micrograms per cubic meter
µmhos/cm	micromhos per centimeter
ACL	Alternate Concentration Limit
AEA	Atomic Energy Act
AERMOD	AMS/EPA Regulatory Model
ALARA	as low as reasonably achievable
AMS	American Meteorological Society
amsl	above mean sea level
AOR	Area of Review
API	American Petroleum Institute
ASOS	Automated Surface Observation Station
ASTM	ASTM International
ATV	all-terrain vehicle
AWWARF	American Water Works Association Research Foundation
BBS	breeding bird survey
bgs	below ground surface
BLM	Bureau of Land Management
BMP	best management practice
BNSF	Burlington Northern Santa Fe
BPT	best practicable technology
$CaCO^3$	calcium carbonate
CAD/GIS	computer aided drafting/geographic information system
CBR	Crow Butte Resources, Inc.
CESQG	conditionally exempt small-quantity generator
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm/sec	centimeters per second
cm^2	square centimeters
CO	carbon monoxide
CO_2	carbon dioxide
COOP	Cooperative Observer Program
CPF	central processing facility
CPM	counts per minute
DAC	derived air concentration
dBA	A-weighted decibel
DDW	deep disposal well
DEM	Digital Elevation Model
DFIRM	Digital Flood Insurance Rate Map
DLG	Digital Line Graph
DOT	U.S. Department of Transportation
dpm	disintegrations per minute
DPS	Distinct Population Segment
DQO	data quality objective
DUSA	Dension Mines (USA)

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Deleted: microCuries
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EA	Environmental Assessment	
Eh	oxidation-reduction potential	
ELI	Energy Laboratories, Inc.	
EPA	U.S. Environmental Protection Agency	
ER	Environmental Report	
ESA	Ecological Study Area	
ESRI	Earth Sciences and Research Institute	
ET	evapotranspiration	
FEMA	Federal Emergency Management Agency	
FESA	Federal Endangered Species Act	
ft/day	feet per day	
ft^2/day	square feet per day	
GAM(NAT)	natural gamma	
GEIS	Generic Environmental Impact Statement	
GM	Geiger-Mueller	
GNIS	Geographical Names Information System	
gpd	gallons per day	
gpm	gallons per minute	
GPS	global positioning system	
GR	gamma ray	
H_2O_2	hydrogen peroxide	
H_2S	hydrogen sulfide	
HDPE	high-density polyethylene	
HMR	Hazardous Materials Regulations	
HSMS	Health and Safety Management System	
HUC	hydrologic unit code	
HUC12	12-digit hydrologic unit code	Deleted: -
ICRP	International Commission on Radiological Protection	
ISL	in-situ leach	
ISR	in-situ recovery	
IX	ion exchange	
JFD	Joint Frequency Distribution	
km^2	square kilometers	
LAN	local area network	
lbs	pounds	
LLD	lower limit of detection	
LSA	Low Specific Activity	
LULC	land use and land cover data	
Ma	million years	
MBTA	Migratory Bird Treaty Act	
MCL	Maximum Contaminant Level	
md	millidarcies	
MDC	Minimum Detectable Concentration	
MEA	Marsland Expansion Area	
meq	milliequivalents	
meq/L	milliequivalents per liter	Deleted: ¶
mg/cm^2	milligrams per square centimeter	

mg/L	milligrams per liter
Mgal/da	million gallons per day
mi^2	square miles
MM	Modified Mercalli
mph	miles per hour
mR/hr	milli-Roentgens per hour
mRem/yr	millirems per year
MU	mine unit
Na_2S	sodium sulfide
NAAQS	National Ambient Air Quality Standards
$NaCO_3$	sodium carbonate
NAD 1927	North American Datum of 1927
$NaHCO_3$	sodium bicarbonate
NAIP	National Agriculture Imagery Program
NaOH	sodium hydroxide
NCDC	National Climate Data Center
NDA	Nebraska Department of Agriculture
NDED	Nebraska Department of Economic Development
NDEQ	Nebraska Department of Environmental Quality
NDHHS	Nebraska Department of Health and Human Services
NDNR	Nebraska Department of Natural Resources
NED	National Elevation Dataset
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NGPC	Nebraska Game and Parks Commission
NGS	National Geodetic Survey
NGWA	National Groundwater Association
NHD	National Hydrology Dataset
NHPA	National Historic Preservation Act
NLCD	National Land Cover Data
NMSS	Nuclear Material Safety and Safeguards
N-N	neutron-neutron
NNHP	Nebraska Natural Heritage Program
NNLP	Nebraska Natural Legacy Project
NOAA	National Oceanic and Atmospheric Administration
NOGCC	Nebraska Oil and Gas Conservation Commission
NOI	Notice of Intent
NOx	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NRC	U.S. Nuclear Regulatory Commission
NRCS	Natural Resource Conservation Service
NREL	National Renewable Energy Laboratory
NRHP	National Register of Historic Places
NSHS	Nebraska State Historical Society
NTEA	North Trend Expansion Area
NTU	nephelometric turbidity units
NVLAP	National Voluntary Laboratory Accreditation Program

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NWI	National Wetlands Inventory
NWS	National Weather Service
O_2	gaseous oxygen
OHSAS	Occupational Health and Safety Management System
OSHA	Occupational Safety and Health Administration
OSLD	optically stimulated luminescence dosimeter
PFYC	Potential Fossil Yield Classification
$PM_{2.5}$	particulate matter with a diameter less than 2.5 microns
PM_{10}	particulate matter with a diameter less than 10 microns
pCi/L	picoCuries per liter
PPE	personal protective equipment
ppm	parts per million
PPMP	preoperational/preconstruction monitoring program
PSD	prevention of significant deterioration
psi	pounds per square inch
PVC	polyvinyl chloride
QA	quality assurance
QAM	Quality Assurance Manual
QC	quality control
RCRA	Resource Conservation and Recovery Act
RES	Single Point Resistance
RFFA	reasonably foreseeable future actions
RG	Regulatory Guide
RL	reporting limit
RMP	Risk Management Program
RO	reverse osmosis
ROI	radius of influence
RSA	Resource Study Area
RSO	Radiation Safety Officer
RUSLE	Revised Universal Soil Loss Equation
S.U.	standard units
SCDA	Sequential Control and Data Acquisition
SCS	Soil Conservation Service
SDR-17	Standard Dimension Ratio 17
SEIS	Supplemental Environmental Impact Statement
SER	Safety Evaluation Report
SERP	Safety and Environmental Review Panel
SH	State Highway
SHEQMS	Safety, Health, and Environment Quality Management System
SHPO	State Historic Preservation Office
SO_2	sulfur dioxide
SOP	standard operating procedure
SP	spontaneous potential
SPCC	Spill Prevention, Control, and Countermeasure
SS	stainless steel
SSURGO	Soil Survey Geographic Database
SSPT	statistic spontaneous potential

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SWMA	State Wildlife Management Area
SWPPP	Storm Water Pollution Prevention Plan
TCEA	Three Crow Expansion Area
TDS	total dissolved solids
TEDE	total effective dose equivalent
TLD	thermoluminescent dosimeter
TMDL	total maximum daily load
TSP	total suspended particulates
TSS	total suspended solids
UCL	upper control limit
UDC	uranyl dicarbonate
UIC	underground injection control
UMTRCA	Uranium Mill Tailings Radiation Control Act
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USDA	U.S. Department of Agriculture
USDW	underground source of drinking water
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USLE	Universal Soil Loss Equation
UTC	uranyl tricarbonate
VCD	voltage current direct
VOC	volatile organic compound
VRM	visual resource management
VTPD	vehicle trips per day
WFC	Wyoming Fuel Company
WRCC	Western Regional Climate Center
XRD	x-ray diffraction
yd^3	cubic yards
ZOEI	Zone of Endangering Influence

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1 INTRODUCTION OF THE ENVIRONMENTAL REPORT

1.1 Introduction

Crow Butte Resources, Inc. (CBR) submits this Environmental Report (ER) in support of a license amendment application to the United States Nuclear Regulatory Commission (NRC) for amendment of Radioactive Source Materials License SUA-1534. The amendment request concerns the proposed development of additional uranium in-situ recovery (ISR) mining resources located in Dawes County and Sioux County, Nebraska. The area proposed for use as a satellite facility to the main CBR Central Processing Facility (CPF) is referred to as the Marsland Expansion Area (MEA).

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By letter dated November 27, 2007, CBR applied for a renewal of Source Materials License No. SUA-1534 for the CPF. This renewal will allow for the continued operation of the current CPF. The NRC issued a draft license by letter dated May 23, 2011. Following comments by CBR, the NRC issued a second draft of the CBR renewal license on August 11, 2011. As part of the licensing process, the NRC issued a Safety Evaluation Report (SER) for the license renewal dated December 2012 (NRC 2012). The SER documents the safety portion of the NRC staff's review of the license renewal application, as amended, and includes an analysis to determine CBR's compliance with these and other applicable 10 Code of Federal Regulations (CFR) Part 40 requirements, and applicable requirements set forth in 10 CFR Part 40, Appendix A (NRC 2012). The SER also evaluates CBR's compliance with applicable requirements in 10 CFR Part 20, "Standards for Protection against Radiation." An Environmental Assessment (EA) is also being prepared in parallel with the SER to address environmental impacts of the proposed action, which complies with the NRC's implementation regulations for the National Environmental Policy Act (NEPA; NRC 2012). While negotiations continue, the current license remains in effect.

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This ER provides the supplemental information necessary to determine the environmental impacts of amending License No. SUA-1534 to allow uranium recovery in the MEA. The amendment application is submitted in accordance with the licensing requirements contained in 10 CFR Part 40 and provides the NRC staff with the necessary information to support the preparation of a Supplemental Environmental Impact Statement (SEIS) as required in 10 CFR Part 51.

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The proposed MEA is located within the southern portion of Dawes County, which is within the Nebraska-South Dakota-Wyoming Uranium Milling Region identified in the NRC Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities (GEIS). The GEIS provides the NRC with a starting point for new ISR facilities, as well as for applications to amend or renew existing ISR licenses. The NRC will use the site-specific information provided in the CBR ER to determine whether the proposed activities and site characteristics are consistent with those evaluated in the GEIS. The NRC will then determine relevant sections, findings, and conclusions in the GEIS that can be incorporated by reference into an SEIS. When such conditions are met, the NRC will prepare an SEIS for the CBR amendment, fulfilling agency responsibilities under the NEPA.

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This ER has been prepared using suggested guidelines and a standard format from NRC. The ER is presented primarily in the format provided in RG-1748, Environmental Review Guidance for Licensing Actions Associated with Nuclear Material Safety and Safeguards (NMSS) Programs

(August 2003). The pertinent guidance in RG-1748 was used to ensure that complete information is provided to NRC for review. In addition, NRC document RG-1569, Standard Review Plan for In Situ Leach Uranium Extraction License Applications (June 2003) was consulted to ensure that all necessary information is provided that will allow NRC Staff to complete their review of this amendment application.

1.1.1 Crow Butte Uranium Project Background

The original CBR was developed by Wyoming Fuel Company (WFC), which constructed an R&D Facility in 1986. The project was subsequently acquired (Ferret 1987) and operated by Ferret Exploration Company of Nebraska until May 1994, when the name was changed to CBR. This change was only a name change and not an ownership change. CBR is the owner and operator of the CPF.

The land (fee and leases) at the CPF is owned by Crow Butte Land Company, which is a Nebraska corporation. All of the officers and directors of Crow Butte Land Company are U.S. citizens. Crow Butte Land Company is owned by CBR, which is the licensed operator of the facility. CBR, which does business as Cameco Resources, is also a Nebraska corporation. All of its officers are U.S. citizens, as are two thirds of its directors. CBR is owned by Cameco US Holdings, Inc., which is a U.S. corporation registered in Nevada. For Cameco US Holdings, three quarters of the officers are U.S. citizens, as are two thirds of the directors. Cameco US Holdings is held by Cameco Corporation, a Canadian corporation publicly traded on both the Toronto and New York Stock Exchanges.

The R&D Facility was located in N ½ SE ¼ of section 19, Township (T) 31 North (N), Range (R) 51 West (W). Operations at this facility were initiated in July 1986, and mining took place in two wellfields (WF-1 and WF-2). Mining in WF-2 was completed in 1987, and restoration of that wellfield has been completed. WF-1 was incorporated into Mine Unit (MU) 1 of the current operations.

The CPF is located in Section 19, T31N, R51W, Dawes County, Nebraska (**Figure 1.1-1**). The current license area occupies approximately 2,861 acres, and the surface area affected over the estimated life of the project is approximately 2,000 acres.

CBR has successfully operated the current processing area since commercial operations began in 1991. Production of uranium has been maintained at design quantities throughout that period with no adverse environmental impacts. Groundwater restoration for MU 1 has been completed and approved by the NRC and Nebraska Department of Environmental Quality (NDEQ), with NRC issuing the final approval on February 12, 2003. The operating history and timelines for the current production area are discussed in more detail in Section 1.1.3.

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1.1.2 Site Location and Description

The proposed MEA project site is located within sections 26, 35, 36 of T30N, R51W; sections 1, 2, 11, 2, 13 of T29N R51W and sections 7, 18, 19, 20, 29, 30 of T29N, R50W (**Figure 1.1-2**). The project area occupies 4,622.3 acres. The Marsland satellite facility is located approximately 11 miles (17.7 km) south-southeast of the CPF and approximately 4.5 miles (7.2 km) northeast of the community of Marsland. **Figure 1.1-3** shows the locations of the current license area and the proposed MEA.

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All mineral resources leased within the MEA are privately owned, with the exception of the SW ¼ section of section 36 of T30N, R51W. This quarter section is designed as State Trust Land and is a small part of the nearly 1,300,000 acres of land now held in trust for Nebraska's K-12 public schools (NBELF 2013). The surface and mineral rights are under lease between Cameco and the State of Nebraska. There are no federal surfaces or minerals in the MEA license boundary. **Figure 1.1-4** shows land ownership in the proposed MEA.

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1.1.3 Operating Plans, Design Throughput, and Processing

The CPF is licensed for a flowrate of 9,000 gallons per minute (gpm), excluding restoration flow, under License No. SUA-1534. Total annual production is limited to 2,000,000 pounds of yellowcake, per license condition 10.2 of License SUA-1534.

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Uranium extracted from the Marsland wellfield will be processed at a satellite facility located within the MEA. The MEA will operate at an overall average production flowrate of 6,000 gpm (excluding 1,500 gpm for restoration). The anticipated bleed rate is assumed to be 0.5 to 2.0 percent of the total mining flow. The MEA will operate with an expected annual production rate of approximately 600,000 pounds (lbs) of U_3O_8. Indicated ore reserves as U_3O_8 for the MEA are 6,161,679 lbs, with an additional inferred estimate of 3,389,518 lbs. Total reserves for the MEA are currently estimated at 9,551,197 lbs. The uranium extracted from the MEA will be loaded onto ion exchange (IX) resin in the MEA satellite facility, which will then be transported by tanker truck to the main plant for elution, precipitation, drying, and packaging. Barren resin will be returned to the MEA satellite facility by tanker truck. The MEA operations are discussed in more detail in Section 1.3.2

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The proposed MEA occupies approximately 4,622.3 acres. Over the life of the project, an estimated 1,753 acres may be impacted.

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Proposed Operating Timelines

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1.1.3.1 Current Production Area

Sufficient reserves in the current license area have been estimated to allow mining operations to continue until the end of 2014. Completion of groundwater restoration in the current license area is scheduled for 2032, with site remediation to be completed by 2042. Projected production and restoration timelines for the CPF are shown on **Figure 1.1-5**. The current status of the 11 MUs are shown in **Table 1.1-1**. In 2010, the total annual production rate for the CPF was 751,632 lbs of U_3O_8, and in 2009 it was 734,047 lbs of U_3O_8. Additional MU plans are developed approximately 1 year prior to the planned commencement of new mining operations. For the current production area, production is ongoing in MUs 7, 8, 9, 10, and 11. MU 1 has been restored, and restoration is occurring in MUs 2, 3, 4, 5, and 6. The layout of the current and planned MUs in the current CPF license area is shown on **Figure 1.1-1**.

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Additional MU plans are developed approximately 1 year prior to the planned commencement of new mining operations.

1.1.3.2 Marsland Expansion Area

The proposed MEA project site map and timeline are shown on **Figures 1.1-2** and **1.1-6**, respectively. There is a potential for 11 MUs, with construction for MU 1 to commence in 2014.

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Production for the project (all MUs) will start in 2015 and terminate in 2033. Restoration in designated MUs will commence in the year 2020 and will be completed in 2039. Site reclamation will be completed in 2040.

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The MEA will be subdivided into an appropriate number of MUs (**Figure 1.1-7**). Each MU will contain 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 MEA satellite facility to the wellhouses will be either polyvinyl chloride (PVC) or high-density polyethylene (HDPE) with butt-welded joints or equivalent. Pressure switches will be installed to each injection manifold in the wellhouse to alert the plant and wellfield operators of increasing manifold pressures. Pressure gauges, pressure shutdown switches, and pressure transducers will be used to monitor and control trunkline pressures. Oxidizer will be added to the injection stream, and all injection lines off of the injection manifold will be equipped with totalizing flowmeters, which will be monitored in the satellite Control Room. The MEA wellfields will be designed consistent with the existing CPF wellfields. More detailed information about the site operations is discussed in Section 1.3.2.

1.1.3.3 Three Crow Expansion Area Timeline

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On July 12, 2010, CBR submitted a Class III underground injection control (UIC) Application and Aquifer Exemption Petition to the NDEQ for the proposed Three Crow Expansion Area (TCEA), which will be used as a satellite facility supporting the CPF. On Aug. 3, 2010, CBR submitted a request to the NRC for an amendment to Source Materials License SUA-1534 for the development of the TCEA (Young 2010; ML102230170). By email dated April 14, 2011 (Leftwich 2011; ML11160020), Cameco requested that the NRC suspend review of the TCEA application so that the option of a pipeline to carry mine fluids directly to the main plant could be evaluated. By letter dated October 11, 2012 (Leftwich 2012; ML12299A211), Cameco advised the NRC that the pipeline option would not be pursued. CBR requested that NRC restart the application process for TCEA, with the project to be operated as a satellite facility to the main CBR operation located near Crawford, Nebraska. The major change in the originally proposed TCEA satellite facility is that surge/evaporation ponds are deemed to no longer be required to support project and associated deep disposal well (DDW) operations. TCEA construction is planned for completion in 2016, with production from 2016 to 2041, restoration from 2023 to 2045, and completion of final site reclamation in 2047.

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1.1.3.4 North Trend Expansion Area Timeline

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The proposed North Trend Expansion Area (NTEA) will consist of a support satellite facility for the CPF. CBR has received approval from the NDEQ for a Class III UIC permit (NDEQ 2011a) and an aquifer exemption (NDEQ 2011b) that will allow for construction and operation of the satellite facility for ISR mining of the proposed NTEA. A radioactive source material license amendment (CBR 2007) for the NTEA is pending before the NRC for the proposed NTEA. Current plans are for this project to be constructed in 2023, with production from 2024 to 2032, and groundwater restoration activities ongoing from 2029 through 2039. Final site reclamation would be completed in 2041.

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The locations of the CPF, TCEA, and NTEA are shown on **Figure 1.1-3**.

1.2 Purpose and Need for the Proposed Action

NRC Source Materials License SUA-1534 authorizes CBR to conduct mining operations in the current license area. Based on current plans, mining timelines, and reserve estimates, CBR could continue production at the present annual levels of approximately 700,000 pounds of U_3O_8 until the end of 2014, when reserves would begin to significantly deplete. CBR estimates that by 2014, production in the current license area would decrease to the point where commercial operations would no longer be economical and would be discontinued. Groundwater restoration, surface reclamation, and decommissioning would become the primary activities.

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CBR has developed commercially viable uranium resources in the area near the current license area. Development and recovery of these resources using satellite facilities will allow CBR to extend the operation of the existing CPF in the current license area. The use of satellite facilities in these areas will minimize the cost and environmental impact from construction activities.

The timely approval of uranium recovery activities in the MEA and NTEA will allow CBR to maintain uranium production at currently licensed quantities and provide a smooth transition of mining activities from the CPF license area to the satellite facility. CBR has developed a talented, qualified workforce mostly of local residents. If the MEA and NTEA are not developed, CBR estimates that some of these personnel (e.g., well drilling, well and wellfield construction) will no longer be required and workforce reduction will begin as early as 2013.

Failure to develop these additional resources would leave a large resource unavailable for energy production supplies. Although CBR is continuing to develop estimates of the reserves at MEA, the current indicated ore reserves as U_3O_8 for the MEA are 6,161,679 lbs, with an additional inferred estimate of 3,389,518 lbs. Total reserves for the MEA are currently estimated at 9,551,197 lbs. The MEA will operate with an expected annual production rate of approximately 600,000 lbs U_3O_8.

In 2012, total domestic U.S. uranium concentrate production was approximately 4,100,000 lbs of U_3O_8, of which more than 800,000 lbs (or approximately 20 percent) was produced at the CPF (EIA 2013a). During the same year, U.S. civilian nuclear power reactors purchased 58,000,000 lbs U_3O_8e (equivalent) from U.S. and foreign suppliers, with approximately 17 percent supplied by domestic producers (EIA 2013b). Foreign-origin uranium accounted for the remaining 83 percent of deliveries. The CPF (including the MEA, TCEA, and NTEA) represents an important source of new domestic uranium supplies essential to providing a continuing source of fuel to power generation facilities.

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In addition to leaving a large deposit of valuable mineral resources untapped, a denial of this amendment request would result in the loss of a large investment in time and money made by CBR for the rights to and development of these valuable deposits.

Denial of the amendment request would have an adverse economic effect on the individuals that have surface leases with CBR and own the mineral rights in the MEA.

1.3 The Proposed Action

1.3.1 Site Location and Layout

The location of the current license area of the CPF is in sections 11, 12, 13, 24 of T31N, R52W and sections 18, 19, 20, 29, 30 of T31 N, R51W, Dawes County, Nebraska. The proposed MEA is located in sections 26, 35, 36 of T30N, R51W; sections 1, 2, 11, 12, 13 of T29N, R51W; and sections 7, 18, 19, 20, 29, 30 of T29N, R50W. The maps used in this and other sections of this amendment application are Vector 7.5-minute quad maps. These are computer-aided drafting/geographic information system (CAD/GIS) drawings where each road, stream, and contour line is an individual entity. The layers in these maps were derived from the U.S. Census Bureau's TIGER/Line data, U.S. Geological Survey (USGS) Digital Line Graph (DLG) Data, USGS Digital Elevation Model (DEM) data, Bureau of Land Management (BLM) Section Line data, National Geodetic Survey (NGS) Benchmark data, and USGS Geographical Names Information System (GNIS) data. This base map was then used for each of the figures prepared for this document with the addition of the pertinent information for that figure.

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The longitudes and latitudes for the site boundary vertices and satellite facility are summarized in **Table 1.3-1**. The datum on topographic maps presented in the application is North American Datum of 1927 (NAD 1927), and the geographic coordinate reference system (map projection) is:

NAD_1927_StatePlane_Nebraska_North_FIPS_2601 (US_Foot).

Figure 1.1-2 shows the general area surrounding the MEA project area, including the proposed MEA, Area of Review (AOR), and Zone of Endangering Influence (ZOEI).

Figure 1.1-1 shows the general project site layout and Restricted Areas for the current license area including the CPF building area, the Reverse Osmosis (RO) facility, the current MU boundaries, the DDW, and the R&D and commercial evaporation ponds.

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Figure 1.1-7 shows the proposed locations of the satellite facility, MUs, access roads, fencing (license boundary perimeter), and Restricted Areas within the MEA. The latitude and longitude for the center of the satellite facility are provided in **Table 1.3-1**.

Figure 1.1-3 shows the project location in relation to the CPF and the proposed MEA. This figure shows topographical features, drainage and surface water features, nearby population centers, and political boundaries as well as principal highways, railroads, transmission lines, and waterways.

1.3.2 Description of Proposed Facility

Production of uranium by ISR 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 IX, and then from the IX resin by elution. The leach solution can then be reused for mining. The elution liquid containing the uranium (the "pregnant" eluent) is then processed by precipitation, dewatering, and drying to produce a transportable form of uranium called yellowcake.

The MEA is being developed by CBR in conjunction with the CPF licensed under NRC Source Material License SUA-1534. The MEA will be developed by constructing independent wellfields and mining support facilities while employing existing processing equipment for uranium recovery. Transfer of recovered leach solutions from the area is prohibitive because of the distance over which a relatively large stream would have to be pumped. Therefore, a satellite facility will be constructed in the MEA to provide chemical makeup of leach solutions, recovery of uranium by IX, and restoration capabilities. The IX processes at the satellite facility recover the uranium from the leach solution in a form (loaded IX resin) that is relatively safe and simple to transport by tanker truck to the CPF, which will serve as the CPF for elution and further processing of recovered uranium. Regenerated resin is then transported back to the satellite facility for reuse in the IX circuit.

1.3.2.1 Solution Mining Process and Equipment

Ore body

In the CPF license area, uranium is recovered by ISR from the basal sandstone of the Chadron Formation at a depth that varies from 400 feet to 900 feet. The overall ore body width of the mineralized area varies from 1,000 feet to 5,000 feet. The ore body ranges in grade from less than 0.05 to more than 0.5 percent U_3O_8, with an average grade estimated at 0.27 percent U_3O_8 The layout of the ore body as determined to date is shown in **Figure 1.3-1**.

In the MEA, uranium will also be recovered via ISR from the basal sandstone of the Chadron Formation. The depth of the ore body in the MEA ranges from 800 to 1,250 feet below ground surface (bgs), and the width varies from approximately 1,000 feet to 4,000 feet. The ore body ranges in grade from 0.11 percent to 0.33 percent U_3O_8, with an average grade estimated at 0.22 percent U_3O_8. The ore-grade uranium deposits underlying the MEA are depicted on **Figure 1.3-1**.

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Typical stratigraphic intervals to be mined by the ISR mining method are shown in the geologic cross-sections contained in Section 3.3. For ISR wellfields, the production zone is the geological sandstone unit where the leaching solutions are injected and recovered (i.e., basal sandstone of the Chadron Formation).

1.3.2.2 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.

Well Materials of Construction

The well casing material will be PVC. PVC well casing is 4.5- or 5-inch Standard Dimension Ratio-17 (SDR-17). However, should a larger pump size be required, larger-diameter casing may be employed. The PVC casing joints are 20 feet long. The bottom joint can be made either 10 or 20 feet long, depending on the casing depth. With SDR-17 PVC casing, each joint has a watertight O-ring seal and is held together with a high-strength nylon spline.

There are two types of well screen that will be used for development of the MEA: 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 more durable than PVC screens, are rated for greater depths than PVC screens, are easier to install, 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 necessary at the satellite facility based on site conditions and purpose of the borehole. For example, PVC well screens are currently used in both shallow observation monitor wells and commercial production monitor wells. This practice will continue to be an option for the MEA. PVC screens are used for these types of wells primarily because they typically have much longer screen intervals than other types of wells. This results in employee safety issues due to the handling of the heavy SS screens. In addition, flowrate using PVC screens is less of a concern for these types of wells.

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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 inch have been used successfully at CBR. In most cases, a slot size of 0.020 inch is sufficient to prevent sand from entering the screens.

The SS well screen consists of longitudinal ribs of SS with an 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 inch have been used historically at CBR.

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Well Construction Methods

Pilot holes for monitor, production, and injection wells will be drilled through 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 will be logged, reamed, casing set, and cemented to isolate the completion interval from all other aquifers. Three well construction methods are described. Any of these methods is appropriate for monitor wells and have been approved by the NDEQ under the current Crow Butte Class III UIC Permit and recently issued Class III UIC Permit for the NTEA satellite facility. All wells will be constructed in accordance with the provisions of this section.

Of the three methods, CBR routinely uses Method 1, shown on **Figure 1.3-2**. Method 2, shown on **Figure 1.3-3**, may be used by the CBR geologic staff when there is a need to study the geology of an area and to determine the best placement of the screens without having to attach screens to the casing string. Method 3, shown on **Figure 1.3-4**, is not routinely used, but 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 constructing monitor wells and have been approved by the NDEQ under the UIC Permit.

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- 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 select a casing depth, and will then begin to review the local area wells for the best location (depth) to install the screened interval. The well is cased through the mining zone and cemented in place. Cement flows down the inside of the casing, exits out the bottom, and flows back up the annulus to the surface. Cement may be pushed out of the bottom of the casing by using a rubber cement plug pushed to the bottom, or may be displaced using fresh water. If the cement is displaced with water, a rig will need to drill

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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 to 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 the drill 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 develop the well.

Method 1 is the primary method used for all injection and production wells. A slight variation of this method is used for monitor wells. Monitor wells are cased to the top of the mining zone and cemented using water displacement. After allowing the cement to set up (harden), the excess cement is drilled out of the casing and the well is logged to determine where to place the well screens.

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Method 1 is similar to Method 2, except that a 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 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 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 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.

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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 cement plug and weep holes are used to place the cement.

- Method No. 3

This method involves setting 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 plugging 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 weepholes 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 sufficiently cured, the residual cement and plug are drilled out and the well is developed by airlifting or pumping.

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For all three well completion methods, casing centralizers, located at a maximum spacing of 100 feet, are run on the casing to ensure that 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 that cement returns to the surface. In almost all cement jobs, returns to the surface are observed. In rare cases, 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 placing 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.

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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 CBR geology staff. The location and amount of drill screen to be set in a well is based upon the geologic and economic factors. 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 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 geology staff based on the location of sands and ore grade material. The zones to be mined are correlated and selected by reviewing geophysical logs, which also confirms that the screened intervals between wells are hydrologically connected. 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 production zone is calculated. The number of screens to be placed in the well must cover the production zone, and the screen-to-blank ratio must exceed 50 percent. Care should be taken to ensure that those zones impacted by nearby wells are covered by screens, and not left blank. A well completion report is documented for each well and submitted to the NDEQ. These data are kept available on site for review. All wells are constructed by a licensed/certified water well contractor, as defined by the Nebraska Health and Human Services System, Water Well Standards and Licensing Act, Article 46.

1.3.2.3 Cement/Grout Specifications

All cement will be ASTM International (ASTM) Type I, II or American Petroleum Institute (API) Class B or G and will meet the following criteria:

- The cement will have a density of no less than 11.5 lbs/gal.
- A bentonite grout shall be mixed as close as possible to a concentration of 1.5 lb. bentonite per gallon of water (1 quart polymer per 100 gallons of water may be premixed to prevent the clays from hydrating prematurely) and shall have a density of 9.2 lbs./gal or higher.

1.3.2.4 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. Deleted: ,

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

1. Loading of uranium complexes onto an IX resin Deleted: ;
2. Reconstitution of the leach solution by addition of carbon dioxide (CO_2) and/or sodium bicarbonate ($NaHCO_3$) and an oxidizer Deleted: ;
3. Elution of uranium complexes from the resin Deleted: ; and
4. Precipitation of uranium Deleted: .

The first two steps will be performed at the satellite facility. Steps 3 and 4 will be performed at the CPF. The process flow sheet for the above steps is shown on **Figure 1.3-5**. The left side of **Figure 1.3-5** depicts the uranium extraction process completed at the satellite facility. The right side of the figure shows the uranium recovery steps that will be performed at the CPF. Once the IX resin at the satellite facility is loaded to capacity with uranium complexes, the resin will be transferred to the CPF for uranium recovery.

Uranium Extraction

The recovery of uranium from the leach solution in the satellite facility will take place in the IX columns. The uranium-bearing leach solution enters the pressurized downflow IX 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:

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

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

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 are shown in **Table 1.3-2.**

Resin Transport and Elution

Once the majority of the IX 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 transported by tanker truck to the CPF for elution and final processing. Once the resin has been stripped of the uranium by elution, it will be returned to the satellite facility for reuse in the IX circuit.

At the CPF, the loaded resin 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, the resin is rinsed with a solution containing $NaHCO_3$. This rinse removes the high chloride eluent 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.

Precipitation

When a sufficient volume of pregnant eluent 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 CO_2. The decarbonization can be represented as follows:

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

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

H_2O_2 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.

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 MEA wastewater system. The management of these wastewaters is discussed in Section 3.12.2.1.

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The operation of the satellite facility will produce a production bleed stream continuously withdrawn from the recovered lixiviant stream at a rate that is expected to be 0.5 to 2.0 percent of the total volume of recovered lixiviant. The production bleed stream is taken following the recovery of uranium by IX and has the same chemical characteristics as the lixiviant. The production bleed waste stream will be managed by a DDW well injection, which will be constructed at the satellite facility.

The other source of wastewater resulting from uranium mining activities in the MEA is the eluent bleed stream at the CPF. This is an existing source of wastewater at the CPF currently produced at a rate of approximately 5 to 10 gpm. It is likely that the eluent bleed stream will increase by a maximum of 10 percent due to processing of IX resin from the satellite facility. The eluent bleed waste stream will be managed by reuse in the processing facility or disposal by DDW injection at the CPF.

All byproduct material produced as a result of the operation of the satellite facility 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 onsite disposal of these materials.

Based on the proposed project development schedule and the water balance of the MEA project, liquid waste disposal methods will be phased for the MEA operations. Initially, two DDWs will be used as the primary disposal option, and as flows increase over the years due the addition of new MUs and restoration activities, additional disposal options will be added. Liquid waste disposal operations and alternatives are discussed in more detail in Sections 2.3.1.3 (waste management), 3.12.2.1 (liquid waste disposal options), and 3.12.2.2 (project water balance).

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1.3.2.5 Logging Procedures and Other Tests

Appropriate geophysical logs and other tests are conducted during the drilling and construction of new Class III wells. These are determined based on the intended function, depth, construction, and other characteristics of the well; availability of similar data in the area of the drilling site; and the need for additional information that may arise from time to time as the construction of the well progresses.

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Logging Equipment

CBR currently owns three operational logging units. All were built by Century Geophysical Corporation in Tulsa, Oklahoma. These units are capable of logging drill holes to a depth of approximately 2,000 feet.

These trucks are capable of using a wide variety of tools. All of these tools (or probes, as used by CBR) measure Single Point Resistance (RES), static spontaneous potential (SSP), Natural

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Gamma (GAM[NAT]), and Deviation. Some of the probes used by CBR are also capable of measuring temperature, 16-inch normal resistance, and 64-inch normal resistance (**Table 1.3-3**). Deviation with these units is measured using a slant angle and azimuth technique. Standardized procedures are used by trained personnel to carry out the logging tasks.

Groundwater Measurements

Groundwater sampling and water level measurements are two tests typically conducted for new wells. Results of the groundwater sampling and analysis are used to evaluate water quality baseline values for future restoration to groundwater standards, and water level measurements provide for a more detailed understanding of the hydraulic gradient within the MEA. Groundwater monitoring for new wells is discussed below.

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, formation, and borehole walls along the screened interval. The primary goal for well development is to allow formation water to enter the well screen.

Initially, well development is performed by airlifting and cleanup with a drill rig. 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 continues until clear, sediment-free formation water is produced.

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When the water begins to clear, the development flow will be temporarily stopped and/or the flowrate will be varied. Sampling and examination for turbidity will continue. When varying the development rate no longer causes the sample to become turbid, the initial development will be deemed complete.

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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. pH and conductivity are monitored 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.

Following well installation, 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 for injection into the DDW (see additional discussions in Section 3.12.2.1). Alternatively, these fluids may be transported to the CPF evaporation ponds, but only if there are fluid separation equipment issues at the MEA satellite facility. Additional wellfield and process waste are discussed below.

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Well Integrity Testing

All wells (i.e., injection, production, and monitor) are field tested under pressure-packer tests to demonstrate the mechanical integrity of the well casing. Every well will be tested after well construction before it can be placed into service; after any workover with a drill rig or servicing with equipment or procedures that could damage the well casing; at least once every 5 years; and whenever there is any question of casing integrity. To ensure the accuracy of the integrity tests, periodic comparisons are made between the field pressure gauges and a calibrated test gauge. The mechanical integrity test procedure has been approved by the NDEQ and is currently contained in the Safety, Health, Environment and Quality Management System (SHEQMS) Volume III, Operating Manual. These same procedures will be used at the MEA.

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The following general mechanical integrity test procedure is employed:

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- The well is tested after well development and prior to the well being placed into service. The test consists of placement of 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 pounds per square inch [psi]).
- The well is then "closed in" and the pressure is monitored for a minimum of 20 minutes.
- If more than 10 percent of the pressure is lost during this 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.

CBR submits all integrity testing records to the NDEQ for review after the initial construction of an MU or wellfield. Test results are also maintained on site for regulatory review.

1.3.2.6 Wellfield Design and Operation

The proposed MEA MU timeline and MU map are shown on **Figures 1.1-6** and **1.1-7**, respectively. The preliminary map and mine timeline are based on current knowledge of the area. As the MEA is developed, the mine timeline and an MU map will be further developed. The MEA will be subdivided into an appropriate number of MUs. Each MU will contain wellhouses where injection and recovery solutions from the satellite facility building are distributed to the individual wells. The injection and production manifold piping from the satellite process facility to the wellhouses will be either PVC or HDPE with butt-welded joints or equivalent. Injection pressure will be monitored in the wellhouse manifolds. Oxidizer will be added to the injection stream, and all injection lines off of the injection manifold will be equipped with totalizing flowmeters, which will be monitored in the satellite Control Room. The MEA wellfield will be designed consistent with the existing CBR wellfields.

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The wellfield injection/production pattern employed is based on a hexagonal seven-spot pattern, 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 placed in a normal pattern are expected to be between 65 and 150 feet apart. A typical wellfield layout is shown on **Figure 1.3-6**. 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 the monitor well ring, prior to stability monitoring, 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 the amount of water produced and injected is the wellfield "bleed". The minimum over-production or bleed rates will be a nominal 0.5 percent of the total wellfield production rate, and the maximum bleed rate typically approaches 2.0 percent. Bleed is adjusted as necessary to ensure that the perimeter ore zone monitor wells are influenced by the cone of depression until stability monitoring described in Section 5.4.1.5 begins.

Monitor wells will be placed in the basal sandstone of the Chadron Formation and in the first significant water-bearing Brule sand above the basal sandstone of 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. As the MEA is developed, the MU map showing the locations of monitor wells will be developed further.

Injection of solutions for mining will be at a rate of 6,000 gpm with a 0.5 to 2.0 percent production bleed stream. Production solutions returning from the wells to the production manifold will be monitored with a totalizing flowmeter. All pipelines and trunklines will be pressure checked for leaks and buried prior to production operations.

A water balance for the proposed satellite facility is shown on **Figure 1.3-7** and **Appendix T**. The liquid waste generated at the satellite facility will be primarily the production bleed which, at a maximum, is estimated at 1.2 percent of the production flow. At 6,000 gpm process flow, the maximum volume of liquid waste in the year 2024 would be approximately 31 gpm. CBR proposes to handle the liquid waste using DDW injections. Detailed discussions of the MEA water balance calculation and evaluation are discussed in Section 3.12.2.2.

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Regional information, previous CBR license and 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. Calculations for MEA result in a value of 0.53 psi. As such, the injection pressure for the MEA will be limited to less than 0.53 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 3.4.3.2, a regional pumping test has been conducted to assess the hydraulic characteristics of the basal sandstone of the Chadron Formation and overlying confining units. Pumping tests will also be performed for each MU not covered by the regional pump test to demonstrate hydraulic containment above the production zone, demonstrate communication among the production zone mining and exterior monitor wells, and to further evaluate the hydrologic properties of the basal sandstone of the Chadron Formation.

A full and detailed analysis of the potential impacts of the mining operations at the MEA on surrounding water users will be provided in an Industrial Groundwater Use Permit application. A similar permit application was submitted by Ferret Exploration of Nebraska (predecessor to CBR) in 1991. The application states that water levels in the City of Crawford (approximately 3 miles [4.8 km], northwest of the mining area) could potentially be impacted by approximately 20 feet by consumptive withdrawal of water from the basal sandstone of the Chadron Formation during mining and restoration operations (based on a 20-year operational period). The nearest town to the MEA site is the community of Marsland, which is located approximately 3.5 miles (5.6 km) southwest of the MEA license boundary. There is no public water supply for the community of Marsland, with residences scattered throughout the MEA AOR being supplied with domestic water from private wells. Private well use is discussed in more detail in Section 3.4.1.

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No impact to other users of groundwater is expected because there is no documented existing use of the basal sandstone of the Chadron Formation in the proposed MEA or associated AOR.

Because the basal sandstone of the Chadron Formation (production zone) is a deep confined aquifer, no surface water impacts are expected. Based on available information, all water supply wells within the MEA and AOR are completed in the relatively shallow Arikaree and/or Brule Formation, with no domestic or agricultural use of groundwater from the basal sandstone of the Chadron Formation.

Further, the geologic and hydrologic data presented in Sections 3.3 and 3.4, respectively, demonstrate that (1) uranium mineralization is limited to the basal sandstone of the Chadron Formation, and (2) the basal sandstone of the Chadron Formation is isolated from underlying and overlying sands. Hence, the mining operations are expected to impact water quality only in the basal sandstone of the Chadron Formation, and restoration operations will be conducted in the basal sandstone of the Chadron Formation following completion of mining.

Based on a bleed of 0.5 to 2.0 percent, the potential impact from consumptive use of groundwater is expected to be minimal. A bleed of 0.5 to 1.5 percent has been successfully applied in the current licensed area. In this regard, the vast majority (on the order of 98 percent) of groundwater used in the mining process will be treated and re-injected (**Figure 1.3-7**). Potential impacts on groundwater quality due to consumptive use outside the license area are expected to be negligible.

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.
- Water removed from storage is discharged instantaneously with a decline in head.

- The pumping well is fully penetrating.
- Well diameter is small, so well storage is negligible.

Based on a drawdown response observed at the most distant observation well locations (Monitor 2 and Monitor 8), the ROI during the pumping test was estimated to be in excess of approximately 8,800 feet. More than 0.8 foot of drawdown was achieved during testing in all observation wells completed in the basal sandstone of the Chadron Formation, with a maximum drawdown of 23.40 feet observed in CPW-2010-1A (pumping well) during the test. Furthermore, during pumping and recovery periods, no discernible drawdown or recovery responses attributed to the test were observed in overlying Brule Formation observation wells, which supports the conclusion that adequate confinement exists between the overlying Brule Formation and the basal sandstone of the Chadron Formation. The results of the pumping test are provided in more detail in Section 3.4.3.2.

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As discussed in Section 6 of this document, an extensive water sampling program will be conducted prior to, during, and following mining operations at the satellite facility to identify any potential impacts to water resources in 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 license area to establish pre-mining baseline water quality. Water quality sampling will continue throughout the operational phase of mining for detection of excursions. Water quality will also be sampled 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 2.0 percent 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.

Injection pressures are monitored in the wellhouse at the manifold with an audible and visible alarm monitored 24 hours per day, 7 days per week in the control room. The alarms are set to prevent pressure in excess of 100 psi at the wellhouse manifold, below the 125 psi integrity test pressure. Due to line losses, pressures at the wellheads remain below that which is monitored at wellhouse manifold.

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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 abandoned and replaced as necessary.

Water levels will be routinely measured 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 indicate fluid migration from the production zone. Adjustments to well flowrates or complete shutdown of individual wells may be required to correct this situation. Increases in water levels in the overlying aquifer may also indicate casing failure in a production, injection, or monitor well. Isolation and shutdown of individual wells can identify wells causing the water level increases.

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To ensure that 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 2 weeks as discussed in Section 6.2.2.

1.3.2.7 Central Processing Facility, Satellite Facility, 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 will be recovered from the leach solution by IX at the satellite facility. The subsequent processing of the loaded IX 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 CPF. The CPF has been expanded in response to the increase in the IX resin handling, elution, precipitation, thickening, and drying circuits to handle additional production from the proposed NTEA and TCEA. Depending on the mining timelines for the existing CPF wellfields and the MEA, it is possible that the belt filter and dryer capacity of the CPF may need to be increased.

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Marsland Satellite Facility Equipment

Only the equipment proposed for the satellite facility is described in this section. The equipment and processes in the CPF are covered under the existing NRC Source Materials License Number SUA-1534. A general arrangement of equipment for the satellite facility is shown on **Figure 1.1-8**. The satellite facility equipment will be housed in a building approximately 130 feet long by 100 feet wide. The satellite facility equipment includes the following systems:

- IX
- Filtration
- Resin transfer
- Chemical addition

The satellite facility will be located within a 1.8-acre area in section 30, T31N, R52W. The DDW will be located nearby. **Figure 1.1-7** shows the plan view of these facilities.

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The satellite facility will house the IX columns, water treatment equipment, resin transfer facilities, pumps for injection of lixiviant, wastewater tanks, and an employee lunch room/ break area. Bulk soda ash, CO_2, and O_2 in compressed form and/or H_2O_2 will be stored adjacent to the

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satellite facility or in the wellfield. $NaHCO_3$ and/or gaseous CO_2 are added to the lixiviant as the fluid leaves the satellite facility for the wellfields. O_2 is added to the injection line for each injection well at the wellhouses.

The IX system consists of eight fixed-bed IX columns. The IX columns will be operated as three sets of two columns in series with two columns available for restoration. The IX system is designed to process recovered leach solution at a rate of 6,000 gpm. Once a set of columns is loaded with uranium, the resin is transported by truck to the CPF. The downflow columns are pressurized, sealed systems so there is no overflow of water, O_2 stays in solution, and radon emissions are contained. Radon releases from the pressurized downflow columns only when the individual columns are disconnected from the circuit and opened to remove the resin for elution. One disadvantage of the downflow column is that there must be good pressure control. Exposure pathways associated with downflow columns to be used at MEA are discussed in Section 4.12.2.1.

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After the IX process, the barren leach solution recovered from the wellfield is replenished with an oxidant and leaching chemicals (i.e., $NaHCO_3$ and/or CO_2). The injection filtration system consists of optional backwashable filters, with an option of installing polishing filters downstream. The lixiviant injection pumps are centrifugal type.

Areas in the proposed satellite facility where fumes or gases could be generated are discussed in Section 4.12.2. The potential sources are minimal in the satellite facility because 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 satellite facility air to the atmosphere.

Chemical Storage Facilities

Chemical storage facilities at the satellite facility 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. Other non-hazardous bulk process chemicals (e.g., $NaCO_3$) that do not have the potential to impact radiological safety may be stored within the satellite facilities.

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Process Related Chemicals

Process-related chemicals stored in bulk at the satellite facility will include CO_2, O_2, and/or H_2O_2. Sodium sulfide may also be stored for use as a reductant during groundwater restoration.

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- CO_2

CO_2 is stored adjacent to the satellite facility, where it will be added to the lixiviant prior to leaving the satellite facility.

- O_2

O_2 is also typically stored at the satellite facility, or within wellfield areas (where it is centrally located) for addition to the injection stream in each wellhouse. Because O_2 readily supports combustion, fire and explosion are the principal hazards that must be controlled. The O_2 storage facility will be located a safe distance from the satellite facility and other chemical storage areas

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for isolation. The storage facility will be designed to meet industry standards in the National Fire Protection Act (NFPA-50; NFPA 1996).

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O_2 service pipelines and components must be clean of oil and grease because O_2 will cause these substances to burn with explosive violence if ignited. All components intended for use with the O_2 distribution system will be properly cleaned following recommended methods in CGA G-4.1 (CGA 2000). The design and installation of O_2 distribution systems is based on CGA G-4.4 (CGA 1993).

- Sodium Sulfide

Hazardous materials typically used during groundwater restoration activities include the addition of a chemical reductant (i.e., sodium sulfide [Na_2S] or hydrogen sulfide [H_2S] gas). To minimize potential impacts to radiological safety, these materials are stored outside of process areas. Na_2S is currently used as the chemical reductant during groundwater restoration at the CPF. The material consists of a dry flaked product and is typically purchased on pallets of 55-pound bags or in super sacks of 1,000 pounds. The bulk inventory is stored outside process areas in a cool, dry, clean environment to prevent contact with any acid, oxidizer, or other material that may react with the product. H_2S gas has never been used at the CPF. In the event that CBR determines that use of H_2S as a chemical reductant is necessary, proper safety precautions will be taken to minimize potential impacts to radiological and chemical safety.

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As part of the SHEQMS, a risk assessment was completed to identify 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 is located only at the existing CPF and will not be used at the satellite facility.

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None of the hazardous chemicals used at the CPF are regulated under the U.S. Environmental Protection Agency (EPA) 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.

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1.3.2.8 Non-Process Related Chemicals

Non-process related chemicals that will be stored at the satellite facility 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 facility. All gasoline and diesel storage tanks are located aboveground and within secondary containment structures to meet regulatory requirements.

1.3.2.9 Satellite Facility Instrumentation and Control

The wellhouses 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 measure total production and injection flow and indicate the pressure being applied to the injection trunklines. Wellhouses will be equipped with wet alarms to monitor the presence of liquids in the wellhouse sumps. The system is monitored 24 hours per day, 7 days per week by control room operators. The operators rely on visual and audible alarms from a variety of systems to control mine operations. Power failures, pressure exceedances, and flow disruption are some of the conditions for which alarm systems will be monitored.

Instrumentation will monitor the total flow into the satellite facility, the total injection flow leaving the facility, and the total waste flow leaving the facility. Instrumentation on the facility injection manifold will 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 are equipped with pressure-reducing valves 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. During power failures, overpressurizing of wells is not possible, as all pump systems are shut down.

The basic control system at the satellite facility and associated wellfields 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 facility recovery operations.

The SCDA system will be interconnected throughout the facility via a Local Area Network (LAN) to computer display screens. The software used to display facility processes and collect data incorporates a series of menus which allows the facility 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 are out of tolerance. In addition, each wellhouse 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 wellhouse to alert the facility and wellfield operators of increasing manifold pressures. All critical equipment will be equipped with uninterruptible 30-minute power supply systems to be used in the event of a power failure.

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Through this system, not only will the facility operators be able to monitor and control every aspect of the operation in real time, 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 CBR personnel to anticipate problem areas and to remain in compliance with appropriate regulatory requirements.

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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 facility. Specifications for this equipment are included in the SHEQMS Volume IV, Health Physics Manual.

1.3.2.10 Gaseous and Airborne Particulate Control

This section describes the gaseous effluent control systems that will be installed in the MEA.

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 that could potentially produce radon-222 (i.e., resin transfer tank and wastewater tanks). Redundant exhaust fans will direct collected gases to discharge piping that will exhaust fumes to the outside atmosphere. The fans will be designed 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 (RG) 8.31. Airflow through any openings in the vessels will be from the process area into the vessel and 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 facility process building.

A tank ventilation system of this type is used in the CPF process area. Operational radiological in-plant monitoring for radon concentrations has proven this system to be effective for minimizing employee exposure.

Work Area Ventilation System

The ventilation system at the proposed MEA facilities would be similar to that used at the CPF. Exhaust fans would exhaust air within the building outside to the top of the building, drawing in fresh air. The discharge stacks will be located away from the building ventilation intakes and positioned on the leeward side of the satellite building (based on predominant wind direction) to prevent introducing exhausted emissions into the facility. These exhaust fans would be located at different levels to ensure that areas where radon could accumulate are ventilated sufficiently. The exhaust fans will create a negative flow, ensuring that air will not enter the process areas from vessels and systems within the satellite building. There will be redundant fans of the same size and capacity, which will operate only when the primary fans are inoperative due to maintenance or repair.

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. Radon daughter monitoring at the proposed satellite facility would be used to verify that radon daughters are maintained below the 25 percent derived air concentration (DAC) action level. Ongoing operations would ensure that the ventilation system operates satisfactorily and as designed through the use of standard operating procedures (SOPs).

Minor radon emissions may occur in a wellfield from wellheads and wellhouses. Vents will not be installed on wellhead enclosures, but SOPs will be followed when accessing a wellhead

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enclosure in order to ensure minimal exposures to personnel. Wellhouse buildings will be ventilated with either roof- or wall-mounted fans. When the buildings are accessed, the doors will be opened, allowing for additional ventilation of the building prior to entry by personnel. Radon emissions associated with wellfield operations will quickly disperse into the atmosphere.

Other emissions to the air are limited to exhaust and dust from limited vehicular traffic. No significant amounts of process chemicals will be used at the satellite facility. 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 MEA site are discussed in Section 4.6.2. The satellite facility operational building would not house combustion devices, except for the propane heaters used for heating the building as needed.

Occupational and public exposures to radon emitted from the MUs and from the satellite processing facility were analyzed using the MILDOS-AREA computer model to ensure that the discharged amount would be within regulatory dose limits. The results of this modeling are presented in Section 4.12.2.3 through 4.12.2.6.

1.3.2.11 Liquid Waste

Sources of Liquid Waste

ISR mining produces several sources of liquid waste. The potential wastewater sources at the satellite facility will be similar to those currently generated and managed at the CPF. These sources include the following:

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Water Generated during Well Development

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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. Well development water will be captured in water trucks specifically labeled for such purpose and equipped with signage indicating that these trucks may only discharge their contents to the MEA wastewater disposal system.

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Well development water will typically be transported to the MEA satellite building and transferred to the well workover fluid tank for eventual disposal in the DDWs. Use of this tank, as well as a backup option, are described in Section 3.12.2.1.

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Liquid Process Waste

The operation of the satellite facility results in one primary source of liquid waste, a production bleed. This bleed will be routed to a wastewater tank in the satellite building and then pumped from the tank to the DDW.

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Waste Petroleum Products and Chemicals

Small quantities of waste petroleum products and chemicals typical of ISR facilities will be generated and will include items such as waste oil and out-of-date or partially used reagents/chemicals. All such wastes that are non-hazardous will be temporarily stored in appropriate sealed containers above ground prior to disposal by a contracted waste disposal entity. Additional discussions of the management of these products and chemicals are presented in Section 3.12.2.1.

Aquifer Restoration Waste

Following mining operations at MEA, 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

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Only the groundwater sweep and groundwater treatment activities will generate wastewater. During groundwater sweep, water is 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.

Groundwater treatment activities involve the use of process equipment to lower the ion concentration of the groundwater in the affected mining area. An RO unit will be used to reduce the total dissolved solids (TDS) in 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 requires that procedural and engineering controls be implemented so that runoff will not pose a potential source of pollution. The design and engineering controls for the proposed MEA facilities will be such that any potentially contaminated stormwater runoff or snowmelt (e.g., any tankage diking, or curbing outside the satellite building) will be collected and disposed of in the DDW. Engineering and procedural controls contained in a Stormwater Pollution Prevention Plan (SWPPP), in combination with the design of the project facilities, will ensure that stormwater runoff is not a potential source of pollution.

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Domestic Sewage

Domestic sewage from the satellite facility restroom/toilets and lavatories and the sink in the lunchroom/break area 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 CPF. A similar permit will be required for the Marsland satellite facility. Because the groundwater on the MEA site is not

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found at shallow depths, and the site is remote with a relatively small work force, impacts are expected to be minimal.

Chemical toilets may be temporarily located at the MUs and other drilling areas. These toilets will be maintained by a licensed contractor. No impacts associated with the use of chemical toilets are anticipated during site activities.

CBR will employee an estimated 10 to 12 employees at the proposed MEA satellite facility. Assuming 13 gallons per day (gpd) for each employee (based on estimate for industrial employees by EPA), a total of approximately 130 to 160 gpd of sanitary waste would be generated (EPA 2002). An assumed additional 50 gpd of miscellaneous sanitary wastewater (e.g., from restroom/toilets, lavatories, and the sink in the lunchroom/break area) would result in approximately 180 to 210 gpd of sanitary wastewater being discharged to the septic system.

The number of temporary construction employees for the proposed satellite facility is estimated at 10 to 15 personnel. An assumed average of five to 10 full-time employees during construction would result in a total of 15 to 25 employees onsite for some periods. This would result in approximately 200 to 325 gpd of sanitary waste generation. During initial construction, portable sanitary units will be provided and serviced by a third-party contractor.

The septic system will be designed, constructed, operated, and permitted per applicable NDEQ Title 124 regulations.

Laboratory Waste

There will be no laboratory located in the MEA satellite building.

Liquid Waste Disposal

CBR has operated a DDW at the CPF for more than 10 years with excellent results and no serious compliance issues. A second DDW was added in 2011. CBR expects that the liquid waste stream at the MEA site will be chemically and radiologically similar to the waste disposed of in the current DDW.

CBR plans to install DDWs at the MEA site 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 MEA site will be disposed of in the planned DDWs.

Detailed discussions of liquid waste management and disposal are provided in Sections 2.3.1.3, 3.12.2.1 and 3.12.2.2.

1.3.2.12 Solid Waste

Solid waste generated at the MEA site 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.

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Liquid waste from the laboratory will be disposed of in the DDW. Approximately 1,000 gallons per month of nonhazardous liquid waste from the laboratory, comprising sample discards, lab solutions, dish washing wastewater, and lab cleanup wastewater will be disposed of in the DDW via surge/equalization tanks.

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 that are not contaminated or that may be successfully decontaminated. Release of contaminated equipment and materials is discussed in further detail in Section 5 of the Technical Report. Non-contaminated solid waste will be collected on the site in designated areas and disposed of in the nearest permitted sanitary landfill.

11(e).2 Byproduct Material

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

11(e).2 byproduct material generated at ISR facilities consists of filters, personal protective equipment (PPE), spent resin, piping, and other materials. These materials will be stored on site until 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, 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. An area will be maintained inside the restricted area boundary for storage of contaminated materials prior to their disposal.

Septic System Solid Waste

Domestic liquid wastes from the restroom, toilets, lavatories, and a sink in the lunchroom/break area will be disposed of in an approved septic system that meets the requirements of the State of Nebraska. The satellite building will not have a laboratory. Solid materials collected in septic systems must be disposed of by companies or individuals licensed by the State of Nebraska. NDEQ regulations for control of these systems are contained in Title 124.

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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. 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 spent waste oil and batteries. CBR estimates that the proposed 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 the SHEQMS Program Volume VI, Environmental Manual, to control and manage these types of wastes.

Additional discussions of solid wastes are presented in Sections 3.12.3 and 4.2.2.

1.3.2.13 Flooding and Erosion Potential

The potential for flooding or erosion that could impact the proposed in-situ MEA mining processing facilities and MUs has been assessed through two separate studies. The assessment is discussed in Section 4.3.1.1. The complete report of the hydrologic and erosion study, including tables and figures, is provided in **Appendix K-1** (ARCADIS 2012). The complete report of the hydrologic and flood study, including tables and figures, is provided in **Appendix K-2** (ARCADIS 2013). The studies addressed guidance in RG-1569 for an NRC licensee to assess the potential effects of erosion or surface water flooding on a proposed uranium in-situ facility. The ultimate objective of the studies was to determine whether the potential for erosion or flooding may require special design features or mitigation measures to be implemented.

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The studies focused on catchment and watershed delineation, hydrologic characteristics, determination of areas most prone to flooding and erosion due to rainfall runoff, and determination of flood flow characteristics. The analysis presented in **Appendix K-1** identifies proposed wells and facilities in areas of moderate to high risk for erosion that may require mitigation measures. The analysis presented in **Appendix K-2** provides estimates of storm-related discharge rates and velocities within the MEA. Seven primary tasks comprise the comprehensive hydrologic and erosion analysis:

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- Data collection and analysis: evaluating rainfall, digital elevation data, soil, and land use data
- Watershed delineation: dividing the project area basin into watersheds for detailed hydrologic analysis
- Hydrologic and erosion analysis: determining the flood routing characteristics of watersheds and generate the erosion risk map using hydrologic, land use, and soil data
- Erosion risk assessment: identifying MEA wells and other site facilities in locations of high erosion potential that may require erosion mitigation
- Flood discharge assessment: determining estimated storm-specific discharge rates within MEA watersheds
- Flood velocity assessment: determining estimated storm-specific flood velocities within MEA watersheds

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1.3.2.13.1 Data Collection

Similar data collection processes were followed for the studies presented in **Appendix K-1** and **Appendix K-2**. The data necessary to complete the studies included digital terrain data or a DEM, existing floodplain maps, land use and land cover data (LULC), National Hydrography Dataset (USGS NHD) published stream network data, soil data, and rainfall data.

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The terrain data were downloaded from the USGS National Elevation Dataset (NED) at a resolution of 30 meters. DEM data were used throughout the model domain to describe watershed topography and streams within the hydrologic model. The project area is in the watershed HUC12 101500020607 (Belmont Cemetery-Niobrara River Basin).

Floodplain maps in the form of Federal Emergency Management Agency (FEMA) Digital Flood Insurance Rate Maps (DFIRM) were downloaded from the FEMA Map Service Center (FEMA

2011). Land use data for the study area were the National Land Cover Data (NLCD) 2006, which were downloaded from the USGS seamless online Data Warehouse.

Supplementary data used to prepare and recondition the DEM include the USGS NHD published stream network, NHD Flowline (Simley and Carswell 2009) and the NRCS published 12-digit hydrologic unit code (HUC12) watershed delineation (NRCS 2009).

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Soil data were downloaded from the NRCS geospatial data gateway, Soil Survey Geographic Database (SSURGO). Regional soil characteristics, most importantly the infiltration rate, were represented by the Soil Conservation Service (SCS) Curve Number Method. Meteorological data, including precipitation, evaporation, and runoff values, were collected from the National Ocean and Atmospheric Administration (NOAA), the National Weather Service (NWS), and the National Climate Data Center (NCDC).

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1.3.2.13.2 Analysis Procedures

A detailed description of procedures used for watershed delineation and basin characteristics, hydrologic and soil erosion analysis, and modeling is presented in **Appendix K-1.** Procedures for analysis of flood potential are presented in **Appendix K-2.**

A GIS-based erosion model (Revised Universal Soil Loss Equation [RUSLE]).was used to investigate potential erosion in the project area. The model provides a fine spatial resolution of the model results. The RUSLE model is relatively simple and is one of the most practical methods to estimate soil erosion potential and the effects of different management practices. It was selected due to its wide acceptance, including for construction site management at the federal level in NPDES Phase II permitting (Wachal and Banks 2007, EPA 2000).

The RUSLE is the modified version of U.S. Department of Agriculture's Universal Soil Loss Equation (USLE), which has been used to measure soil loss from agriculture lands with relatively uniform slopes. The RUSLE modified certain factors in USLE to more accurately account for more complex terrain. The output of the RUSLE model is an annual rate of erosion and sedimentation in tons per acre per year, as opposed to erosion resulting from specific storm events. A detailed description of RUSLE is presented in **Appendix K-1.**

For the flood analysis, software developed by the U.S. Army Corps of Engineers Hydrologic Engineering Center was used to delineate watershed boundaries and approximate rainfall-runoff volumes. Detailed descriptions of models and modeling procedures used are presented in **Appendix K-2**. HEC-GeoRAS software was used to construct a hydraulic model to calculate flow velocity through the study area. Peak runoff calculated from the HEC-GeoHMS modeling was applied as the peak flow in the HEC-GeoRAS modeling.

1.3.2.13.3 Erosion Risk and Flood Analysis

MUs and other MEA facility locations were compared to the RUSLE map to evaluate erosion risk potential for each location. The proposed wellfield, the satellite building, and the areas adjacent to the satellite building were all evaluated for potential placement of the access road and DDW. **Table 1.3-4** lists the risk of erosion for each wellfield. Maps displaying the average annual erosion potential as estimated by the RUSLE model in relation to the MUs and satellite facility location are provided in **Appendix K-1**.

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MU A and MU 1 carry low or very low erosion risk throughout, while MU C, MU D, MU E, and MU F carry very low erosion risk throughout. MU 5 has multiple locations of moderate erosion risk. MU 2, MU 3, MU 4, and MU B have locations of moderate and high erosion risk. Although MU 2, MU 3, MU 4, and MU B have areas of high erosion risk, only 2 to 7 percent of the area within the units is at a moderate to high risk. Placement of well locations around areas of moderate and high potential erosion should be feasible in these units, particularly in MU 3, where only 2 percent of the land is at an increased risk of erosion. In comparison, 11 percent of MU 5 carries a moderate risk of erosion. Though the overall risk of MU 5 is lower than in other units, it may be more difficult to place wells without additional mitigation measures due to the widespread risk of erosion in the unit.

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If wells cannot be placed outside of areas within the wellfields deemed to have moderate to high risks, mitigation measures (e.g., berms) can be implemented to minimize the potential for flooding and erosion. The mitigation measures can be defined during final engineering and prior to any construction. Model results indicate that the risk of erosion is low or very low at the satellite facility, satellite facility access road, and DDW. Therefore, the probable need for erosion mitigation in this area is low.

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As part of the concentrated flow analysis, drainage lines (i.e., channels, gulleys, or areas of concentrated flow) and DFIRM floodplain extents were compared to MU locations. Although drainage lines are the primary contributor to increased erosion risk as part of the RUSLE analysis, the model was unable to accurately define erosion rates in these areas of concentrated flow during flood events. Thus, published FEMA DFIRM 100-year floodplain extents were compared to MUs in the area. MU locations within the 100-year floodplain should be considered at risk to flooding, as well as erosion caused by flood events. Further analysis, mitigation measures, or modification of well locations should be considered for those wells near concentrated flow routes or in the 100-year floodplain during the final engineering phase and prior to well installation and construction activities.

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Figures 22 through **27** of **Appendix K-1** display the drainage lines and floodplain extents relative to the MU and satellite facility locations. Drainage line 21 (NRCS HUC number 149152245) runs generally north-to-south and crosses MUs 2, 3, 4, and 5. Well locations in these MUs should be positioned outside of the floodplain or should include flood protection measures in the final engineering plans. Drainage line 24 (NRCS HUC number 149157281) crosses the proposed access road to the satellite facility. However, the proposed access road and satellite facility are not within the 100-year floodplain. The access road should be constructed with consideration to the location of the drainage and potential for concentrated runoff and erosion to occur. Drainage line 21 is predicted to accumulate notably more surface runoff than other drainages and therefore has a higher potential for flooding and erosion. Further analysis, mitigation measures, or modification of well locations will be considered for those wells near concentrated flow routes during the final engineering phase and prior to well installation and construction activities.

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1.3.2.13.4 Flood Risk Analysis

The hydrologic and flood study presented in **Appendix K-2** divides the MEA into two study areas based on drainage characteristics: Hydrologic Project South and Hydrologic Project East. Hydrologic Project South contains the majority of sub-basins and drainages where project facilities and activities would occur (e.g., wellfields and satellite facility). Drainage lines 21 and 24 described above in Erosion and Risk Analysis above are both located within Hydrologic

Project South. Peak discharge rates and flood velocities were calculated for storms with return intervals of 10, 25, 50, and 100 years and are provided in **Appendix K-2**. Model results for the 100-year storm event are described below.

Peak discharge rates for the main drainages where they exit the MEA permit boundary are summarized in **Tables 1.3-5 and 1.3-6**. The peak discharge for Hydrologic Project South during a 100-year storm is estimated to be 1,455 cubic feet per second (cfs), whereas the peak discharge for Hydrologic Project East during the same storm is estimated to be 2,659 cfs. These discharge values are almost double the rates expected for storms with a 10-year recurrence interval.

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In order to determine the potential risk of project facilities and infrastructure due to flooding, the velocity of flood waters within MEA drainages during a 100-year storm were calculated using the HEC-RAS model. For the western tributary within Hydrologic Project South (drainage line 24 of **Appendix K-2**), the maximum flow velocity is estimated to be 5.8 ft/s. For the main stem drainage within Hydrologic Project South (drainage line 21 of **Appendix K-2**), the maximum flow velocity is estimated to be 6.3 ft/s upstream of the confluence with the western tributary and 6.5 ft/s downstream of the confluence. The maximum flow velocity for the main stem drainage within Hydrologic Project East is estimated to be 8.9 ft/s.

Although not within FEMA-designated flood zones, portions of the MEA may be subject to concentrated water flow during storm runoff and may also be at risk of damage. FEMA-designated flood zones supersede any estimated flood widths presented in **Appendix K-2**. For locations within or adjacent to the drainages assessed in this study, but beyond the FEMA flood zones, model results can be used as described below to estimate areas potentially affected under these circumstances, in addition to peak discharge rates and flood velocity. For example, the location where the access road to the proposed satellite facility crosses drainage line 24 (**Appendix K-2**) is outside of a FEMA-designated flood zone. However, model results indicate that runoff velocity within that drainage during a 100-year storm is estimated to be between 2.8 and 3.3 ft/s. Model results also indicate that the total width of flowing water at the access road crossing during a 100-year storm would be between approximately 140 and 220 feet.

1.3.2.13.5 Flood Risk Planning

CBR will use the results of the two hydrologic and erosion studies in support of current and future planning and additional project design and layout. Once more detailed engineering commences, the results of these studies will be used to assess the potential for erosion and flooding that may require implementation of special design features or mitigation measures (e.g., berms around areas of MUs, strategically located drainage channels, culverts on roadways). Additional hydrologic and erosion analysis may be required during specific phases of site grading and engineering design to supplement the current studies. For example, specific phases requiring additional analysis may include the final design of MUs (locations of buildings, wells, and piping), DDWs, or the satellite facility building and associated structures.

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1.3.2.14 Surface Water Management and Erosion Control

In general, CBR will carry out tasks including the following in regard to surface water management and erosion control.

CBR will use ditches, diversions, culverts, and other best management practices (BMPs) to control surface water flow within the permit boundary.

An erosion and sediment control plan will be developed and implemented during construction, operation, and reclamation activities in order to reduce soil losses within the license area and to protect surface and subsurface assets.

Using the results of erosion and flood analyses, CBR will construct facilities outside of these flood-prone boundaries in order to avoid potential impacts to facilities from flooding and potential impacts to major ephemeral drainages, and the Niobrara River in the event of any potential spills or leaks. When possible, CBR will locate surface structures/wells outside of the 100-year flood zone boundaries. Any facilities that will have to be built within the 100-year flood zone boundaries will be protected from flood damage by the use of control measures such as diversion/collection ditches, channels, storm drains, slope drains, and/or berms.

Pipelines will be buried below the frost line, and pipeline valve stations will be located outside of the 100-year flood zone in order to avoid damage due to potential surface flooding.

Efforts will be made to avoid placement of production, injection, and monitor wells in potential flood-prone areas (using results of erosion and flood risk analyses), but if it is necessary to place such wells in these areas, surface water control measures (e.g., diversion or erosion control structures) will be used. Wellheads in these areas can be built so that the casing extends above grade and is mounted in a concrete pad. In addition, an aboveground protective housing can be used to protect the well casing in the event of flooding. CBR currently uses an anchored metal or plastic protective housing (similar to a 55-gallon drum with the ends cut out), which affords protection in the event of flooding. As applicable, well heads will be sealed in order to withstand brief periods of submergence.

CBR will carry out all construction tasks in compliance with applicable NPDES stormwater general permit requirements.

Sections 4.4.1 and 4.4.2 describe mitigation measures to protect surface water from potential spills and leaks. Section 4.4.3 describes mitigation measures to protect groundwater from potential spills and leaks.

1.3.2.15 Erosion Control During Construction and Decommissioning

The greatest potential for erosion and sedimentation will be during the construction and decommissioning phases of the MEA project. Land management and farming techniques will be used by CBR in order to minimize the erosion of disturbed, reclaimed, and native areas. Mitigation measures are discussed in Section 5.1. CBR will typically prepare and seed ground areas that are disturbed as soon as possible in order to minimize the potential for erosion. As discussed above, erosion controls will be used in order to reduce overland flow velocity, reduce runoff volume, and minimize the transport of sediment into drainages. Examples include, runoff control diversion structures, storm drains, slope drains, channels, mulch, cover crops, rip-rap, sediment fences, and other controls. Construction of the MUs will be sequenced so that only part of the site is affected at one time. This sequencing coordinates the timing of land-disturbing activities and the installation of erosion and sediment control measures (EPA 2013). This will

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assist with the erosion and sediment control because it helps to ensure that BMPs are installed where necessary and when appropriate (EPA 2013).

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The need to control sediment will be most critical during wellfield construction and immediately after redistributing topsoil. Sediment control features that may be required include silt fences, sediment basins, sediment traps, vegetation buffers, and other features. CBR will use existing roads when possible and limit the various access road widths, which will minimize the surface disturbance to soil and vegetation. Traffic will be limited to established roadways to the extent possible.

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Erosion and sediment controls will be developed prior to commencement of construction, at a time when site disturbance activities are clearly defined.

1.4 Security

CBR security measures for the current operation are specified in the Security Plan and Security Threat chapter in Volume VIII, Emergency Manual. 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
- 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 CPF 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 IX resin removed from the restricted area for transfer to other areas.

At the MEA, licensed stored material would typically include loaded IX resin and byproduct waste awaiting disposal. Lixiviant would be found in production piping in the wellfield and wellhouses, production trunkline to the satellite facility, and within piping located in the satellite building. Loaded IX 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 CPF.

1.4.1 Marsland Satellite Facility Security

Entrance to the MEA will be via Squaw Mound Road west 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 locked when not in use. The satellite facility site within the license area will be properly posted in accordance with 10 CFR § 20.1902 (e). The primary and alternate access routes to the satellite facility are shown in **Figure 1.4.-1** and discussed in Section 4.2.

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The security fence surrounding the license area serves as a control for industrial/property protection (**Figure 1.1-7**). Appropriate signage will be placed on all fencing advising of access restrictions.

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Restricted area at the 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 satellite facility are shown on **Figure 1.1-8**. 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 of a radiological condition. When evaluating the likelihood of specific conditions, normal and unique situations that can reasonably be expected to occur will be considered.

All visitors, contractors, or inspectors entering the satellite facility site will be required to register at the facility office and will not be permitted inside the facility or wellfield areas without proper authorization. All visitors needing safety equipment, such as hardhats 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 (RSO) or designee. Training requirements associated with visitors and contractors are discussed in Section 5.5 of the MEA Technical Report.

The satellite facility will routinely operate 24 hours per day and 7 days per week so that CBR employees will normally be on site except for occasional shutdowns. The satellite facility structure will be equipped with locks to prevent unauthorized access. All facility 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, they will be escorted to the main entrance for departure.

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Access by unauthorized personnel to the stored and non-stored licensed materials (pregnant lixiviant solution, loaded IX resin, and byproduct 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 IX resin and parked within or near the satellite facility building.

Wellhouses where pregnant lixiviant solutions would be present in the production piping would be kept locked. Only authorized personnel would have keys to the wellhouses. The production trunk line conveying pregnant lixiviant from the wellhouses to the satellite building would be located within perimeter fencing that only authorized personnel would be allowed to enter. Gates associated with perimeter fencing enclosing any operating wellfield would be kept locked when operators and workers are not present (e.g., remote from the satellite facility). Security may be increased by installing continuous video surveillance of outside areas.

CBR maintains and enforces requirements of the SHEQMS, Volume IV Health Physics Manual, which specify 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.

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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 Sections 3.11.2.2 and 4.12.2.3 through 4.12.2.6, for a downwind receptor near the MEA is 93 millirems per year (mRem/yr). This is based on an occupancy factor of 100 percent or 8,760 hours per year. If the routine visitor were on site for 10 hours per month, the visitor would receive an annual dose of 3 mRem/yr. It is unlikely that even frequent visitors to the MEA could receive annual doses near the 100 mRem public dose limit.

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1.4.2 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 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.

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Transport of licensed/hazardous material by CBR employees will generally be restricted to moving IX resin from a satellite facility to the CPF 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 in a 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 cargo while on the road
- 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 vehicle is to be kept visible by an employee at all times when left outside a restricted area.

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The security guidelines and procedures apply to all transport assignments. All drivers and non-driving personnel are expected to know and adhere to these guidelines and procedures when performing any load-related activity.

1.4.3 Contamination Control Program

CBR will perform surveys for surface contamination in operating and clean areas of the satellite facility in accordance with the guidelines contained in RG 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 disintegrations per minute (dpm)/100 square centimeters (cm^2) (25 percent 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 a 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 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 distance separating the satellite facility and the CPF, where the RSO and radiation staff are based, it would be more efficient to have properly trained full-time personnel at the MEA site available to perform surveys for releasing items from the restricted area. Such a person would be the Lead Operator or a facility/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 the required radiation safety training. They would also be subject to additional hands-on training as to the survey instruments and procedures. The release limits are set by the Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct or Source Materials (NRC 1987).

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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 Geiger-Mueller (GM) survey meter with a beta/gamma probe with an end window thickness of not more than 7 milligrams per square centimeter (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 RG 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 satellite facility will be conducted, concentrating on facility 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 satellite facility will be implemented in accordance with the SHEQMS Volume IV, Health Physics Manual.

As noted earlier, Cameco is evaluating the implications of short-lived beta-emitting isotopes to contamination control, for both personal contamination and for free release of objects at the CPF, and will incorporate the results of that evaluation, as appropriate, into the Radiation Protection Program for both the CPF and the MEA.

1.5 Applicable Regulatory Requirements, Permits, and Required Consultations

1.5.1 Environmental Approvals for the Current Licensed Area

As discussed previously, this is an amendment application for Radioactive Source Materials License SUA-1534, originally submitted in September of 1987 and renewed in 1998. A license renewal application for continued operation of the CPF was submitted to the NRC on November 27, 2007. NRC approval is pending. A license amendment for the addition of the proposed NTEA satellite facility was submitted to the NRC on May 30, 2007. NRC approval is pending.

All other required permits for the existing CPF have been obtained and maintained as required by applicable regulatory requirements. The NDEQ has approved a Class III UIC permit and the NDEQ/EPA has approved the Petition for Aquifer Exemption for the proposed NTEA. A summary of the relevant permits and authorizations for the CPF license area is given in **Table 1.5-1**. Permits and authorizations anticipated for the satellite facility are shown in **Table 1.5-2**.

1.5.1.1 Environmental Approvals and Permits

The MEA will be subject to permitting requirements similar to the CPF. **Table 1.5-2** contains a summary list of the type of permit or authorization, the granting authority, and the status.

1.5.1.2 Licensing and Permitting Consultations

During the preparation of this License Amendment application and the NDEQ Class III UIC Application for MEA, the following agency officials were contacted:

U.S. Nuclear Regulatory Commission
Mr. Ronald Burrows, Project Manager
Decommissioning and Uranium Recovery Licensing Directorate
Davison of Waste Management and Environmental Protection
Office of Federal and State Materials and Environmental Management Programs
Mailstop T8-5
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Nebraska Department of Environmental Quality
Ms. Jenny Coughlin
Nebraska Department of Environmental Quality
Suite 400, The Atrium
1200 North N Street
P.O. Box 98922
Lincoln, NE 68509-8922

1.5.2 Environmental Consultations

During the preparation of this license amendment application, several agencies were consulted for information required for various sections of the application:

1.5.2.1 Land Use (Section 3.1)

Elaine Connelly
Nebraska Maps & More
School of Natural Resources
101 Hardin Hall
3310 Holdrege Street
Lincoln, NE 68583-0961

Echo Clark
Tax Assessor
Dawes County
451 Main St.
Chadron, NE 69337
308-432-0103

1.5.2.2 Surface Water (Section 3.4.2)

Assistance was requested in providing available surface water flow and water quality data for the Niobrara River in the proposed project area:

Tom Hayden
Supervisor
Water Field Office Operations
Nebraska Department of Natural Resources
Bridgeport Field Office

Guy H. Lindeman, P.E.
Nebraska Department of Natural Resources
301 Centennial Mall So.
PO Box 94676
Lincoln, NE. 68509

Dave Ihrie
Planning Section, Water Division
Nebraska Department of Environmental Quality
1200 "N" Street, Suite 400
Lincoln, NE 68509-8922
402-471-0283

Bill Peck
U.S. Reclamation Bureau
Field Office
1706 West 3rd St.
McCook, NE 69001

1.5.2.3 Ecological Resources (Section 3.5)

Preparation of the ecology discussion (Section 2.8) required consultations with the following individuals and agencies:

Greg Schenbeck
Wildlife Manager
Pine Ridge Field Office
Nebraska Game and Parks Commission
Chadron, NE

1.5.2.4 Historic, Scenic and Cultural Resources (Section 3.8)

Preparation of the historic, scenic, and cultural resources discussion required consultations with the following individuals and agencies:

Teresa Fatemi
Nebraska State Historical Society
State Historic Preservation Office
1420 P Street
Lincoln, NE 68508

Trisha Nelson
Archaeological Collections Manager
Nebraska State Historic Society
P.O. Box 82554
Lincoln, NE 68501

1.5.2.5 Population Distribution (Section 3.10)

Preparation of the population distribution discussion (Section 3.10) required consultations with the following individuals and agencies:

T. Vogl, School Clerk, Crawford Public Schools

1.5.2.6 Groundwater Quality Restoration, Surface Reclamation, and Facility Decommissioning (Section 3.4.3 and 6.0)

Ms. Jenny Coughlin
Nebraska Department of Environmental Quality
Suite 400, The Atrium
1200 North N Street
P.O. Box 98922
Lincoln, NE 68509-8922

Table 1.1-1 Current Crow Butte Production Area Mine Unit Status

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Table 1.3-1 Latitude and Longitude and Coordinates for Marsland Permit Boundary and Satellite Facility

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Table 1.3-2 Typical Lixiviant Concentrations

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Table 1.3-3 Background Information for Logging Probes used at the Marsland Expansion Area

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Table 1.3-4 Summary of Risk of Erosion for Proposed MEA Mine Units

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Table 1.3-5 The Peak Flow for Hydrologic Project South

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Table 1.3-6 The Peak Flow for Hydrologic Project East

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Table 1.5-1 Environmental Approvals for Crow Butte Project

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Table 1.5-2 Environmental Approvals for Proposed Marsland Expansion Area

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Figure 1.1-1 Current License Area Project Layout

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Figure 1.1-2 Project Location Map ZOEI and AOR

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Figure 1.1-3 Crow Butte Resources Inc. Current Permit Area and Proposed Expansion Areas

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Figure 1.1-4 Marsland Expansion Area Land Ownership

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Figure 1.1-5 Current Production Area Mine Unit Timeline

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Figure 1.1-6 Marsland Expansion Area Mining and Restoration Timeline

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Figure 1.1-7 General Arrangement Satellite Facility View

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Figure 1.1-8 Marsland Expansion Area Satellite Building Layout

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Figure 1.3-1 Marsland Expansion Area Estimated Ore Body

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Figure 1.3-2 Typical Mineralized Zone Completion for Injection/Production Wells – Method No. 1

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Figure 1.3-3 Typical Mineralized Zone Completion for Injection/Production Wells – Method No. 2

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Figure 1.3-4 Typical Mineralized Zone Completion for Injection/Production Wells – Method No. 3

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Figure 1.3-5 Marsland Expansion Area Satellite Facility and Current CBR Production Facility Process Flow Diagram

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Figure 1.3-6 Typical Wellfield Layout

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Figure 1.3-7 Water Balance for Marsland Satellite Facility

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Figure 1.4-1 Proposed Access Route Between Marsland Expansion Area Satellite Facility and Crow Butte Central Processing Facility

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2 ALTERNATIVES TO PROPOSED ACTION

2.1 No-Action Alternative

2.1.1 Summary of Current Activity

CBR currently operates the CPF, a commercial ISR uranium mining operation located approximately 4 miles (6.4 km) southeast of the City of Crawford in Dawes County, Nebraska. Operation is allowed under NRC Source Materials License SUA-1534. The CPF is located approximately 11 miles (17.7 km) north-northwest of the proposed MEA satellite facility.

An R&D facility was operated in 1986 and 1987. Construction of the commercial process facility began in 1988, with production beginning in April of 1991. The total license area is 2,861 acres, and the surface area affected by the current commercial project is approximately 2,000 acres. Facilities include the R&D facility (which now houses the Restoration Circuit), the CPF and office building, solar evaporation ponds, parking, access roads, and wellfields.

In the CPF license area, uranium is recovered by in-situ leaching from the basal sandstone of the Chadron Formation at depths that vary from 400 to 900 feet. The overall width of the mineralized area varies from 1,000 to 5,000 feet. The ore body ranges in grade from less than 0.05 percent to more than 0.5 percent U_3O_8, with an average grade estimated at 0.27 percent U_3O_8. Production is currently in progress in MUs 6 through 11. Groundwater restoration has been completed and regulatory approval has been received in MU 1. Groundwater restoration is currently underway in MUs 2 through 6.

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The CPF is operating with a licensed flowrate of 9,000 gpm. Maximum allowable throughput from the facility under SUA-1534 is currently 2,000,000 pounds of U_3O_8 per year.

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2.1.2 Impacts of the No-Action Alternative

The no-action alternative would allow CBR to continue mining operations in the CPF license area, with mining limited to remaining reserves at the CPF site. Based on current plans and mining timelines discussed in Section 1 (**Table 1.1-1** and **Figure 1.1-5**), CBR could continue production at the CPF license area until 2014, when reserves are expected to be depleted to the point where commercial production would no longer be economical and would be discontinued shortly thereafter. Groundwater restoration and reclamation would become the primary activities, with final groundwater restoration in 2023 and reclamation completed in 2025.

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Assuming favorable regulatory action by the NRC and State of Nebraska and, that the MEA is licensed, and commercial production remains economical, mining operations are estimated to begin at the proposed NTEA satellite facilities in 2024 and last for approximately 8 years (until 2032). As discussed in the NTEA Technical Report (Application for Amendment of NRC Source Materials License SUA-1534; CBR 2007), NTEA reserves would be depleted in 2032.

When commercially recoverable resources are depleted in the CPF license area, all activities at the site not associated with groundwater restoration and decommissioning will be completed, resulting in the loss of a significant portion of the total employment at the site. In actuality, some of these jobs would be lost before 2014. For example, the well drilling, installation, and wellfield construction activities would be completed several years before the completion of mining activities, and these positions would no longer be necessary. At the completion of decommissioning, all employment opportunities at the mine would be terminated. If approved, mining operations at the MEA would extend current employment levels through 2023, at which time the NTEA would be ready to start producing. The impacts to the local economy from the approval of mining operations at MEA, including employment opportunities, are evaluated in the MEA Technical Report (CBR 2007).

In addition to the loss of significant employment opportunities in the City of Crawford and Dawes County, the premature closing of the CPF before commercially viable resources are recovered would adversely affect the economic base of Dawes County. As discussed in further detail in Sections 4.10.3 and 7, the CPF currently provides a significant economic impact to the local Dawes County economy as shown in **Table 4.10-2**.

If this amendment request is denied, the negative impact on the Dawes County economy would be felt as early as 2013, when employment levels for drilling and construction activities would be cut, and purchases of services and materials would diminish. In the event that NTEA, TCEA, and MEA are approved, employment would continue at current levels. The potential positive economic impact to the local economy from construction and operation of the MEA is demonstrated in **Table 4.10-2**.

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A decision to not amend SUA-1534 to allow mining in the MEA would leave a large resource unavailable for energy production supplies. Although CBR is continuing to develop estimates of the reserves at MEA, the current indicated ore reserves as U_3O_8 for the MEA are 6,161,679 lbs. with an additional inferred estimate of 3,389,518 lbs. Total reserves for the MEA are currently estimated at 9,551,197 lbs. The MEA will operate with an expected annual production rate of approximately 600,000 lbs U_3O_8.

In 2012, total domestic U.S. uranium concentrate production was approximately 4,100,000 pounds U_3O_8, of which approximately 800,000 pounds (or approximately 20 percent) was produced at the CPF (EIA 2013a). During the same year, purchases of domestic U.S. uranium by U.S. civilian nuclear power reactors from U.S. and foreign suppliers were approximately 58,000,000 pounds U_3O_8e (equivalent) with approximately 17 percent supplied by domestic producers (EIA 2013b). Foreign-origin uranium accounted for the remaining 83 percent of deliveries. The CPF (including the MEA, TCEA, and NTEA) represents an important source of new domestic uranium supplies essential to providing a continuing source of fuel to power generation facilities.

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In addition to leaving a large deposit of valuable mineral resources untapped, a denial of this amendment request would result in the loss of a large investment in time and money made by CBR for the rights to and development of these valuable deposits.

Denial of the amendment request would have an adverse economic effect on the individuals that have surface leases with CBR and own the mineral rights in the MEA.

2.2 Proposed Action

The proposed MEA timeline and MU map are shown on **Figures 1.1-6** and **1.1-7**, respectively. There will be a total of 11 MUs, with construction for MU 1 to commence in 2014. Production

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for the project will start in 2015 and terminate in the year 2039. Restoration in designated MUs will commence in the year 2020 and will be completed in 2044. Site reclamation will be completed in 2046. The ore grade as U_3O_8 ranges from 0.11 to 0.33 percent with an average ore grade of 0.22 percent.

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The proposed MEA contains a licensed area of approximately 4,622.3 acres. Of this potential licensed area, the total surface area to be affected by mining operations will be approximately 591 acres for the proposed MUs, processing facility, disposal well, well sites, and access roads. Currently, these areas are cropland (71.7 acres) and livestock range (491.2 acres).

The proposed satellite facility will be located within a 1.8-acre area in sections 26, 35 of T30N; R51W; sections 1, 2, 12, 13 of T29N R51W; and sections 7, 18, 19, 20 29, 30 of T29N, R50W. This area will also contain the chemical storage area. The DDW will be located approximately 0.3 mile (0.48 km) north-northwest of the satellite facilities (**Figure 1.1-7**). **Figure 1.1-8** shows the plan view of the satellite building.

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Figure 1.1-3 shows the locations of the current license area and the proposed MEA.

The MEA will be developed and operated by CBR. All land within the proposed license boundary of the MEA is privately owned. CBR has obtained surface and mineral leases from the appropriate landowners necessary to construct and operate the required ISR facilities.

Commercial production at the CPF is expected to extend for the next several years, with the uranium reserves largely depleted by 2014. Commercial production at the proposed MEA would occur over 24 years between 2015 and 2039. The aquifer will be restored and reclaimed concurrent with operations, plus an additional period at the end of the project for final decommissioning and surface reclamation. The combined CPF and MEA projects would be completely restored and reclaimed by 2046. More detailed timelines are provided in Section 1.

The CPF recovers uranium from the basal sandstone of the Chadron Formation. In the MEA, uranium will also be recovered from the basal sandstone of the Chadron Formation. The depth in the MEA ranges from 800 to 1,250 feet. The width varies from 1,000 to 4,000 feet.

The satellite facility process structure will be a building approximately 130 feet long by 100 feet wide. The proposed satellite facility equipment will include the following systems:

- IX
- Filtration
- Resin transfer
- Chemical addition

The in-situ process consists of an oxidation step and a dissolution step. The oxidants used in the facility are H_2O_2 and/or O_2. A $NaHCO_3$ lixiviant is used for the dissolution step.

The uranium-bearing solution resulting from the leaching of uranium underground is recovered from the wellfield and piped to the satellite facility for extraction. The satellite facility process employs the following steps:

- Loading of uranium complexes onto an IX resin

- Reconstitution of the solution by the addition of $NaHCO_3$ and O_2
- Shipment of loaded IX resin to the CPF
- Restoration of groundwater following mining activities

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The satellite facility will be designed for a maximum flowrate, excluding restoration flow, of 6,000 gpm (restoration would account for another 1,500 gpm). Uranium-bearing resin will be transported to the CPF for elution and packaging of yellowcake.

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The operation of the satellite facility results in a number of effluent streams. Airborne effluents are limited to the release of radon-222 gas during the uranium recovery process. Liquid wastes are handled through evaporation and/or deep well injection.

Groundwater restoration activities consist of four steps:

- Groundwater transfer
- Groundwater sweep
- Groundwater treatment
- Aquifer recirculation

Groundwater restoration will take place concurrently with development and production. The primary goal of the groundwater restoration is to return the water quality of the affected zone to a chemical quality consistent with baseline conditions required by 10 CFR 40, Appendix A, Criterion 5(B)(5) (or an approved alternate concentration limit [ACL] under 5[B][5][c]); or, as a secondary goal, to the quality level specified by the NDEQ.

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Following groundwater restoration, all injection and recovery wells will be reclaimed using appropriate plugging and abandonment procedures. In addition, a sequential land reclamation and revegetation program will be implemented on the site. This reclamation will be performed on all disturbed areas, including the satellite facility, wellfields, and roads. The current estimate of the total acreage that may be affected over the life of the project is 1,760 acres.

CBR will maintain financial responsibility for groundwater restoration, facility decommissioning, and surface reclamation. Currently, an irrevocable letter of credit is maintained based on the estimated costs of the aforementioned activities.

The environmental impacts of the requested action will be minimal as discussed in Section 4. The primary radiological air impacts will be from the release of radon gas during production and will be minimized by the use of pressurized downflow IX columns. In addition, radon gas quickly dissipates in the atmosphere and results in a minimal additional exposure to the public as discussed in Section 4.12. All drying and packaging will be performed at the CPF using a vacuum drying system, thereby minimizing the potential for radioactive air particulate releases at MEA.

ISR alters the geochemistry and the water quality in the mining zone. CBR has proven in the current licensed area that impacts to groundwater can be controlled through stringent well construction techniques, wellfield operating methodologies that minimize excursions, and the use of best practicable technologies (BPTs) to restore the groundwater to premining baseline or class of use after mining activities are complete.

The impacts discussed in Section 4 include short-term and long-term impacts. However, it should be noted that the uranium ISR mining technique allows the entire mine site to be decommissioned and returned to unrestricted use within a relatively short time.

Commercial production at the CPF including the proposed MEA and NTEA is expected to extend over the next 27 years with the uranium reserves at both areas depleted by 2039. The MEA site alone will produce U_3O_8 from 2014 through 2039. Commercial production at the proposed MEA would occur over 24 years from late 2015 through 2039. Aquifer restoration and reclamation will be done concurrent with operations, plus an additional period at the end of the project for final decommissioning activities and surface reclamation. All three projects would be completely restored and reclaimed by 2046. More detailed timelines are provided in Section 1.

2.3 Reasonable Alternatives

2.3.1 Process Alternatives

2.3.1.1 Lixiviant Chemistry

CBR is employing a $NaHCO_3$ lixiviant that is an alkaline solution. Where the groundwater contains carbonate, as it does at CBR, an alkaline lixiviant will mobilize fewer hazardous elements from the ore body and will require less chemical addition than an acidic lixiviant. Also, test results at other projects indicate only limited success with acidic lixiviants, while the $NaHCO_3$ has proven highly successful to date at the CBR operations. Alternate leach solutions include ammonium carbonate solutions and acidic leach solutions. These solutions have been used in solution mining programs in other locations; however, operators have experienced difficulty in restoring and stabilizing the aquifer. Consequently, these solutions were excluded from consideration.

2.3.1.2 Groundwater Restoration

The restoration of the R&D project, the successful completion of restoration in MU 1, and the current restoration activities in MUs 2 through 6 at the current licensed CPF demonstrate the effectiveness of the restoration methods. These methods (groundwater sweep, permeate/reductant injection, and aquifer recirculation) have been shown to restore groundwater to premining quality. No feasible alternative groundwater restoration method is currently available for the CPF and proposed MEA. The NRC and NDEQ consider the method currently employed at the CPF as the BPT.

2.3.1.3 Waste Management

Liquid Waste

Liquid wastes generated from in situ production and restoration activities are typically handled by one of three methods: solar evaporation in ponds, DDW injection, or land application. All three methods are permitted at the CPF. The use of DDWs in conjunction with storage/evaporation ponds to dispose of the high TDS liquid wastes that primarily result from the yellowcake processing and drying facilities is considered the best alternative to dispose of these types of

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wastes. Alternative wastewater disposal options that were considered for MEA were DDW injection, surge/evaporation ponds, point source discharge and/or land application. In addition, surge tanks were evaluated as waste management facilities to support the selected DDW alternative.

The proposed method of liquid waste disposal at MEA will be DDW injection without the need for supporting surge/evaporation ponds or surge tanks. The justification for this proposed action is discussed in Section 3.12.2.1. There are currently no plans for any point source discharges or land application of wastewaters. However, the land application option could be applied in the future if such disposal is deemed feasible and more beneficial for a specific wastewater stream. Any such action would require an NRC license amendment and a discharge permit from the NDEQ.

Based on the proposed project development schedule and the water balance of the MEA project, additional liquid waste disposal methods will be phased for the MEA operations. For approximately the first 6 years of operation (2015 through 2020), the MEA operations will send wastewaters to storage tanks located in the satellite building, which will then be discharged to two onsite DDWs. There will be no evaporation ponds or large surge tanks located outside the satellite building. The proposed waste management system will be sufficient to handle the total quantities of wastewaters that will be generated during startup. Production and restoration flows will increase in 2021 to the extent that additional wastewater management and controls will be needed because the increased flows may exceed the capacity of two DDWs.

During the first 6 years of operations, CBR will assess the maximum injection rates of the DDWs and the overall efficiency of the waste management system. Efforts will be made to maximize the DDW injection rates, minimize the amounts of wastewaters generated during production and restoration that require disposal, better quantify actual site wastewater flows, and assess viable waste management alternatives and environmental implications. This time period will allow CBR time to develop an updated waste management system that will be the most optimum for handling the increasing wastewater flows. Additional wastewater management systems to be evaluated will include additional DDWs, surge tanks, surge/evaporation ponds, and process modifications to minimize liquid waste generation.

As stated above, CBR considered and rejected using either surge/evaporation ponds, point source discharge, or land application as a disposal method for currently planned operations at Marsland due to required treatment and monitoring costs and potential environmental impacts. However, as the project develops, a determination will be made as to the extent of additional wastewater management alternatives that may be needed in addition to the DDWs to handle all of the generated wastewater streams amenable to disposal by DDW. Additional alternative evaluations will consider options such as additional DDWs, surge tanks, surge/evaporation ponds, land application, or treated wastewater discharge. CBR will be able to assess the maximum injection rates for the two initial DDWs, and the resulting information will be of value in planning future DDWs and/or other disposal options. CBR will submit the necessary license amendment(s) and waste alternative analyses to the NRC and request approval as per applicable license condition(s), as well as permits required by the NDEQ and other appropriate state agencies.

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Surge Tanks

Surge tanks may be a viable option in the future in addressing increased production and restoration flows. If a reasonable number of surge tanks can handle the proposed wastewater volumes, then that may be the only option required. This would assume that additional DDWs would be added and the overall disposal capacity was sufficient.

Surge tanks offer the following advantages over evaporation ponds:

- Less waste solids would be generated with tanks because the tanks would be enclosed and windblown dust and dirt would not enter the tanks as it would with open evaporation ponds.
- Tank sediments could be managed and removed in a more environmentally acceptable manner compared to evaporation ponds.
- Tanks would eliminate the potential for exposure of wildlife (birds, small mammals, amphibians, and reptiles) to the open evaporation ponds.
- Tanks would have less potential of contamination to the surrounding area compared to the potential of spray via enhanced evaporation (sprayers) from the evaporation ponds.
- Tanks (mounted on concrete foundations with spill contaminant) would have less potential of contamination of the soils underneath and around the tanks (e.g., liner leaks of ponds).
- Potential radon emissions would be less of a risk with enclosed tanks (vented in a manner to minimize employee/public exposures) compared to large, open ponds (e.g., evaporation spray systems).
- Tanks would require a smaller footprint than evaporation pond(s).
- Waste volumes of tanks would be less than for evaporation ponds (ponds will generate liners and additional expected contaminated soils to be disposed of as byproduct material).

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Surge/Evaporation Ponds

Surge/evaporation ponds could be a viable alternative in the future if additional surge capacity requirements exceed what could be reasonably handled with additional storage tanks (e.g., size constraints) and DDWs. The surge/evaporation ponds would allow for additional wastewater disposal through passive or enhanced (spray systems) evaporation, especially during the warmer times of the year. Additional surge tanks could be used to the extent possible to minimize the size of any required surge/evaporation ponds. A stated above, prior to the increase in wastewater flows that would result in two DDWs not being able to adequately dispose of the generated wastewaters, viable waste management alternatives will be evaluated in detail. The objective of the alternatives evaluation will be to select options that will adequately handle the maximum amounts of produced wastewaters, while providing for protection of the environment and safe operations by the employees.

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Evaporation ponds are commonly used at ISR facilities for the disposal of liquid wastes, which involves pumping liquids into one or more ponds and allowing natural solar radiation to reduce the volume through evaporation. Wastewaters discharged to evaporation ponds are not always treated prior to discharge to the ponds, which can result in concentration of radionuclides and other metals as the liquids evaporate. The basic design criteria for an evaporation pond system are contained in 10 CFR Part 40, Appendix A, Criteria 5A and 5E. The NRC has established standards for the location of pond(s), design and construction of the required clay or geosynthetic liner systems, pond embankments, and leak detection systems (NRC 2003, NRC 2008). Pond inspection and maintenance criteria are also established by NRC regulations.

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Evaporation pond effectiveness depends on how much waste is being generated over a given time period, evaporation rates for the area being used, and how quickly liquid wastes are generated. Evaporation rates will vary seasonally, being dependent largely upon temperature and relative humidity, with the rate of evaporation being highest during warm, dry conditions and lower during cool, humid conditions. The pond size and surface area can be increased in order to enhance evaporation when the evaporation rates are low or seasonal conditions reduce evaporation.

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NRC recommends that evaporation ponds include sufficient freeboard and reserve capacity. The NRC recommends a freeboard of approximately 3 to 6 feet (distance from water level to top of embankment) and a reserve capacity that will allow the entire contents of one or more ponds to be transferred to other ponds in the event of a leak requiring repair or to handle additional wastewater volumes.

With ponds being open to the atmosphere, dust and dirt can be blown into the ponds, with the concentrations of dissolved solids increasing due to evaporation. This could result in the precipitation of salts form the solution. Periodic cleaning of the ponds may be required in order to maintain good repair and the necessary freeboard. The accumulated pond sediments may need to be disposed of as byproduct material at a licensed disposal facility. When the site is permanently closed, pond liners, accumulated materials, and any contaminated solid underlying or adjacent to the pond liner may need to be disposed of as byproduct material.

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During the winter months in northwest Nebraska, ponds can ice over, resulting in reduced evaporation rates. In order to adequately manage wastewaters year-round in this region, additional storage capacity or additional disposal options would be needed for a typical ISR facility (e.g., land application and/or point source discharge).

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Land Application

In general, liquid waste disposal using the land application alternative would involve pre-treatment of liquid waste in lined settling ponds followed by application of treated waste through center pivot or other types of irrigation sprinklers to agricultural production areas. Application would be seasonally restricted to the approximately mid-March through early-July winter wheat growing season. Treatment may require IX columns, RO, and barium/radium sulfate precipitation to decrease uranium and radium levels in the wastewater below the permitted discharge limits. Until the site and facilities are decommissioned, any byproduct material in storage facilities and within tanks, ponds, and radium-settling basins would need to be managed to prevent any releases (NRC 2003).

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Land application would require the construction of additional facilities, including radium settling pond(s), outlet pond(s) to intercept treated water from the radium settling pond(s), storage pond(s) to store treated water during the non-irrigation season, and emergency containment pond(s). Storage tanks could alternatively be used in place of the settling, storage, and emergency containment ponds.

Although not a preferred option at this time, land application may be a feasible option in the future when used in conjunction with other disposal options such as disposal via DDW with support facilities such as surge tanks or ponds. If land application disposal is determined to be needed in the future, a facility specific land application plan under a license amendment application will be submitted to the NRC for review and approval. In addition, required permits/approvals from the NDEQ and other applicable state agencies will be obtained.

Discharge to Surface Drainage

Discharge of wastewater would be expected to require treatment similar to what is described above for land application. Radionuclides and specific radionuclide parameters would have to meet applicable NDEQ and NRC discharge standards. An NPDES permit would have to be obtained from the NDEQ, and a license condition allowing the activity issued by the NRC. Although not a preferred option at this time, it may viable for future disposal if warranted due to capacity issues.

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See additional discussions of liquid waste disposal in Section 3.12.2.1 and the project water balance in Section 3.12.2.2.

Solid Waste

All solid wastes are transported from the site for disposal. Non-contaminated waste is shipped to an approved sanitary landfill. Contaminated wastes are shipped to an NRC-approved facility for disposal. Should an NRC (or Agreement State)-licensed disposal facility not be available to CBR at the time of decommissioning, on-site burial may be necessary. This alternative could incur long-term monitoring requirements and higher reclamation costs. At this time, CBR believes that off-site disposal of 11(e)2 byproduct material from the MEA at a licensed disposal facility is the best alternative, and there are no plans for on-site disposal.

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2.4 Alternatives Considered but Eliminated

As a part of the alternatives analysis conducted by CBR, several mining alternatives were considered. Due to the significant environmental impacts and cost associated with these alternative mining methods in relation to the MEA ore body, they were eliminated from further consideration.

2.4.1 Mining Alternatives

Underground and open pit mining represent the two currently available alternatives to IRM mining for the uranium deposits in the project area. Neither of these methods is economically viable for producing the MEA reserves at this time for several reasons, including the spatial characteristics of the mineral deposit and environmental factors. The depth of the deposit and subsequent overburden ratio make surface mining impractical. Surface mining is commonly undertaken on large, shallow (less than 300 feet) ore deposits. At the MEA, uranium is recovered from depths ranging from about 800 to 1,250 feet bgs.

In addition, the physical characteristics of the deposit and the overlying materials make underground mining infeasible for the MEA. The costs of mine development, including surface facilities, shaft, subsurface stations, ventilation systems, and drifting, would decrease the economic efficiency of the project.

From an environmental perspective, open-pit mining or underground mining and the associated milling process involve higher risks to employees, the public, and the environment. Radiological exposure to the personnel in these processes is increased not only from the mining process but also from milling and the resultant mill tailings. Moreover, the personnel injury rate is historically much higher in open-pit and underground mines than at ISR solution mining operations.

Both open-pit and underground mining methods would require substantial dewatering to depress the potentiometric surface of the local aquifers and provide access to the ore. The groundwater would contain naturally high levels of radium-226 that would have to be removed prior to discharge, resulting in additional radioactive solids that would have to be disposed. For conventional mining, a mill tailings pond containing 5,000,000 to 10,000,000 tons of solid tailings waste from the uranium mill would also be required.

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In a comparison of the overall impacts of uranium ISR with conventional mining, an NRC evaluation (NRC 1982) concluded that environmental and socioeconomic advantages of ISR include the following:

1. Significantly less surface area is disturbed than in surface mining, and the degree of disruption is much lower.
2. No mill tailings are produced, and the volume of solid wastes is reduced significantly. The gross quantity of solid wastes produced by ISR is generally less than 1 percent of that produced by conventional milling methods (more than 948 kg [2,090 lb] of tailings usually result from processing each metric ton [2,200 lb] of ore).
3. Because no ore and overburden stockpiles or tailings pile(s) are created and the crushing and grinding ore-processing operations are not needed, the air pollution problems caused by windblown dusts from these sources are eliminated.
4. The tailings produced by conventional mills contain essentially all of the radium-226 originally present in the ore. By comparison, less than 5 percent of the radium in an ore body is brought to the surface when ISR methods are used. Consequently, operating personnel are not exposed to the radionuclides present in and emanating from the ore and tailings, and the potential for radiation exposure is significantly lower than that associated with conventional mining and milling.
5. By removing the solid wastes from the site to a licensed waste disposal site and otherwise restricting them from contaminating the surface and subsurface environment, the entire mine site can be returned to unrestricted use within a relatively short time.
6. Solution mining results in significantly less water consumption than conventional mining and milling.
7. The socioeconomic advantages of uranium ISR include:
   - The ability to mine a lower grade ore
   - A lower capital investment

- Less risk to the miner
- Shorter lead time before production begins
- Lower manpower requirements

Finally, and perhaps most important, because CBR is an established commercial solution mining site, there are no viable alternative mining methods at this time. The current market price of uranium makes an established solution mining operation the most economically viable method of mining uranium at the MEA at this time.

The uranium ISR process is used when specific conditions exist, including the following (EPA 2008):

- *The ore is too deep to be mined economically by conventional means.*
- *The uranium is present in multiple-layered roll fronts.*
- *The ore body is below the water table.*
- *The ore grade is low, and the ore body is too thin to mine by conventional means.*
- *A highly permeable rock formation exists in which uranium can be economically produced.*

These conditions exist at the MEA site.

2.4.2 Production Facility Alternatives

The option existed for CBR to construct a new yellowcake production facility for the MEA project rather than the proposed satellite facility. The selected option was the construction of a new satellite facility instead because the existing CBR production facility is only approximately11 miles (17.7 km) to the north-northwest of the proposed MEA site.

The use of the existing facility as a centralized processing facility will allow processing of uranium-loaded resin from the CBR's proposed MEA satellite facility and two other nearby proposed satellite facilities (NTEA and TCEA). Such a centralized design enhances the economics of uranium production in the region by maximizing production capacity while minimizing further capital expenditures on processing facilities. The construction and operational cost of a satellite facility would be significantly lower than that of a new production facility. The potential for release of radiological particulates would be lower for a satellite facility due to it being a "wet" process because no yellowcake would be produced. Other advantages include: less land disturbance for the operating assets; non-radiological air emissions (e.g., fugitive dust, diesel, and gasoline emissions) during operations would be lower; fewer employees working at the site would be potentially exposed to radiation; there would be less byproduct and other types of waste generated that would need to be handled and disposed of; smaller deposits located within the MEA can be mined with the resin trucked to the CPF; and the front end of the "milling" process can begin independent of the larger CPF.

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In summary, the construction and operation of a new processing facility was not deemed to be a viable economical alternative and would result in more environmental impacts than a new satellite facility. Transportation of the uranium-loaded resin from the satellite facility to the CPF would serve as an additional risk. However, such risk is deemed minimal with the use of trucks designed for hauling resin, trained drivers, required speed of the vehicles, conditions of the roadways, minimal amount of road traffic in the area, and relative short distance between the two facilities.

2.5 Cumulative Effects

2.5.1 Cumulative Radiological Impacts

On October 17, 2006, CBR submitted a license amendment request to the NRC requesting an increase in the licensed flow at the CPF. License Condition 10.5 of SUA-1534 limited current operation to an annual facility throughput of 5,000 gpm exclusive of restoration flow. CBR requested an amendment to this license condition to increase production and assist restoration efforts. The production increase was to be accomplished by expanding the existing facility and mining existing wellfields to lower levels of soluble uranium. CBR requested approval to increase the annual facility throughput to 9,000 gpm exclusive of restoration flow. The amendment request did not change the annual licensed production rate of 2,000,000 pounds of U_3O_8 per year. NRC issued the license amendment on November 30, 2007.

The only environmental impact of the increased flowrate at the current operation is a corresponding increase in the emission of radon-222 from the current operation. The amendment estimated a 22 percent increase in the maximum public dose, and that the maximum public dose would remain well below the limit found in 10 CFR § 20.1301.

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2.5.2 Future Development

CBR has identified several additional areas in the region near the CPF that are being considered for development. Licensing and permitting efforts are ongoing for two additional satellite facilities (NTEA and TCEA). Development of additional facilities is not currently planned, although such development depends on further site investigations by CBR and the future of the uranium market. If conditions warrant, CBR could submit additional license amendment requests to permit development of these additional resources. However, CBR currently projects that development of these areas would be primarily intended to maintain production allowed under the current license as reserves in the current licensed area and at the MEA are depleted.

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2.6 Comparison of the Predicted Environmental Impacts

Table 2.6-1 summarizes the environmental impacts for the no-action alternative (Section 2.1), the preferred alternative (Section 2.2), and the process alternatives (Section 2.3.1). The predicted impacts for the mining alternatives discussed in Section 2.4 are not included for comparison because these alternatives were rejected due to significant environmental and economic impacts. Environmental impacts are discussed in greater detail in Section 4.

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Table 2.6-1 Comparison of Predicted Environmental Impacts

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3 DESCRIPTION OF THE AFFECTED ENVIRONMENT

3.1 Land Use

This section evaluates the effects of the proposed uranium mining on the physical, ecological, and social characteristics of the surrounding environments. Land and water use in the current CBR license area are discussed in the license renewal application previously submitted for NRC License Number SUA-1534 (NRC 2007a). Land and water use for the proposed NTEA are discussed in a license amendment application submitted to the NRC on May 30, 2007 (NRC 2007b). In addition, land and water use are discussed in a license amendment application for the proposed TCEA (NRC 2010), which is pending.

This section describes the nature and extent of present and projected land and water use and trends in population or industrial patterns. The information for the CPF was initially developed over a 9-month period in 1982 as part of the R&D License Application, updated in 1987 for the Commercial License Application, and in 1997 and 2007 during license renewal. The information for the MEA was developed in 2011. Preliminary data were obtained from several sources including previous licensing documents supported by field studies and interviews with various state and local officials.

RG 1569 requires a discussion of land and water use in the proposed MEA, and within a 2-mile (3.3 km) distance from the site boundary. The NDEQ requires an assessment of a 2.25-mile (3.62 km) radius of the proposed project site boundary (AOR) for the Class III UIC application. Therefore, the NRC's 2-mile (3.2 km) radius has been extended to 2.25 miles (3.62 km) for consistency. Land use within the MEA and the 2.25-mile (3.62 km) AOR is illustrated on **Figure 3.1-1**

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Land use and water use data were updated from previous license applications by additional data collection and review, personal communications, and site reconnaissance. Population distribution characteristics were updated using current 2010 Census data and other applicable sources (USCB 2011).

Little change in land use has been noted in recent decades, reflecting the stagnant nature of economic activity and a slight decline in the populations of the City of Crawford and Dawes County.

3.1.1 General Setting

The MEA is located in southwestern Dawes County, Nebraska, just south of the Pine Ridge. The center of the MEA is located approximately 4 miles (6.4 km) north-northeast of the community of Marsland (**Figures 1.1-3** and **3.1-1**). The main access route to the MEA is via State Highway (SH) 2/71 west of Marsland, then east along Niobrara Street and River Road, and then north on either Squaw Mound Road or Hollibaugh Road.

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3.1.2 Land Use

Land use of the MEA and surrounding AOR is dominated by agricultural uses (**Figures 3.1-1** and **3.5-1**). **Table 3.1-1** describes major land use types, including those depicted on **Figure 3.1-1**. Land use acreages for the AOR (**Table 3.1-2**) and MEA (**Table 3.1-3**) are presented in **Figure 3.1-1** in 22.5 sectors centered on each of 16 compass points radiating out from the proposed satellite facility. Major land uses within the MEA and AOR are further discussed below.

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Rangeland comprises the greatest land cover within the 2.25-mile (3.62 km) AOR (73 percent). Forest lands (13.4 percent), cropland (7.8 percent), and recreational land (3.3 percent) are the other significant

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land cover types. Less than 0.07 percent (30 acres) of the AOR is accounted for by wetlands. Scattered rural residences are mostly associated with agricultural operations.

Residential and commercial land uses in Dawes County are concentrated within the city limits of Crawford and Chadron and in the communities of Whitney and Marsland. Industrial land uses within the city limits of Crawford are generally associated with railroad facilities.

Within the MEA, rangeland is the dominant land use (80 percent), with cropland (10 percent) and forestland (7.8 percent) accounting for smaller areas (**Table 3.1-3**).

3.1.2.1 Agriculture

Several of the soil types found in the vicinity of the MEA are classified as prime farmland. However, in Dawes County, soils are classified by the U.S. Natural Resource Conservation Service (NRCS) as prime farmland only if irrigated. According to 2009 Census of Agriculture for Nebraska, nearly 9 percent of Dawes County agricultural land is irrigated, and about 16 percent of harvested cropland acreage is irrigated (NASS 2009a). The remainder of the irrigated land is used for pasture, habitat, or rangeland (NASS 2009b). Irrigated land is found in both the MEA and the AOR.

Tables 3.1-4 and **3.1-5** show agricultural productivity and livestock inventory, respectively, within Dawes County. Wheat and forage are the major crops grown on croplands in Dawes County. Most of these crops are used for livestock feed, while the remaining crops are commercially sold. In 2010, total wheat production in Dawes County was 1,195,000 bushels, a decrease of 24 percent from 2009 production (NASS 2011). In 2010, 96,600 tons of forage was grown; this was a decrease of approximately 11 percent from the 2009 harvest. Non-livestock agricultural lands in Dawes County had a value of $13.61 per acre, indicating that crop production on existing farmed lands in the AOR have a potential value (assuming full use of lands) of $39,801, and $6,041 in the MEA (NASS 2009a).

In 2007, 69,429 head of livestock was reported in Dawes County (NASS 2009a). The livestock inventory for Dawes County indicates that cattle account for more than 90 percent of all livestock. Livestock, poultry, and their products account for approximately 75 percent of the total market value of all agricultural products sold in 2007; this is a slight decrease from 2002, when livestock accounted for approximately 86 percent of market value. In 2007, cash receipts for livestock and products totaled $34.3 million in Dawes County (NASS 2009a). Livestock, poultry, and their products carried a value of $40.40 per acre, indicating that livestock production on rangeland within the AOR has a potential value (assuming full use of lands) of approximately $1.1 million, and $145,448 in the MEA (NASS 2009a).

The market value of crops of $13.61 per acre was calculated as follows:

Market value of crops, including nursery and greenhouse crops ÷ Land in Farms: $11,550,000 ÷848,753 acres = $13.61/acre.

The market value of livestock, poultry, and their products of $40.40 was calculated as follows:

Market value of livestock, poultry, and their products ÷ Land in farms
$34,286,000 ÷ 848,753 acres = $40.40/acre

These values were calculated using the data from Table 1. County Summary Highlights: 2007 for Dawes County (NASS 2009a). The methodology used for the calculations was from a publication by Doris N. Petersan (Petersan 2005).

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3.1.2.2 Recreation

Recreational opportunities provided by federal and state lands in Dawes County have become an increasingly important component of the local economy. There are no developed recreation facilities within the MEA or the AOR. Nearby recreational facilities in Dawes County include the Ponderosa State Wildlife Management Area (SWMA), Chadron State Park, Soldier Creek Wilderness Area, the Red Cloud Picnic Area, trails in the Nebraska National Forest, Box Butte Reservoir State Recreation Area, and Fort Robinson State Park (DeLorme Maps 2005). Approximate distances from the proposed MEA satellite facility to local and regional recreational facilities are presented in **Table 3.1-6**.

3.1.2.3 Residential

In 2010, there were a total of 567 houses in the City of Crawford, with 470 occupied (334 by owners and 136 by renters), and 418 houses in the Village of Hemingford, with 315 occupied (253 by owners and 82 by renters) (USCB 2011).

Based on site reconnaissance in May 2011 and a combination of Google Earth and Nebraska Department of Natural Resources (NDNR) aerial imagery of the area, there are two housing units in the MEA, only one of which was occupied at the time of the reconnaissance. The occupied residence is located in SW¼ NW¼ section 7, and the unoccupied residence is located in T29N, R50W and SE ¼ NE¼ section 2, T29N, R51W, as shown on **Figure 3.1-2**. The AOR contains an additional 25 structures, of which seven are occupied. There are a total of eight occupied housing units within the MEA and the 2.25-mile (3.62 km) AOR.

Table 3.1-7 shows the distance to the nearest residence within the 2.25-mile (3.62 km) AOR and to the nearest site boundary from the center of the MEA for each 22.5° sector centered on each compass point. There are two residences within 1 mile (1.6 km) of the center point of the proposed MEA.

3.1.2.4 Habitat

Habitat lands are those dedicated wholly or partially to the production, protection, or management of species of fish or wildlife. Significant areas classified as habitat nearest to the MEA include the Ponderosa SWMA, located approximately 5.2 miles (8.4 km) north of the MEA boundary; the Fort Robinson SWMA, located 13.7 miles (22.0 km) northwest of the MEA boundary; and the Petersen SWMA, located 13.8 miles (22.2 km) north-northwest. There is no land within the MEA used primarily for wildlife habitat. Wildlife habitat is a secondary use of rangeland, forestland, and recreational land within the MEA and the 2.25-mile (3.62 km) AOR. An evaluation of habitat in the MEA is included in Section 3.5, with habitat types in the MEA shown in **Figure 3.5-1**.

3.1.2.5 Industrial and Mining

Numerous exploratory wells targeting mineral resources and hydrocarbons have been drilled in the MEA and the AOR. Besides CBR, Conoco, Amoco Minerals, Santa Fe Mining, and Union Carbide have also drilled exploratory test holes for uranium resources in the general area. With the exception of these exploratory wells, there are no other industrial facilities within the 2.25-mile (3.62 km) AOR.

There is one abandoned oil and gas exploratory well located within the MEA or the 0.25-mile (0.4 km) ZOEI, but four abandoned wells are present within the 2.25-mile (3.62 km) AOR (**Figure 3.1-3**). Based upon review of public records, all referenced oil and gas wells have been properly plugged and abandoned in accordance with the Nebraska Oil and Gas Conservation Commission regulations (NOGCC

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2011). A discussion of oil and gas test holes pertinent to the MEA is presented in Section 3.3.1.1 (see Pierre Shale subheading under Montana Group).

The nearest operating uranium recovery is the CBR operations located approximately 7.5 miles (12.1 km) to the north-northwest of the MEA (NRC 2011a). The location of the MEA site in relation to other proposed CBR satellite facilities is shown in **Figure 1.1-3**.

Project descriptions and locations of operating and proposed uranium recovery facilities in neighboring Wyoming and South Dakota can be found at the NRC website (NRC 2011a). The other uranium in-situ facilities nearest to the MEA in eastern Wyoming and western South Dakota in different stages of development are identified in **Table 3.1-8**. There are no existing or proposed uranium recovery facilities located within 75 miles (120.7 km) of the proposed MEA project. The nearest operating uranium recovery facility is the Power Resources, Inc. Smith Ranch/Highland Central Processing Plant in Wyoming, and the nearest proposed uranium in-situ facilities are Powertech Uranium Corporation's Dewey-Burdock facility located in Fall River and Custer Counties of South Dakota, and the Uranium One's Moore Ranch project located in Converse County, Wyoming. The NRC maintains a status of major uranium recovery licensing applications in the U.S., which is periodically updated (NRC 2013).

Other than CBR uranium recovery activities, there are no other known planned uranium recovery operations in Nebraska (NRC 2011b). There are two nuclear power reactors located in extreme eastern Nebraska that are more than 300 miles (482.8 km) from the proposed MEA project site. The nearest licensed nuclear fuel cycle facility (a gas centrifuge uranium enrichment facility) is located in Idaho Falls, Idaho and operated by AREVA Enrichment Services.

3.1.2.6 Commercial and Services

There are no known retail or commercial establishments within the MEA or the 2.25-mile (3.62 km) AOR. The nearest retail and commercial establishments are located in Crawford and Hemingford, which are more than 11 miles (17.7 km) from the MEA.

3.2 Transportation and Utilities

SH 2/71 runs to the west of the MEA. It converges with U.S. Highway 20 in the City of Crawford north-northwest of the MEA. The northern portion of the MEA is accessed from SH 2/71 via East Belmont Road; the southern portion of the MEA is accessed from SH 2/71 via River Road and Hollibaugh Road. The 2010 average daily traffic counts for a segment of SH 2/71 near Marsland at the southern end of the MEA was 675 total vehicles, including 90 heavy commercial vehicles. Traffic levels on SH 2/71 increase to 695 total vehicles, including 90 heavy commercial vehicles in the vicinity of East Belmont Road (NDOR 2010). Secondary and private roads connect with East Belmont Road, River Road, Hollibaugh Road, and Squaw Mound Road to provide access to residences and agricultural lands within the MEA. No railways cross the MEA; a Burlington Northern Santa Fe rail line runs to the west of the MEA and through a small portion of the 2.25-mile (3.62 km) AOR between the MEA and SH 2/71.

3.3 Geology, Seismology and Soils

This section describes the regional and local geology, seismology, and soils related to the MEA and area. The geology of the CPF, NTEA, and TCEA has been discussed in previous license applications submitted to the NRC. Detailed information contained in these reports (e.g., laboratory results and field data that describe formation characteristics [lithology, mineralogy, permeability] for the Pierre Shale, Chadron

Formation, and the Brule Formation at the CPF), also applies in a general sense to the MEA. These data, in addition to new information from exploratory drilling/logging activities within the MEA, are used to describe the geology and seismology in this section.

3.3.1 Geology and Seismology

3.3.1.1 Regional Setting

As shown on **Figure 1.1-3**, the proposed northwest corner of the license boundary of the MEA occurs approximately 11 miles (17.7 km) south-southeast of the southeast corner of the city limits of the City of Crawford, Nebraska in sections 26, 35, 36 (SW ¼) of Township 30 North, Range 51 West; sections 1, 2, 11, 12, 13 of Township 29 North, Range 51 West; and sections 7, 18, 19, 20, 29, 30 of Township 29 North, Range 50 West. The City of Crawford is 25 miles (40.2 km) west of Chadron, Nebraska and 70 miles (112.6 km) north of Scottsbluff, Nebraska. The City of Crawford is 21 miles (33.8 km) south of the South Dakota state line and 33 miles (53.1 km) east of the Wyoming state line. The Marsland area is located near the northern limits of the High Plains section of the Great Plains physiographic province. Topography of the Marsland area includes gently sloping, rolling hills with outlying, broad ridges dissected by intermittent and perennial streams. The most prominent physiographic feature in the region is the Pine Ridge Escarpment, which rises roughly 300 to 900 feet above the basal plain and bounds three sides of the Crawford Basin. Colluvial and alluvial deposits originating from this escarpment cover the permit area. The elevation of the MEA ranges from 3,880 to 4,400 feet above mean sea level (amsl).

- Regional Stratigraphy

Table 3.3-1 summarizes the regional stratigraphic section for northwest Nebraska that includes the White River Group (Brule Formation through basal sandstone of the Chadron Formation). A geologic map of bedrock in northwestern Nebraska is shown on **Figure 3.3-1**. The bedrock map depicts the occurrence of the Miocene Ogallala Group, Miocene Arikaree Group, the Eocene-Oligocene White River Group, and Upper Cretaceous strata belonging to the Montana Group and Colorado Group. The Upper Cretaceous Pierre Shale, the unconformably overlying White River Group (Brule Formation, Chadron Formation, and Chamberlain Pass Formation), and the Arikaree Group outcrop in the vicinity of the City of Crawford and MEA (**Figure 3.3-1**, see inset).

- MEA Stratigraphy

The local stratigraphy of the MEA consists of the following geological units in descending order: alluvial sediments, upper Harrison Beds, Monroe Creek - Harrison Formation, Gering Formation, Brule Formation, upper Chadron Formation, upper/middle Chadron Formation, middle Chadron Formation, basal sandstone of the Chadron Formation, and Pierre Shale. The channel sandstone facies of the basal sandstone of the Chadron Formation represents the production zone and target of solution mining in the MEA. The general stratigraphic section for the MEA is summarized in **Table 3.3-2**. **Figure 3.3-2** is a cross-section index map depicting the locations of 14 north-south and east-west cross-sections through the MEA depicted on **Figures 3.3-3a** through **3.3-3n**.

Though a thick (approximately 1,200 to 1,500 feet), regionally extensive stratigraphic section of sedimentary units underlies the Pierre Shale, those units are not relevant to this proposal. The absence of sandstone units for more than 1,000 feet below the top of the Pierre Shale precludes the need for monitoring zones below the surface of the Pierre Shale. Discussion in this report is limited to the Arikaree Group, White River Group, and Pierre Shale (Petrotek 2004; Wyoming Fuel Company 1983).

This section provides a detailed description of the stratigraphy of the MEA based on an extensive review of existing site-specific drilling logs and published literature. Geological units are described from stratigraphically youngest to stratigraphically oldest. Revised nomenclature for these stratigraphic units is discussed, where applicable, and referred to throughout this application. To be consistent with historical permitting, the majority of stratigraphic nomenclature used in previous submittals to the NRC and the NDEQ has been preserved.

The cross-sections shown in **Figures 3.3-2 and Figures 3.3-3a** through **3.3-3n** are based on 57 boreholes. There were a total of over 2,180 pre-mining boreholes drilled within the MEA AOR.

All exploration holes are logged using down hole geophysical methods. Resistivity, Spontaneous Potential, Gamma, and drill hole Deviation are measured along with depth to provide the data logs. Logs are printed out as well as saved onto compact disc (CD) for data storage. Logging procedures have been described in detail in Section 3.1.2.4 of the MEA Technical Report.

Additionally, Cameco Resources' geologists evaluate the drill cuttings removed during the drilling process (if available), and write a description of the observed lithology for each drill hole. These "Lithologic Log" descriptions include observed depths of identified strata, color, textures, oxidation state, minerals observed and other uranium markers. These lithology log descriptions are correlated to the geophysical logs to provide better understanding of the borehole.

All exploration and development holes drilled in the MEA have been abandoned in accordance with the requirements of State of Nebraska Title 135, Chapter 5.002 and the Mineral Exploration Permit as approved by NDEQ. The Hole Plugging Plan as outlined in Attachment 2 of the approved Application for Mineral Exploration Holes for Mineral Exploration Permit NE#0210824 is shown below (NDEQ 2009).

The locations for all drill holes have been surveyed either by certified public land surveyors, or have been located through the use of differentially corrected Global Positioning System (GPS) by Cameco Resources personnel for positional and elevation data. All drill holes are capped with an aluminum cap stamped with the hole ID number, Section, Township and Range and "CBR" on the surface.

- Alluvium

Quaternary alluvium as thick as 30 feet overlies the Arikaree Group along drainages in the study area. In general, the alluvium consists of fragments of locally outcropping Oligocene-Miocene sedimentary rocks, sand, gravel, sandy soil horizons, and may include weathered portions of the Arikaree Formation. Because alluvium is unconsolidated and may incorporate one or both of the vadose and phreatic (shallow groundwater) zones, log signatures within this unit vary in comparison with those of geologic units in the underlying units. On most MEA logs, resistivity values for alluvium are very high, beyond the log scale, indicating the presence of either soil vapor or fresh water (**Figure 3.3-4**).

In general, shallow zones with elevated resistivity are also distinguished by a negatively deflected SP curve, suggesting the presence of a permeable zone and formation fluid with lower resistivity than the fluid within the borehole. Although these log signatures suggest that the base of the alluvium can be readily identified in geophysical logs, this relationship has not been verified at the MEA. Therefore, the alluvium-Arikaree Group contact illustrated on cross-sections **Figures 3.3-3a** through **3.3-3n** is an inferred contact.

- Arikaree Group (Oligocene-Miocene)

The Oligocene–Miocene Arikaree Group is a water-bearing unit overlain by alluvium. The thickness varies from 50 to 210 feet depending upon the degree of erosion. The Arikaree lies unconformably above the Brule Formation and is composed of the upper Harrison Beds, Harrison-Monroe Creek, and Gering Formations, aged youngest to oldest, respectively (**Table 3.3-2**; Collings and Knode 1984; Swinehart et al. 1985; LaGarry 1998; McFadden and Hunt 1998).

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Literature has named the upper Harrison Beds the Marsland Formation or split into the Harrison and Monroe Creek Formations. This application uses nomenclature presented in Swinehart et al. (1985), which uses the upper Harrison Beds, Harrison-Monroe Creek, and Gering Formations.

The Arikaree Group contains numerous channel and floodplain deposits. In some locations, cross bedding is observed. Grain size increases from very fine to fine to medium. The coarsest materials are epiclasts from the White River Group and the Rocky Mountains (Bradley and Rainwater 1956; Tedford et al. 1985; Hoganson et al. 1998).

An isopach map of the undifferentiated Arikaree Group is shown on **Figure 3.3-5**. Within the license boundary, the thickness of the Arikaree Group ranges from approximately 50 to 210 feet and averages about 106 feet. The unit is thickest throughout the central portion of the license boundary but thins on both the northwest and southeast ends of the project. The unit is stratigraphically continuous across the MEA.

On geophysical logs, the Arikaree Group is characterized by an off-scale resistivity signature (**Figure 3.3-4**). The neutron-neutron (N-N) or SP curve exhibits small fluctuations and is relatively straight. The SP or N-N curve can also be off the scale. The gamma curve indicates no anomalous radioactivity. No distinguishing features are seen within the geophysical logs to ascertain contacts within the Arikaree Group. The contact between the Arikaree Group and the overlying alluvium is difficult to ascertain. Often the SP or N-N curve will begin at the base of the alluvium, and the resistivity will move sharply to the right. The contact between the Arikaree and Brule Formations is indicated where the resistivity begins to move left (becomes lower). Little change is seen within the gamma or SP curves.

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Upper Harrison Beds

The upper Harrison Beds are composed of buff to gray fine sand without abundant silt and clay, white sand with abundant silt and clay, and a siliceous pedogenic horizon. Thickness of this unit can be up to 150 feet. Convolute laminae occur within the fine sand and contain very little silt or clay. The massive unlaminated white sand was deposited by sheet flow following rains and/or flooding after a heavy ash fall. The lower part of the upper Harrison Beds contains large blocks of sandstone formed from underlying strata; this indicates fluvial channel deposition. Cross-stratified beds are also found (Cook 1915; Witzel 1974; Hunt 1981; Vicars and Breyer 1981).

The upper Harrison Beds contain preserved paleosurfaces overlain by silica cement. The paleosurfaces are valleys, which were infilled by ephemeral stream deposits and overlain by aeolian volcaniclastic sands. Freshwater ostracods, animal burrow, and root casts are abundant (Hunt 1981).

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Harrison - Monroe Creek Formation

The Harrison-Monroe Creek Formation can be divided into upper, middle, and lower portions. All of the portions are similar, and the middle and lower portions are sometimes undistinguished.

The upper portion of the Harrison-Monroe Creek Formation is fine grey sand. This sand is generally 200 feet thick and is massively bedded. The sands were deposited from channel fills. Concretions can be found within the unit (Witzel 1974; McFadden and Hunt 1998).

The middle portion of the Harrison-Monroe Creek Formation is composed of fine, unconsolidated grey sediments. The lower portion is composed of compact fine sandy silt and clay, pinkish to buff in color, and a fine to medium grained gray sand. In the vicinity of Harrison and Crawford, the middle portion of the Harrison-Monroe Creek Formation is 285 to more than 360 feet thick and the lower portion ranges in thickness from 185 to 220 feet (Witzel 1974; McFadden and Hunt 1998).

Grey concretions composed of long, irregular fine grained cylindrical masses are found in the middle and lower portions of the Harrison-Monroe Creek Formation (Lugn 1939; Witzel 1974; Collings and Knode 1984). According to Schultz (1941) and Svoboda (1950), the concretions were formed when groundwater enriched with calcium carbonate ($CaCO_3$) flowed through deposited sediments and calcite was precipitated "...in a situation similar to stalactite formation only in a horizontal direction" (Svoboda 1950). Schultz (1941) mapped the orientations of the concretions and found that, within northwest Nebraska, the trend orientation was to the southeast and away from uplift. This finding agrees with groundwater flow at the time of formation (Witzel 1974).

Gering Formation

The Gering Formation is mainly composed of gray, grayish-brown volcaniclastic fine to medium grained sandstones, silty sandstones, silt and local beds of ash, coarse sand, and fine gravel. Most of the sand is laminated and contains local cross beds. Beds of greenish-white bentonitic diatomaceous earth, which weathers into hard white layers, are found throughout most of the Gering. Wellman (1964) divided the Gering into upper and lower units. The two portions of the Gering Formation are separated by a volcanic ash that is up to 6 feet thick. At some localities outside of the MEA, the Gering Formation is up to 200 feet thick. Towards Chadron, the Formation thins to about 70 feet (Cady and Scherer 1946; Witzel 1974; Collings and Knode 1984; McFadden and Hunt 1998).

The upper portion of the Gering is finer grained than the lower portion. It is composed of sandy siltstones and silty, fine grained sandstones deposited by floodplains. There are some clay pebble conglomerates and clay lenses. It is distinguished from the overlying Harrison-Monroe Creek Formation by having pipy concretions which are less elongated in form (Witzel 1974).

The lower portion of the Gering contains coarse to fine grained sandstone, silty fine grained sandstone, sandy siltstone, and silty claystone. Channel deposits formed the coarse to fine grained sandstones. Distal and proximal floodplains formed the sandy siltstone and silty claystone, respectively. The unconformable contact between the Brule and Gering Formations is readily observed when coarse sediments of the Gering Formation are in contact with the finer grained Brule Formation. When the sediments of the Gering are fine grained, the contact is more difficult to discern (Witzel 1974; Collings and Knode 1984; McFadden and Hunt 1998). The contact can also be determined by a change in slope or color. The Gering Formation is white in color and forms steeper slopes than the underlying Whitney Member of the Brule Formation (Witzel 1974).

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- White River Group (Eocene-Oligocene)

The White River Group consists of the Chamberlain Pass Formation overlain by the Chadron Formation, which is, in turn, overlain by the Brule Formation (**Table 3.3-2**). Strata assigned to this group were deposited within fluvial, lacustrine, and eolian environments (Terry and LaGarry 1998). In northwest Nebraska, it rests unconformably on weathered Pierre Shale. The bulk of the White River Group consists of air fall and reworked volcaniclastics derived from sources in Nevada and Utah (Larson and Evanoff 1998; Terry and LaGarry 1998).

There have been various interpretations of the history of stratigraphic nomenclature for the White River Group of Nebraska and South Dakota as described by Harksen and Macdonald (1969). The following stratigraphic nomenclature retains the formal and informal members based on nomenclature by Schultz and Stout (1955), but also includes more recent nomenclature (Terry and LaGarry 1998; Terry 1998; LaGarry 1998; Hoganson et al. 1998).

Brule Formation

The Oligocene Brule Formation represents the youngest unit within the White River Group, which outcrops throughout most of the Crow Butte area. The unit conformably overlies the Chadron Formation and is unconformably overlain by sandstones of the Arikaree Group (**Figure 3.3-1**). The Brule Formation was originally subdivided by Swinehart et al. (1985) and later revised by LaGarry (1998) into three members, from youngest to oldest: the "brown siltstone" member, the Whitney Member, and underlying Orella Member (**Table 3.3-2**). The "brown siltstone" member consists of pale brown and brown, nodular, cross bedded eolian volcaniclastic siltstones and sandy siltstones.

The contact with the underlying Whitney Member varies from a gradational contact to a sharp disconformity where the "brown siltstone" fills valleys incised into the older strata of the Whitney Member. The Whitney Member consists mostly of pale brown, massive, typically nodular eolian siltstones with rare thin interbeds of brown and bluish-green sandstone and volcanic ash. The basal 10 meters of the Whitney Member consist of white or green laminated fluvial siltstones, sheet sandstones, and channel sandstones. The contact between the Whitney Member and the underlying Orella Member is intertonguing. The Orella Member consists of pale brown, brown, and brownish-orange volcaniclastic overbank clayey siltstones and silty claystones, brown and bluish-green overbank sheet sandstones, and thin volcanic ashes. Rare thick, fine to medium grained, channelized sandstones appear throughout the Orella Member. These sandstones appear to have very limited lateral extent. The overall thickness of the Brule Formation within the MEA is generally less than 400 feet and ranges from approximately 50 to 350 feet.

An isopach map of the undifferentiated Brule Formation is shown on **Figure 3.3-6**. The thickness ranges from approximately 50 to 350 feet and averages about 170 feet. The unit steadily increases in thickness from the southeast to the northwest end of the project, and the unit is stratigraphically continuous.

The contact between the Brule Formation and underlying Chadron Formation is difficult to identify in some places, as it is intertonguing (LaGarry 1998). Regionally, the contact is recognized as the lithologic change from thinly interbedded and less pedogenically modified brown, orange, and tan volcaniclastic clayey siltstones and sheet sandstones of the Orella Member to pedogenically modified green, red, and pink volcaniclastic silty claystones of Big Cottonwood Creek Member in the upper Chadron Formation (Terry and LaGarry 1998). The Brule Formation is characterized by rapidly fluctuating geophysical log curves, or "log chatter" (**Figure 3.3-4**). This response is recognized in resistivity curves, and to a lesser extent in SP curves, throughout the MEA. Such fluctuations result from resistivity contrasts between the thinly interbedded siltstones and sandstones of the Orella Member. Because the sandstones are porous and constitute a part of the regional aquifer, the contacts with the interbedded, dry siltstones are sharp and easily recognized on logs (Gutentag et al. 1984). Lateral correlation of beds within the Brule Formation is very difficult due to generally thin bed thicknesses and limited lateral extent.

The contact between the interbedded siltstones and sandstone of the Brule Formation and the silty claystones of the upper Chadron Formation is distinguished by a drop-off of "log chatter" and establishment of relatively flat or straight curves (i.e., the shale baseline) on both resistivity and SP logs (**Figure 3.3-4**). Because of the intertonguing nature of the lower Brule and upper Chadron Formations, thin, isolated sandstones and siltstones may be present in the upper Chadron, making it appear that the formation contact is deeper in some wells. **Figures 3.3-3a** through **3.3-3n** depict the subsurface geology of the Brule Formation within the MEA.

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Chadron Formation

The Eocene-Oligocene Chadron Formation is in the lower part of the White River Group (**Table 3.3-2**). The Chadron Formation conformably overlies the basal sandstone and is conformably overlain by the Brule Formation. From top to bottom, the Chadron Formation historically consists of the following stratigraphic units: Big Cottonwood Creek Member (herein referred to as the informal upper Chadron and upper/middle Chadron to be consistent with historical permitting), Peanut Peak Member (herein referred to as the informal middle Chadron to also be consistent with historical permitting), and basal sandstone of the Chadron Formation (also known formally as the Chamberlain Pass Formation). The basal sandstone of the Chadron Formation represents the production zone and target of ISR mining within the MEA. **Figures 3.3-3a** through **3.3-3n** depict the subsurface geology of the Chadron Formation within the MEA.

Upper Chadron Formation

The upper Chadron Formation and upper/middle Chadron Formation are composed primarily of volcaniclastic overbank silty claystones interbedded with tabular and lenticular channel sandstones, lacustrine limestones, pedogenic calcretes, marls, volcanic ashes, and gypsum (Terry and LaGarry 1998). Tuffs in the Toadstool Park area that occur in the upper Chadron were dated by $^{40}Ar/^{39}Ar$ methods as late Eocene (~34,000,000 years ago [Ma]) in age (Terry and LaGarry 1998). The lower boundary of this member is an intertonguing contact with the underlying middle Chadron, or is a local unconformity where the upper/middle Chadron fills valleys and depressions (Terry and LaGarry 1998; **Table 3.3-2**). The upper boundary is recognized by a lithologic change from pedogenically modified green, red, and pink volcaniclastic silty claystones of the upper Chadron to thinly interbedded and less pedogenically modified brown, orange, and tan volcaniclastic clayey siltstones and sheet sandstones of the Orella Member of the Brule Formation (Terry and LaGarry 1998; **Table 3.3-2**).

The upper Chadron is the youngest member of the Chadron Formation (**Table 3.3-2**). The upper part of the upper Chadron is light green-gray bentonitic clay grading downward to green and frequently red clay, though interbedded sandstones also occur. An isopach map of the upper Chadron is shown on **Figure 3.3-7**. The available data suggest that the upper Chadron ranges in stratigraphic thickness from approximately 410 to 650 feet and averages about 507 feet across the MEA (**Figures 3.3-3a** through **3.3-3n**). Two core samples (M-1454c, Run 1 and M-1624c, Run 1) were collected from the upper Chadron by CBR at boreholes M-1454c and M1624c, sections 1 and 12, T29N, R51W of the MEA (**Figure 3.3-2**). X-ray diffraction (XRD) analyses of M-1454c Run 1 and M-1624 Run 1 samples indicate varied compositions. M-1454c Run 1 was primarily composed of calcite, montmorillonite, and quartz. Minor amounts of plagioclase, potassium feldspar, and illite/mica were recorded. M-1624c was primarily composed of mixed layered illite/smectite, calcite, and quartz. Minor amounts of plagioclase, potassium feldspar, magnetite, and illite/mica were recorded.

Particle size distribution analyses of M-1454c Run 1 and M-1624c Run 1 give median grain sizes of 0.056 mm (silt) and 0.049 mm (silt), respectively. Both samples are dominated by silt-sized grains; however, M-1454c Run 1 contained more medium sand than M-1624c, which increased the median grain size. M-1454c Run 1 contained 47.25 percent silt and 9.64 percent clay. M-1624c Run 1 contained 54.65 percent silt and 8.73 percent clay. As M-1454c Run 1 and M-1624c Run 1 both contain more than 50 percent combined silt and clay-sized particles, and because more than 67 percent of the silt+clay component is silt, they are classified as siltstones (Brown and Harrell 1991).

Typical gamma ray (GR), SP, and resistivity log signatures for the upper Chadron exhibit curves representative of the relatively flat shale baseline (**Figure 3.3-4**). Fluctuations are present among upper Chadron log curves, representing interbedded siltstones, sandstones, limestones, and volcanic ash deposits that occur less commonly than in the overlying Brule Formation.

Upper/Middle Chadron Formation

The upper/middle Chadron is directly overlain by the upper Chadron (**Table 3.3-2**). At some locations, the upper/middle Chadron is similar in appearance to the channel sandstone facies of the upper portion of the basal sandstone of the Chadron Formation (described later in this section) and is typically very fine to fine grained, well-sorted, poorly cemented sandstone. However, within the MEA permit boundaries, the water-bearing sandstones of the upper/middle Chadron Formation, recognized in other locations such as NTEA, are not present within the MEA. Geophysical logs (discussed below) and core samples indicate the presence of a finer grained facies than that present at NTEA. Therefore, because the sandstones of the upper/middle Chadron are absent, the upper Chadron and middle Chadron Formation comprise a thick continuous mudstone and siltstone sequence within the MEA. **Figures 3.3-3a** through **3.3-3n** show an inferred stratigraphic position for the upper/middle Chadron at the contact between the upper Chadron and middle Chadron units across the permit area.

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Review of geophysical logs from within the permit boundaries indicates that the upper/middle Chadron has poor reservoir characteristics and minimal water saturation. When compared to aquifers of the Brule Formation and basal sandstone of the Chadron Formation (discussed below), inflections in resistivity, N-N, and SP curves are almost wholly unseen within the upper/middle Chadron (**Figures 3.3-3a** through **3.3-3n** and **3.3-4**). At TCEA, the upper/middle Chadron was recognized and correlated primarily on the basis of decreased neutron counts (indicating increased porosity), increased resistivity (indicating the possible presence of relatively fresh water), and other log signature combinations.

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Correlation of the upper/middle Chadron at MEA using GR log signatures is problematic due to the presence of bentonitic deposits throughout the upper and middle Chadron Formation. Occasionally, very minor increases in resistivity are present at the stratigraphic level likely to represent the upper/middle Chadron, but are not consistent across the MEA. These comparatively muted log signatures indicate that water may be intermittently present within the upper/middle Chadron. However, water saturations are not significant enough to create strong log responses as recognized in other known aquifers within the MEA. Therefore, a continuous sandstone aquifer within the upper/middle Chadron is interpreted to be absent within the MEA.

Middle Chadron Formation

The middle Chadron is a clay-rich interval that grades from brick red to grey in color with interbedded bentonitic clay and sands. A light green-gray "sticky" clay within this unit serves as an excellent marker bed in drill cuttings and has been observed in virtually all regional test holes within the MEA, TCEA, NTEA, and the CPF. The middle Chadron unconformably overlies the basal sandstone of the Chadron Formation (Chamberlain Pass Formation) in South Dakota and Nebraska (Terry 1998; **Table 3.3-2**). As described above, the upper boundary is variable and is overlain either by the upper/middle Chadron, where present, or by the upper Chadron (**Table 3.3-2**).

The middle Chadron differs from the overlying upper/middle and upper Chadron in that the middle Chadron is composed of bluish-green, smectite-rich mudstone and claystone; weathers into hummocky, "haystack-shaped" hills and slopes with a popcorn-like surface; is less variegated in color; and contains less silt (Terry 1998). The predominantly clay lithology of the middle Chadron represents a distinct and rapid facies change from the underlying basal sandstone of the Chadron Formation. An isopach map of the middle Chadron is shown on **Figure 3.3-8**. The available data suggest that the middle Chadron typically ranges in thickness from approximately 20 to 290 feet and averages about 180 feet across the MEA.

Two core samples (M-1454c, Run 2 and M-1624c, Run 2) were collected from the middle Chadron by CBR at boreholes M-1454c and M1624c, sections 1 and 12, T29N, R51W of the MEA (**Figure 3.3-2**). XRD analyses of M-1454c Run 2 and M-1624 Run 2 samples indicate varied compositions. Samples M-1454c Run 2 and M-1624c Run 2 are primarily composed of mixed layered illite/smectite; however, M-1454c Run 2 also contains a high amount of calcite. Other minor minerals found within the samples include quartz, plagioclase, potassium feldspar, chlorite, and illite/mica. Particle size distribution analyses of M-1454c Run 2 and M-1624c Run 2 give median grain sizes of 0.027 mm (silt) and 0.065 (very fine sand) mm, respectively. Both were mainly composed of silt sized particles; however, M-1624c Run 2 contained more medium sand than M-1454c Run 2, which increased the median grain size. M-1454c Run 2 contained 46.36 percent silt and 20.65 percent clay. M1624c Run 2 contained 34.6 percent silt and 16.54 percent clay. Both are classified as siltstones (Brown and Harrell 1991).

Typical GR, SP, and resistivity log signatures for the middle Chadron exhibit curves representative of the shale baseline (**Figure 3.3-4**). The contact between the top of the middle Chadron and the overlying upper Chadron is difficult to ascertain due to similarities in grain size. At MEA, due to like lithology and geophysical log responses between the upper/middle and middle Chadron Formation, it is difficult to define the contact between these units. Therefore, **Figures 3.3-3a** through **3.3-3n** show an inferred stratigraphic location for the upper/middle Chadron and middle Chadron contact across the permit area.

The upper and middle Chadron units represent the upper confining zone for the basal sandstone of the Chadron Formation within the MEA (see detailed discussion in Section 3.4.3.3). Isopach maps created for the formations that comprise the upper confining zone are presented as **Figures 3.3-7** (upper Chadron) and **3.3-8** (middle Chadron). Because the upper/middle Chadron is not recognizable on geophysical logs or in cores, its thickness is considered to be zero across the MEA and it is not included as part of either upper confining zone isopach map. The total thickness of the upper confining zone ranges from approximately 430 to 940 feet and averages about 690 feet, and generally appears to thicken toward the south and southwest across the MEA.

Basal Sandstone of the Chadron Formation – Mining Unit

The basal sandstone of the Chadron Formation is the oldest unit in the White River Group. The lower part is a coarse grained, arkosic sandstone with common, discontinuous interbedded thin silt and clay lenses of varying thickness. The basal sandstone of the Chadron Formation overlies a distinct regional unconformity with the underlying Yellow Mounds Paleosol (Terry 1998). The lower contact is easily recognized as a change from the underlying black or bright yellow, pedogenically modified surface of the

Pierre Shale (i.e., the Yellow Mounds Paleosol) to white channel sandstone. In places, the basal sandstone of the Chadron Formation grades upward to fine sandstone containing varying amounts of interstitial clay and persistent clay interbeds. Vertebrate fossils from the basal sandstone of the Chadron Formation in northwestern Nebraska and South Dakota indicate a late Eocene age (Chadronian; Clark et al. 1967; LaGarry et al. 1996; Lillegraven 1970; Vondra 1958). The Upper Interior Paleosol, occurring as a persistent clay horizon, typically brick red in color, developed on top of the basal sandstone of the Chadron Formation and generally marks the upper limit of the basal sandstone of the Chadron Formation (**Table 3.3-2**). The Upper Interior Paleosol represents pedogenically modified distal overbank deposits of a distinct fluvial system developed on the surface of the basal sandstone of the Chadron Formation, which predates deposition of the Chadron Formation.

The basal sandstone of the Chadron Formation occurs at depths ranging from about 817 to 1,130 feet bgs and was encountered in all exploration holes. An isopach map of the basal sandstone of the Chadron Formation across the MEA is presented on **Figure 3.3-9**. Stratigraphic thickness of the unit within the MEA ranges from approximately 20 to 110 feet and averages about 55 feet. The thickest sections of the unit occur in the western portions of the MEA (**Figure 3.3-9**). Up to four distinct sandstone packages are present in the thickest portions of this unit and are separated by variable amounts of interbedded clay. A structure contour map was generated of the contact of the basal sandstone of the Chadron Formation and the Pierre Shale (**Figure 3.3-10**). The structure map indicates that the base of the Chadron Formation dips slightly to the north-northwest across the MEA and ranges in elevation from 3,101 to 3,252 feet amsl (**Figure 3.3-10**).

The greenish-white channel sandstones of the basal sandstone of the Chadron Formation that overlie the Yellow Mounds Paleosol are the target of ISR mining activities in the MEA. Regionally, deposition of the basal sandstone of the Chadron Formation has been attributed to large, high-energy braided streams (Collings and Knode 1984; Hansley et al;. 1989; Hansley and Dickenson 1990). This depositional environment produced lenticular sandstone deposits with numerous facies changes occurring within short distances. Interbedded thin silt and clay lenses most likely represent flood plain or low velocity deposits normally associated with fluvial sedimentation.

Core samples (M-1454C, Runs 3 and 4, and M-1624C, Runs 3 and 4) were collected from the basal sandstone of the Chadron Formation by CBR at boreholes M-1454c and M-1624c in sections 1 and 7, T29N, R51W (**Figure 3.3-2**). XRD analysis of the M1454c sample indicates a varied composition. Run 3 is mainly composed of quartz, whereas Run 4 is mainly composed of mixed-layered smectite. Minor amounts of plagioclase feldspar, potassium feldspar, kaolinite, and illite/mica were found in both samples. Run 3 also yielded trace amounts of calcite, siderite, pyrite, magnetite, and magnesium vanadium oxide, while Run 4 had minor amounts of dolomite and chlorite. Particle size distribution analyses of M-1454c Run 3 and M-1624c Run 4 give median grain sizes of 0.075 mm (very fine sand) and 0.711 (coarse sand) mm, respectively. M-1454c Run 3 contained 29.85 percent silt and 19.92 percent clay. M1624c Run 4 contained 11.56 percent silt and 4.5 percent clay. Both are classified as sandstones (Brown and Harrell 1991).

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The sandstones of the basal sandstone of the Chadron Formation within the CPF are dominated by quartz (50 percent monochrystalline) and feldspar (30 to 40 percent undifferentiated feldspar) with the remainder made up of chert, pyrite, and various heavy metals and polycrystalline and chalcedonic quartz (Collings and Knode 1984). XRD analyses indicate that the basal sandstone of the Chadron Formation within the area of the CPF is 75 percent quartz with the remaining 25 percent consisting of a combination of potassium feldspar, plagioclase, illite, smectite, expandable mixed layer illite-smectite, and kaolinite (Collings and Knode 1984).

Geophysical logs record a unique signature for the basal sandstone of the Chadron Formation (**Figure 3.3-4**). A distinct GR spike is present at the base of the unit in most of the MEA exploration boreholes, indicating an abundance of radioactive material. Increased resistivity (i.e., log curve shift to the right), decreased N-N count (i.e., log curve shift to the left), and decreased SP (i.e., log curve shift to the left) are typically associated with GR spikes. These log signatures support interpretations of a uranium-bearing, fluid-filled sandstone interval. Overlying channel sandstone intervals present in the middle and upper portions of the unit typically have lower GR readings, indicative of both lower amounts of radioactive materials and potentially non-uranium-bearing intervals. Such intervals are typically marked by increased resistivity (i.e., higher porosity and fluid-filled) and lower N-N counts and, in contrast to the uranium-bearing units, typically have positive SP curve deviations. This log response indicates that, within the higher uranium-bearing units, mud filtrate resistivity is higher than formation water resistivity, which may be the result of the presence of higher salinity waters in uranium-bearing units.

Pervasive interbedded clay intervals are indicated by high GR responses accompanied by lower resistivity (i.e., reduced porosity and decrease in water content), an interpretation further supported by driller or geologist's notes. The high radioactivity of these clay-rich units suggests the presence of rhyolitic ash (Hansley and Dickenson 1990). The top of the formation is marked by a gradual return of SP and resistivity curves to the shale baseline.

- Montana Group

Interior Paleosol (Yellow Mounds Paleosol)

The Interior Paleosol of Schultz and Stout (1955) was subsequently divided into the younger Eocene Upper Interior Paleosol and the older Cretaceous Yellow Mounds Paleosol (Pierre Shale) (Terry 1991; Evans and Terry 1994; Terry and Evans 1994; Terry 1998; **Table 3.3-2**). As noted above, the Upper Interior Paleosol represents pedogenically modified distal overbank deposits of a distinct fluvial system developed on the surface of the basal sandstone of the Chadron Formation which predates deposition of the Chadron Formation. The Yellow Mounds Paleosol developed on the Cretaceous Pierre Shale and altered the normally black marine shale to bright yellow, purple, light bluish-grey, and orange.

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Review of available data for the MEA indicates that neither of the two paleosol units could be consistently interpreted based solely on geophysical logs. For simplicity, these units are not represented on the type log or cross-sections.

Pierre Shale

Offshore deposition in the Cretaceous Interior Seaway produced the late Cretaceous Pierre Shale (**Table 3.3-2**). The Pierre Shale is a thick, homogenous black marine shale with low permeability that represents one of the most laterally extensive formations of northwest Nebraska. Regional geologic data indicate that this formation can be up to 1,500 feet thick in the Dawes County area (Wyoming Fuel Company 1983; Petrotek 2004). The southward retreat of the Cretaceous Interior Seaway resulted in the subaerial exposure and weathering of rock units from Early Cretaceous to Eocene age across the northern Great Plains (Lisenbee 1988). This event resulted in the erosion and pedogenic modification of the surface of the Pierre Shale and formation of the brightly colored Yellow Mounds Paleosol (Terry and LaGarry 1998; **Table 3.3-2**). Consequently, the pedogenically modified surface of the Pierre Shale marks a major unconformity with the overlying White River Group and exhibits a paleotopography with considerable relief (DeGraw 1969). The Pierre Shale is underlain by organic-rich shale and marl with minor amounts of sandstone, siltstone, limestone, and chalk of the Niobrara Formation (**Table 3.3-1**).

Core samples (M-1454C, Run 4, and M-1624C, Run 5) were collected from the Pierre Shale by CBR at boreholes M-1454c and M-1624c in sections 1 and 7, T29N, R51W (**Figure 3.3-2**). XRD analysis of the samples indicated a primary composition of mixed layered illite/smectite and quartz, with minor amounts of plagioclase, potassium feldspar, dolomite, pyrite, kaolinite, chlorite, and illite/mica. Particle size distribution analyses of M-1454c Run 4 and M-1624c Run 5 give median grain sizes of 0.007 mm (silt) and 0.005 mm (silt), respectively. M-1454c Run 3 contained 60.15 percent silt and 39.4 percent clay. M1624c Run 4 contained 50.88 percent silt and 47.85 percent clay. Both are classified as claystones (Brown and Harrell 1991).

Typical geophysical log responses for the Pierre Shale exhibit shale baseline curves that are relatively flat or straight (**Figure 3.3-4**; **Appendix C**). On resistance logs, the top of the Pierre Shale is noted where the curves break either sharply to the left or to the right and represent the occurrence of the basal sandstone of the Chadron Formation. SP and resistivity curves qualitatively indicate a lack of permeable water-bearing zones within the Pierre Shale.

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Six deep oil and gas exploration wells were drilled in the vicinity of the MEA: Chicoine 1, Chiocoine 1A, Hollibaugh No. 1, Porter, Roscoe Royal #1, and #1-A Smith (**Appendix C**). Oil and gas exploration wells have typically been drilled to depths much greater than on-lease uranium exploration wells. The character of the entire Pierre Shale in the vicinity of the MEA can best be observed in geophysical logs from three of the six nearby abandoned oil and gas wells (Hollibaugh No. 1, Roscoe Royal #1, and #1-A Smith), and the CBR DDW (CBR UIC #1), which were completed through the entire thickness of the unit. Based on observations from logging, the thickness of the Pierre Shale in the vicinity of the MEA ranges from approximately 750 to more than 1,000 feet. The top of the Pierre Shale was encountered in all wells at depths ranging from approximately 600 to 1,300 feet bgs.

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The Hollibaugh No. 1 well is located within the license boundary (T29N, R51W, section 12) and has a total depth of 3,283 feet bgs. The Pierre Shale was encountered at 1,025 to 1,915 feet bgs. The Roscoe Royal #1 is located about 0.5 mile (0.8 km) north of the license boundary (T30N, R51W, section 23) and has a total depth of 3,956 feet bgs. The Pierre Shale was encountered at 1,200 to 2,287 feet bgs. The #1-A Smith well is located about 0.25 mile (0.4 km) east of the license boundary (T29N, R50W, section 29) and has a total depth of 2,902 feet bgs. The Pierre Shale was encountered at 947 to 1,716 feet bgs. DDW CBR UIC #1 (T31N R52W section 19) is located approximately 10.7 miles (17.2 km) northwest of the MEA license boundary and has a total depth of 3,910 feet bgs. At UIC #1, the Pierre Shale was encountered from 925 to 1,560 feet bgs, where the base of the Pierre Shale is indicated by an increase in resistivity at the contact with the underlying Niobrara Formation (**Appendix C**). Plugging records for these wells are shown in **Appendix D-1.**

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- Stratigraphy of Units Below the Pierre Shale

Underlying the Pierre Shale is a thick sequence of Mississippian through Cretaceous age strata that unconformably overlie Precambrian granite (**Table 3.3-1**). Together with the Pierre Shale, the underlying Niobrara Formation, Carlile Shale, Greenhorn Limestone, and Graneros Shale compose a composite lower confining interval approximately 2,500 feet thick which immediately underlies the basal sandstone of the Chadron Formation. With the exception of the hydrocarbon-bearing "D", "G", and "J" sands of the

Dakota Group (occasionally interbedded with the Graneros and Huntsman Shales; **Table 3.3-1**), there do not appear to be significant sandstone units within this thick sequence of low-permeability strata.

All geologic units encountered during the drilling of oil and gas exploration wells in the vicinity of the MEA appear to be consistent with known regional stratigraphy. Geologic units that are consistently identified in all wells include the Niobrara Formation, Carlile Shale, Greenhorn Limestone, "D" and "J" sands of the Dakota Group, and the Skull Creek Formation (**Table 3.3-1**).

3.3.1.2 Geochemical Description of the Mineralized Zone

The depth to the ore body within the basal sandstone of the Chadron Formation in the MEA ranges from approximately 800 to 1,250 feet bgs (**Table 3.3-2**). The ore grade as U_3O_8 ranges from 0.11 to 0.33 percent with an average ore grade of 0.17 percent.

Hansley et al. (1989) conducted detailed geochemical analysis of the Crow Butte uranium ore to assess both ore genesis and composition. The Crow Butte deposits, including Three Crow, are roll-type deposits with coffinite being the predominant uranium mineral species present. The origin of the uranium is rhyolitic ash, which is abundant within the matrix of the basal sandstone of the Chadron Formation (Hansley et al. 1989). Coffinite is associated with pyrite and high silica activity due to dissolution of the rhyolitic ash which favored formation of coffinite over uraninite in most parts of this sandstone. In addition, smectite is present in the samples examined, with the most common minerals in the sandstone being quartz, plagioclase, potassium feldspar, coffinite, pyrite, marcasite, calcite, illite/smectite, and tyuyamunite. The heavy mineral portion of the samples contained several minerals including those above as well as garnet, magnetite, marcasite, and illmenite. Vanadium was detected in the samples primarily as an amorphous species presumed to have originated from the in-situ ash. Hansley et al. state that at least some uranium and vanadium remain bound to amorphous volcanic material and/or smectite rather than as discrete mineral phases.

Petrographic data obtained and examined by Hansley et al. (1989) suggest that uranium mineralization occurred before lithification of the basal sandstone of the Chadron formation. Hansley states: *"Dissolution of abundant rhyolitic volcanic ash produced uranium (U) and silicon (Si) rich ground waters that were channeled through permeable sandstone at the base of the Chadron by relatively impermeable overlying and underlying beds. The precipitation of early authigenic pyrite created a reducing environment favorable for precipitation and accumulation of U in the basal sandstone. The U has remained in a reduced state, as evidenced by the fact that the unoxidized minerals, coffinite and uraninite, comprise the bulk of the ore."*

Based on similar regional deposition, the MEA ore body is expected to be similar mineralogically and geochemically to that of the ore body at the CPF. The ore bodies in the two areas are within the same geologic unit (the basal sandstone of the Chadron Formation) and have the same mineralization source. The sites are separated by only a few miles, and the cause of mineral deposition in the two areas appears to be similar. Neither site is anticipated to be significantly affected by recharge or other processes.

3.3.1.3 Structural Geology

Regional uplift during the Laramide Orogeny forced the southward retreat of the Cretaceous Interior Seaway, resulting in the subaerial exposure and weathering of rock units from Early Cretaceous to Eocene age across the northern Great Plains (including the Pierre Shale). The depositional basin associated with deformation of the Wyoming thrust belt and initial Laramide uplifts to the west of Nebraska, represented a structural foredeep. The greatest uplift occurred in the Black Hills, which lie north of Sioux and Dawes Counties in southwestern South Dakota. Lisenbee (1988) provides a comprehensive summary of the tectonic history of the Black Hills uplift. The pre-Oligocene Black Hills uplift (<37 million years [Ma]) occurred prior to the deposition of the Eocene-Oligocene strata of the White River Group. Strata of the White River Group cover most of the eroded roots of the Black Hills uplift as well as the syntectonic sedimentary rocks in the Powder River and Williston basins. The Hartville, Laramie, and Black Hills uplifts supplied sediment for rivers that flowed east-southeast across the study area (Clark 1975; Stanley and Benson 1979; Swinehart et al. 1985).

The most prominent structural expression in northwest Nebraska is the Chadron Arch (**Figures 3.3-11** and **3.3-12**). Together with the Chadron Arch, the Black Hills Uplift produced many of the prominent structural features presently observed in the region. The Chadron Arch represents an anticlinal feature that strikes roughly northwest-southeast along the northeastern boundary of Dawes County. Swinehart et al. (1985) suggested multiple phases of probable uplift in northwestern Nebraska near the Chadron Arch between c.a. 28 Ma and <5 Ma. The only known surficial expressions of the Chadron Arch are outcroppings of Cretaceous rocks that predate deposition of the Pierre Shale in the northeastern corner of Dawes County, as well as in small portions of Sheridan County, Nebraska and Shannon County, South Dakota. The general locations of faults in northwest Nebraska are depicted on the State Geologic Map shown on **Figure 3.3-1**.

The 230-mile (370.1 km) long Pine Ridge escarpment exhibits an average of 1,200 feet of relief (Nixon 1995). The Pine Ridge is an arc roughly concentric to the Black Hills Dome, which suggests an apparent structural relationship. Nixon (1995) interpreted the escarpment as representing the southern outermost cuesta of the Black Hills Dome. The escarpment is capped by sandstone of the Arikaree Group with exposed deposits of the White River Group mapped along the topographically lower, northern side of the escarpment.

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The Crow Butte area, including the CPF, NTEA, and TCEA, is within the Crawford Basin (DeGraw 1969). The proposed MEA lies just outside of the southern boundary of the basin along the Cochran Arch. DeGraw (1969) substantiated known structural features and proposed several previously unrecognized structures in western Nebraska based on detailed studies of primarily deep oil test hole data collected from pre-Tertiary subsurface geology. The Crawford Basin was defined by DeGraw (1969) as a triangular asymmetrical basin about 50 miles (80 km) long in an east-west direction and 25 miles (40.2 km) to 30 miles (48.3 km) wide. The basin is bounded by the Toadstool Park Fault on the northwest, the Chadron Arch and Bordeaux Fault to the east, and the Cochran Arch and Pine Ridge Fault to the south (**Figures 3.3-11** and **3.3-12**). The Crawford Basin is structurally folded into a westward-plunging syncline that trends roughly east-west. Note that the Bordeaux Fault, Pine Ridge Fault, and Toadstool Park Fault proposed by DeGraw (1969) are not presented on the State Geologic Map (**Figure 3.3-1**). The Toadstool Park Fault has been mapped at one location (T33N, R53W) and is estimated to have had approximately 60 feet of displacement (Singler and Picard 1980). The City of Crawford is located near the axis of the Crawford Basin. More recent fault interpretations by Hunt (1990) for northwest Nebraska are also shown on **Figure 3.2-12**, which include the Whetstone Fault, Eagle Crag Fault, Niobrara Canyon Fault, and Ranch 33 Fault in the vicinity of the Town of Harrison in Sioux County. The faults identified by Hunt (1990) all trend to the northeast-southwest, sub-parallel to the Pine Ridge Fault (**Figure 3.3-12**).

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The structural map by DeGraw (1969) referenced above was subsequently modified by Stout et al. (1971) to include additional features. Of these, the Niobrara River Fault is most relevant to the MEA. Stout et al. (1971) mapped the Niobrara River Fault as occurring parallel to the Niobrara River in southernmost

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Dawes County and northernmost Box Butte County (**Figure 3.3-12**). No description of the Niobrara River Fault is provided, nor is evidence provided to support the interpretation of its location. As described above, many of the fault locations (e.g., Pine Ridge Fault) interpreted by DeGraw (1969) were based on the apparent displacement of the pre-Tertiary geologic surface (e.g., top of Pierre Shale) or on an unpublished structural contour map of western Nebraska. Structural contour mapping of the pre-Tertiary surface does not indicate any displacement of the surface in the area of the Niobrara River Fault (DeGraw 1969).

As proposed by Stout et al. (1971), the Niobrara River Fault appears to be a western extension of the Hyannis-North Platte Fault and forms the northern boundary of a graben which contains the Niobrara River valley. An unnamed fault forms the southern boundary of the graben. These faults appear to be generally continuous with the Agate Spring Fault complex of eastern Sioux County (Hunt 1990; **Figure 3.3-12**). Approximately 60 feet of vertical displacement of Arikaree Group sediments has occurred along the Agate Springs Fault in T28N, R55W. Radiometric dating of volcanic tuff displaced by the Agate Springs Fault indicates a maximum age of approximately 19.2 million years for the Agate Springs Fault, and by extension, the Niobrara River Fault (Hunt 1990). Because the Agate Springs and Niobrara River Faults are not included in the USGS Quaternary Fold and Fault Database (USGS 2010, a compendium of faults with evidence of movement between 1.6 million years and ago and the present), it can be inferred that the most recent movement along both faults was between 19.2 and 1.6 million years ago.

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Cameco geophysical data were reviewed to determine if additional data support the location of the Niobrara River Fault and associated graben proposed by Stout et al. (1971). **Figure 3.3-13** presents a regional structural contour map of the top of the Pierre Shale. Boring data indicate the presence of a west-east trending structural trough along the top of the Pierre Shale in the vicinity of the Niobrara River. This trough is generally parallel to, but slightly to the north of the proposed graben location (**Figure 3.3-12**). The best evidence of the structural trough is from CBR exploration borings located west of the MEA license boundary, and the feature may extend to the southern portion of the MEA license boundary. Due to lithologic similarities between the lower Arikaree Group and upper Brule Formation, identifying the geologic contact between those units based on geophysical logs or drill cuttings observation is tenuous; therefore, no assessment of potential offset of the Arikaree Group correlative to that observed in outcrop at the Agate Springs Fault has been undertaken.

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It cannot be determined from existing data whether the structural trough represents a graben related to the proposed Niobrara River Fault, a synclinal feature related to the southern limb of the Cochran Arch, or a paleotopographical feature. As further work is completed at MEA, more data will become available regarding the potential presence of the proposed Niobrara River Fault. Additional aquifer pumping tests will be conducted to cover all areas to be mined and to demonstrate the natural confinement of the basal sandstone of the Chadron Formation in the southern portion of the MEA.

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Diffendal (1994) performed lineament analyses on a mosaic of early Miocene synthetic-aperture radar images and largely confirmed known faults in the vicinity of Chadron. Lineaments in the radar image along Pine Ridge, located to the south of Chadron, are attributed to jointing or faulting and trend N40E and N50W (Diffendal 1982). Similar features were also noted west of Fort Robinson. Swinehart et al. (1985) report that these features are likely an extension of the Wheatland-Whalen trend in Wyoming (Hunt 1981; Wheeler and Crone 2001).

Former drilling activities at the Crow Butte Project identified a structural feature, referred to as the White River Fault, located between the CPF Class III permit area and the NTEA (**Figure 3.3-12**). Evidence of a fault was identified during the exploration drilling phase of the Crow Butte Project (Collings and Knode 1984). The fault is manifested in the vicinity of the NTEA as a significant northeast-trending, subsurface fold. The detailed kinematics of the White River Fault were investigated during preparation of the NTEA Petition for Aquifer Exemption. An extensive review of drilling and logging data determined that, while the White River Fault may cut the Pierre Shale at depth along with stratigraphically lower units, there is no evidence that a fault offsets the geologic contact between the Pierre Shale and overlying White River Group or individual members of the White River Group. This fault does not appear to be present in the vicinity of the MEA.

3.3.1.4 Seismology

National Seismic Hazard Maps and Risks

The USGS updated the National Seismic Hazard Maps in 2008, which includes changes in the methodology used to model potential seismicity in any given region (Petersen et al. 2008). Wheeler and Crone (2001) described Quaternary fault zones and their potential seismic activity. Their findings were used to develop the prior National Seismic Hazard Map. The revised maps incorporate new seismic, geologic, and geodetic information on earthquake rates and associated ground shaking. The maps supersede versions released in 1996 and 2002. The next update to the National Seismic Hazard Maps is scheduled for 2014.

The National Hazard Maps show the distribution of earthquake shaking levels that have a certain probability of occurring in the U.S. (**Figure 3.3-14**; USGS 2009g). The hazard rating ranges from the lowest hazard (0.4 %g) to the highest (64+ %g), with the City of Crawford area and the majority of Nebraska being located in a low hazard ranking level of 4 to 8 %g. The term "%g" is a unit of acceleration (movement of earth) measured in terms of gravity (g) (i.e., acceleration due to gravity). Peak acceleration (%g) refers to the maximum acceleration (movement) experienced during a non-uniform earthquake event (i.e., starts off small, achieves a maximum, and then decreases).

The seismic hazard map for Nebraska (**Figure 3.3-15**), represents the %g with a 2 percent probability of exceedances in 50 years (USGS 2009a), meaning that in a given 50-year period, there is only a 2 percent chance of seismic shaking exceeding any given equivalent percentage of acceleration due to Earth's gravity. **Figure 3.3-15** also shows that the modeled peak acceleration due to seismic shaking in the City of Crawford area is very low (6 to 8 %g for the majority of the immediate area and 8 to 10 %g in a much smaller area), meaning that the maximum shaking due to any given earthquake in the region during a 50-year period would be equivalent to only 10 percent or less of the force of gravity at Earth's surface. These estimates demonstrate that the Marsland and City of Crawford area are at the low end of the USGS' hazard ranking system for earthquake risks. Note that the differences between **Figures 3.3-14** and **3.3-15** in hazard ranking values are due to the use of different scales (i.e., 4 to 8 versus 6 to 8, respectively).

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Earthquake Magnitude and Intensity

Earthquakes release different amounts of energy and the strength of this energy can be measured by magnitude and intensity (CDERA 2009). A comparison of the magnitude and intensity scales is shown in **Table 3.3-3** as well as the USGS abbreviated descriptions of the 12 levels on the Modified Mercalli (MM) scale. The Richter Scale is used to measure the magnitude of an earthquake and is a measure of the physical energy released or the vibrational energy associated with the earthquake. In general, earthquakes below 4.0 on the Richter scale do not cause damage, and earthquakes below 2.0 usually cannot be felt. However, earthquakes rated higher than 5.0 on the Richter Scale can cause damage. An earthquake of a magnitude 6.0 is considered strong, and a magnitude of 7.0 is considered a major earthquake.

The MM scale measures the intensity of an earthquake, and consists of 12 increasing levels of intensity that range from imperceptible shaking to catastrophic destruction (USGS 2009b). It is an arbitrary ranking by the USGS based on observed effects rather than mathematics.

For states in the U.S. that had reported earthquakes with a magnitude of 3.5 or greater from 1974 to 2003, the State of Nebraska had a total of eight (less than 0.05 percent of the total of 21,080 earthquakes occurring in the U.S; USGS 2009d). **Figure 3.3-15** is a seismic hazard map of Nebraska (USGS 2009e). A seismicity map of Nebraska that shows the distribution of earthquakes from 1973 to 2013 is shown on **Figure 3.3-16**.

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The first significant earthquake recorded in Nebraska occurred on April 24, 1867, apparently centered near Lawrence, Kansas. It affected an estimated area of 301,159 square miles (mi^2) (780,000 square kilometers [km^2]) including much of Nebraska. Since 1867, there have been at least seven earthquakes of MM Intensity V or greater originating within Nebraska's boundaries. It is thought that the strongest earthquake in Nebraska occurred on November 15, 1877. The total area affected was approximately 138,996 mi^2 (360,000 km^2) including most of Nebraska. The most recent earthquake occurred on November 18, 2010 (depth of 3.1 miles [5 km]), approximately 15 miles (24.1 km) east-southeast of Columbus, Nebraska in Platte County, east central Nebraska (lat. 41.37N long. 97.07W). The magnitude of this earthquake was 3.3 on the Richter Scale. The epicenter was approximately 326 miles (525 km) east southeast of the City of Crawford.

Earthquakes along the Chadron and Cambridge Arches in Western Nebraska

The locations of the Chadron and Cambridge Arches in Nebraska are shown on **Figure 3.3-11**. Earthquakes that have occurred in Nebraska in the vicinity of the Chadron and Cambridge Arches from 1884 to 2009 are identified in **Table 3.3-4**. The MM Intensity of these earthquakes ranged from I to VI, with the majority between I and III. The strongest of these earthquakes centered in Dawes County (near Chadron) occurred July 30, 1934 with an intensity of VI. It affected an estimated area of approximately 23,166 mi^2 (60,000 km^2) in Nebraska, South Dakota, and Wyoming. This earthquake resulted in damaged chimneys, plaster, and china. An earthquake that occurred on March 24, 1938 near Fort Robinson had an intensity of IV; no additional information is available. An Intensity IV earthquake should be felt indoors by many and cause dishes, windows, and doors to be disturbed. An earthquake occurred on March 9, 1963 near Chadron and was reported to last about 1 second. It was not accompanied by any damage or noise and was not even noticed by many of the residents of Chadron. An earthquake occurred on March 28, 1964 near Merriman, the vibrations from which lasted about 1 minute and caused much alarm, but no major damage occurred. Books were knocked off shelves, and closet and cupboard doors swung open. On May 7, 1978, an earthquake with Intensity V occurred in southwestern Cherry County, also near the Chadron Arch. No major damage was reported from this earthquake.

Earthquakes occurring from 1992 through 2007 within 125 miles (201.2 km) of the City of Crawford, in Wyoming, and South Dakota are shown in **Table 3.3-5**. The Richter Scale measurements ranged from 3.0 to 3.8 for Wyoming and 2.5 to 4.0 for South Dakota. The MM Intensity values for Wyoming ranged from II to IV, with all but one of the nine observations ranging from II to III. The MM Intensity values for South Dakota ranged from I to IV, with all but one of the total observations ranging from I to III. The most recent earthquake within the region occurred on November 19, 2011, in South Dakota with the epicenter located 30 miles (48.3 km) west-northwest of the City of Chadron. The earthquake had a magnitude of 2.8 with a depth of approximately 3.0 miles (4.9 km). The most recent earthquake in Wyoming occurred on November 19, 2011 and was located 69 miles (111.0 km) north of Jackson,

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Wyoming, a significant distance from the City of Crawford. It had a magnitude reading of 1.7 with a depth of approximately 1.0 mile (1.2 km).

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Although the risk of major earthquakes in Dawes County and the State of Nebraska is low (Burchett 1990), some low to moderate tectonic activity has occurred (Rothe 1981). This tectonic movement is also suggested by geomorphic and sedimentation patterns during the Pleistocene (Rothe 1981), which reflect such movement. Previous seismic activity along the Cambridge Arch has been reported as possibly related secondary recovery of oil in the Sleepy Hollow oil field located in Red Willow County in southwest Nebraska (Rothe et al. 1981). However, deeper events suggest more recent low-level tectonic activity on the Chadron and Cambridge Arches.

Based on information discussed above, and the historical records for the proposed MEA in northwest Nebraska, no major effects would be expected from earthquakes on ISR activities in the MEA area.

3.3.1.5 Inventory of Economically Significant Deposits and Paleontological Resources

According to the NOGCC there has never been any oil and gas production in Dawes County (NOGCC 2013a). There are no current applications for permits to drill in Dawes County. Two wells are currently producing in Sioux County, but are located at a significant distance southwest of MEA in section 8 Township 25 North, Range 55 West and section 11 Township 25 North, Range 56 West (NOGCC 2011). The only non-fuel mineral produced in Dawes County is sand and gravel. Coal is not produced anywhere in Nebraska (NOGCC 2013b), nor are coal beds expected to be encountered during drilling within the MEA.

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Significant fossil resources, particularly mammalian, are recognized from the Arikaree Group and White River Group in northwestern Nebraska (Hunt 1981; LaGarry et al. 1996; Terry and LaGarry 1998; Tedford et al. 2004). The White River Group, Arikaree Group, and Ogallala Formation are all ranked as Class 5 geologic units in Wyoming under the Potential Fossil Yield Classification (PFYC) System (BLM 2008). Class 5 units are highly fossiliferous geologic units that predictably produce vertebrate fossils or scientifically significant invertebrate or plant fossils that are at risk of human-caused adverse impacts or natural degradation (BLM 2009). PFYC rankings have not been assigned for Nebraska, but due to the abundance of fossils known from these units nearby, similar potential for scientifically significant paleontological resources can be reasonably inferred.

Several quarries near Agate Fossil Beds National Monument, located in Sioux County, contain Miocene mammals. The sites are located about 25 miles (40.2 km) from the MEA. Mammalian orders represented within the upper Harrison Beds and the Harrison-Monroe Creek Formation include Carnivora, Canidae, Amphicyonidae, Ursidae, Mustelidae, Perissodactyla, and Artiodactyla. Fossilized terrestrial beaver burrows called *Daemonelix* are also found in these units (Hunt 1981; NPS 2010). Brontothere (ancient rhinoceros) fossils have been identified in the basal sandstone of the Chadron Formation (Chamberlin Pass Formation) of Sioux County (LaGarry et al. 1996).

3.3.1.6 Soils

The current Crow Butte License Area and the MEA are located in the semiarid northwest region of Nebraska in southern Dawes County. Climate is semiarid (precipitation averages approximately 18 inches per year; SCS 1977). Physiographically, the MEA is located along the southern flank of Pine Ridge, an area of steep, dissected terrain. The numerous drainages present within and adjacent to the MEA are tributary to the Niobrara River, located immediately to the south. Box Butte is located south of the Niobrara River and is slightly lower than but topographically similar to Pine Ridge. Native vegetative cover in the Pine Ridge region is typically mixed-grass prairie and Ponderosa pine trees, but varies across the MEA, with significant areas that are currently cultivated or are degraded rangeland.

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An investigation of MEA soils included review of available published soils data. Soils data for the MEA were obtained from the United States Department of Agriculture (USDA), NRCS Web Soil Survey (SSS 2011). The sources for the Dawes County soils data available from the Web Soil Survey include the Soil Survey of Dawes County, Nebraska, published in February 1977 (SCS 1977), and updated unpublished materials derived from remote sensing images and other digitized soils mapping of Dawes County. Thirty-one soil map units are identified in the project area. Their spatial distributions are illustrated on **Figure 3.3-17**, and their aerial extents summarized in **Table 3.3-6**.

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Soils in the MEA formed through the weathering of Tertiary bedrock material, loess (windblown silt), colluvium, or unconsolidated alluvium. Soils in the project area are shallow to deep silt loams and loamy very fine sands. Soil depth, grain size, and drainage typically increase closer to the Niobrara River and away from the steeper uplands of the MEA (SCS 1977).

Due to the loamy and fine sandy texture of most soils in the MEA, wind and water erosion pose the most significant risks to soil health and productivity, especially where vegetation has been disturbed. These soil textures also dictate the good drainage and high infiltration rates characteristic of most soils in the MEA.

From specific to general, the MEA landscape is composed of various soil series (soils with similar profiles), complexes (two or more series or miscellaneous areas that cannot be mapped separately), and associations (two or more geographically associated series or miscellaneous areas that have a consistent pattern and relative proportion of soils). In certain areas, the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These areas are called land types and are given descriptive names. An example of this is "sandy alluvial land" found within the Busher-Tassel-Vetal association. The General Soil Map of Dawes County, Nebraska (SCS 1977) illustrates the three soil associations that dominate the MEA, which are generally segregated north-to-south according to topographic and physiographic regimes and parent material. The three soil associations described below are not depicted on **Figure 3.3-17**; however, the individual components of each association are illustrated and described fully later in this section.

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The Canyon-Alliance-Rosebud soil association is generally found in the northern portion of the MEA and makes up approximately 40 percent of the project area. This upland soil association consists of "deep to shallow, gently sloping to steep, well-drained loamy and silty soils that formed in material weathered from sandstone" (SCS 1977). Canyon series soils make up about 25 percent of this association, Alliance series soils about 24 percent, and Rosebud series soils about 16 percent. Minor soils and land types make up the remaining 35 percent (SCS 1977).

The Busher-Tassel-Vetal soil association is the most extensive within the MEA (35 percent of the project area) and is found on uplands and footslopes. This soil association consists of "deep and shallow, very gently sloping to steep, well-drained to somewhat excessively-drained, sandy soils that formed in colluvium and in material weathered from sandstone". Busher series soils make up about 35 percent of this association, Tassel series soils about 32 percent, and Vetal series soils about 15 percent. Minor soils and land types make up the remaining 18 percent (SCS 1977).

The Valent-Dwyer-Jayem soil association makes up about 25 percent of the project area and is typically found in uplands adjacent to the Niobrara River in the southern portion of the MEA. This soil association consists of "deep, gently sloping to steep, well-drained to excessively-drained sandy soils". Together, the Valent and Dwyer series soils (which are typically mapped as one unit) make up 68 percent of the association, with Jayem series soils and minor soils and land types both making up about 16 percent each (SCS 1977).

Soil Limitation

The NRCS characterizes soil mapping units and their limitations for a variety of uses based on a wide range of properties such as soil texture, slope, and thickness. In general, MEA soils are moderately to highly susceptible to water erosion, with K-factors (for all soil horizons) of dominant soil map units ranging from 0.15 to 0.55. Hazards for water erosion are lowest in the southern MEA and generally increase uphill and away from the Niobrara River. Hazards for wind erosion are generally high to moderately high within the proposed MUs. Exceptions include MU 6 and portions of MU 1, where the hazard is moderate. MEA soils are particularly susceptible to wind erosion where vegetation cover has been removed.

Almost all soils in the MEA have severe or moderate potential for rutting and compaction, and have limited suitability as natural road surfaces. Due to the high susceptibilities for wind and water erosion prevalent across the MEA, most soils are susceptible to degradation during disturbance. However, almost all MEA soils likely to be disturbed by project activities are also considered highly resilient (i.e., inherent ability to recover degradation) and have high potential for successful restoration. The Tassel soils and Canyon soils in the northern MEA have moderate, or generally favorable, characteristics for restoration. Soil resilience and restoration potential is dependent upon adequate organic matter content, soil structure, low sodium levels, and other factors (SSS 2011).

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Soil Range Classifications

Most land within the MEA is currently used for rangeland. Different soil units support different types and proportions of rangeland vegetation. Knowledge of which types of vegetation represent healthy or poor rangeland conditions facilitates evaluation of restoration efforts and selection of revegetation seed mixes. Five major rangeland site classifications are present within the MEA and are described below: sandy, savannah, shallow limey, silty, and subirrigated. Minor acreages of sandy lowland, shallow to gravel, silty overflow, and mixed rangelands are also present but are not described. Decreaser plants form the majority of climax cover in all range sites (SCS 1977).

Sandy Range Site

Map units 1881, 1882, 5070, 5978, 6091, and portions of unit 5118 are classified as sandy range. Moderately rapid to rapid permeability of the soils heavily influences vegetation types on these soils. A typical climax plant community is about a 50 percent mixture of decreaser plants such as sand bluestem, little bluestem, and prairie junegrass. The remaining 50 percent is perennial grass, forbs, and shrubs. The principal increasers are blue grama, threadleaf sedge, prairie sandreed, needle-and-thread, sand dropseed, western wheatgrass, fringed sagewort, and small soapweed. A site in poor condition will commonly have blue grama, threadleaf sage, sand dropseed, and western ragweed.

Savannah Range Site

Only map unit 5153 is classified as savannah range; however, this range site makes up approximately 10 percent of the MEA. The types of vegetation that occur on this range site are primarily influenced by the wide variations in soil depth, available water capacity, and relief. About 65 percent of climax plant cover is a mixture of such decreaser grasses as little bluestem. big bluestem, side-oats grama, plains muhly, green needlegrass, prairie junegrass, slender wheatgrass, bearded wheatgrass, and western wheatgrass. About 35 percent consists of other perennial grasses, forbs, shrubs. and trees. A site in poor condition typically consists of Ponderosa pine and various species of shrubs and vines.

Shallow Limey Range Site

Map units 5152; 6028; and portions of units 1742, 5118, 5211, and 6043 are classified as shallow limey range sites. The alkaline nature of these soils, along with very low to low available water capacity and shallow rooting depths, influences vegetation types on these soils. Approximately 75 percent of climax plant cover is a mixture of decreaser grasses such as little bluestem, sand bluestem, side-oats grama, needle-and-thread, prairie sandreed, plains muhly, and western wheatgrass. Perennial grasses, forbs, and shrubs make up the remaining 25 percent. These increasers include blue grama, hairy grama, threadleaf sedge, fringed sagewort, common prickly pear, broom snakeweed, skunkbush sumac, and western snowberry.

Silty Range Site

Map units 1356, 1357, 1620, 5105, 5106, 5107, 5200, 5871, and 5947 are classified as silty range sites. The vegetation which grows on these sites is influenced mainly by the moderately slow or moderate permeability of the soils and by their moderate to high available water capacity. About 50 percent of the climax plant cover is a mixture of such decreaser grasses as big bluestem, little bluestem, side-oats grama, western wheatgrass, and prairie junegrass. About 50 percent consists of other perennial grasses, forbs, and shrubs. Blue grama; buffalograss; threadleaf sedge; needle-and-thread; Arkansas rose; and numerous forbs such as dotted gayfeather, false boneset, heath aster, skeletonplant, and scarlet globemallow are the principal increasers. A site in poor condition will typically have blue grama, buffalograss, threadleaf sedge, and sand dropseed.

Subirrigated Range Site

Bankard series soils within the MEA (units 1013 and 1014) are classified as subirrigated range sites. The water table in this range site is typically at a depth of 2 feet in the spring and 6 feet in the early fall. Moisture available from the high water table during the growing season is the main influence on vegetation types on these sites. About 70 percent of the climax cover is a mixture of such decreaser grasses as big bluestem, little bluestem, indiangrass, switchgrass, prairie cordgrass, and Canada wildrye. About 30 percent consists of other perennial grasses such as Kentucky bluegrass, green muhly, western wheatgrass, and sedges. A site in poor condition will typically have Kentucky bluegrass, redtop, foxtail barley, dandelion, western ragweed, blue verbena, and lesser amounts of western wheatgrass and sedges.

Soil Mapping Units

As defined by the NRCS, a map unit is identified and named according to the taxonomic classification of the dominant soils. Map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. **Table 3.3-6** summarizes the soils in map units found within the MEA. The table provides the map unit symbols, map unit names, and estimated acres of the dominant soils in the MEA. The description of each soil mapping unit includes the potential for wind erosion, water erosion, the farmland classification, and the hydric rating. The farmland classification identifies map units as prime farmland, farmland of statewide importance, farmland of local importance, or unique farmland by identifying which soils are best suited to food, feed, fiber, forage, and oilseed crops. The hydric rating indicates the proportion of the map units that meets the criteria for hydric soils, which are an indicator for wetlands. The soils in the MEA are also shown as soil map units on **Figure 3.3-17**.

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Soil map units illustrated on **Figure 3.3-17** consist of soil series, soil complexes, and soil associations, as described above. In addition, certain soil map units represent undifferentiated soil groups made up of two or more soils that could be delineated individually but are shown as one unit because similar interpretations can be made for use and management. The name states the two dominant soil series represented in the group, joined by "and". Four soil map units within the MEA (1742, 5118, 5211, and 6043) are soil complexes, two soil map units (1882 and 5070) are undifferentiated soil groups, and one soil map unit (6043) is a soil association with minor distribution within the MEA (**Figure 3.3-17**). The remaining soil map units represent soil series.

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The following section describes the soil series and mapping units for those soils in Dawes County, which occur within the MEA as shown on **Figure 3.3-17**. Soil map units 1014, 1356, 1882, 5105, 5126, and 5153 (depicted on **Figure 3.3-17**) are composite map units consisting of multiple NRCS units. All units combined are either divisions of the same soil series, complex, group, or association and were combined to provide a less complex soil map. The map unit number used to label composite map units on **Figure 3.3-17** represents the NRCS map unit with the greatest extent within the Proposed MEA. Soil map units that represent combined NRCS map units are noted below, and their constituent NRCS map units are described individually. The descriptions of soil map units that occur within the MEA, as shown on **Figure 3.3-17** and listed in **Table 3.3-6**, are extracted from the NRCS custom Soil Resource Report as provided by the NRCS Web Soil Survey.

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Bankard Series Soils

The Bankard series consists of deep, somewhat poorly drained soils that formed in sandy alluvium on bottom lands along tributaries to the Niobrara River. Slopes range from 0 to 2 percent. Within the MEA, the water table is typically at a depth of 2 to 4 feet, and soils are occasionally frequently flooded. Permeability is rapid, and available water capacity is low. Natural fertility is medium to low, and organic matter content is low. Runoff is slow. Although suited for irrigation, most areas of Bankard series soils are in areas of native grass used for hay or grazing. These soils are not considered prime farmland. They are partially hydric. Bankard soils comprise approximately 7 percent of the MEA. They are mapped as composite unit 1014 on **Figure 3.3-17** and include the following map units:

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1013 – Bankard loamy coarse sand, frequently flooded

This soil is found in bottom lands in the southern portion of the MEA. It is similar to unit 1014 as described below, but is formed in coarser grained alluvial material. Approximately 127 acres of this soil unit are present in the MEA.

1014 – Bankard loamy fine sand, frequently flooded

This soil is found in bottom lands in the MEA. It is similar to other frequently flooded Bankard soils. Some areas are strongly affected by salts and alkali, and salts are visible on the surface in early spring. This soil is marginal for cultivation of alfalfa and forage crops, and drainage systems are necessary to lower the water table in this unit prior to irrigation. Deep-rooted dryfarmed crops benefit from the high water table during dry periods. Soil blowing is a hazard if the soil surface is not protected. Approximately 189 acres of this soil unit are present in the MEA.

Glenberg Series Soils

The Glenberg series consists of very deep, well drained soils that formed in stratified calcareous alluvium on floodplains and river terraces. Slopes range from 0 to 8 percent. Permeability is rapid, and available water capacity is moderate. Natural fertility and organic content are moderate to low. Glenberg series soils are suitable for dryfarming and irrigated farming. Because they are restricted to steeper areas near drainages, only portions of the Glenberg soils within the MEA are currently cultivated. Glenberg soils comprise less than 1 percent of the MEA and include the following map unit:

1036 – Glenberg loamy very fine sand, 0 to 3 percent slopes

This map unit is located on high bottom land areas that are seldom flooded. A lime layer may be present at the surface, and stratification may be less distinct than in other Glenberg soils. Soil blowing is a hazard if the soil is unprotected. Runoff is slow. This map unit is dryfarmed for wheat, oats, and alfalfa and irrigated for alfalfa to a lesser extent. This map unit occurs in areas as large as 100 acres. Approximately 8.5 acres of this soil unit are present within the MEA.

Bridget Series Soils

The Bridget series consists of deep, well drained soils that formed in loamy colluvial and alluvial sediment on foot slopes and stream terraces. Permeability is moderate, and available water capacity is high. Natural fertility is medium, and organic matter content is moderate. In areas where slopes are less than 9 percent, these soils are used mostly for cultivated dryfarmed wheat, oats, or alfalfa. These soils are prime farmland if irrigated. The Bridget soils present within the MEA are partially hydric. Bridget series soils comprise approximately 8 percent of the MEA. They are mapped as composite map unit 1356 on **Figure 3.3-17** and include the following map units:

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1356 – Bridget silt loam, 1 to 3 percent slopes

This soil occurs in areas as large as 500 acres on foot slopes and stream terraces near large drainages. Minor areas in higher landscape positions may have a fine sandy loam surface layer or transitional horizon. This soil is partially hydric. Water erosion and gullying are hazards in areas that receive runoff from adjacent slopes. Soil blowing is a hazard if the soil surface is unprotected. Runoff is slow to medium. Approximately 269 acres of this soil unit are present within the MEA.

1357 – Bridget silt loam, 3 to 6 percent slopes

This soil occurs in areas as large as 200 acres on colluvial foot slopes and uplands. It is similar to map unit 1356, but has a thinner surface layer and occurs on steeper slopes. Bayard, Keith, or Rosebud series soils may make up 25 percent of this unit in the Pine Ridge area. Water erosion is a hazard due to runoff received from adjacent higher areas. Soil blowing is a hazard if the soil surface is unprotected. Runoff is medium. Approximately 105 acres of this soil unit are present within the MEA.

Keith Series Soils

The Keith series consists of deep, well drained soils that formed in loess on uplands and tablelands. Permeability is moderate, and available water capacity is high. Natural fertility is medium, and organic matter content is moderate. Keith series soils are suited for dryfarmed and irrigated crops, primarily winter wheat and alfalfa. These soils are prime farmland if irrigated. Keith series soils comprise approximately 1 percent of the MEA and include the following map unit:

1620 – Keith silt loam, 1 to 3 percent slopes

This soil occurs in areas as large as 500 acres on uplands. The soil profile of this unit is similar to other Keith series soils but has a thicker subsoil and may have a loam or fine sandy loam surface layer. Small areas of Alliance, Duroc, and Richfield soils may be present within this map unit. Water erosion is a hazard in some areas, but soil blowing is the main hazard. Runoff is slow. This soil unit is partially hydric. Approximately 53 acres of this soil unit are present in the MEA.

Rosebud-Canyon Complex Soils

The Rosebud-Canyon soil complex consists of intricately adjoining areas of Rosebud series and Canyon series soils. Rosebud soils are moderately deep, well drained soils that formed in material weathered from sandstone on upland areas. Permeability is moderate, and available water capacity is moderate. Natural fertility is medium, and organic matter content immoderate (excessive). Rosebud soils are suited to both dryfarmed and irrigated crops, such as wheat, oats, and alfalfa. Canyon series soils are described further below. Rosebud-Canyon complex soils comprise approximately 4 percent of the MEA and include the following map unit:

1742 – Rosebud-Canyon loams, 3 to 9 percent slopes

These soils occur in areas as large as 500 acres on gently rolling and rolling uplands. Rosebud soils make up approximately 50 to 70 percent of the map unit, and Canyon soils approximately 15 to 30 percent. Lesser amounts of other soil series make up 10 to 25 percent. Rosebud soils are found on side slopes, and the Canyon soils are on ridgetops and knolls. Soil blowing and water erosion are hazards if these soils are cultivated and the soil surface is not protected. Runoff is medium to rapid, depending on slope gradient and the type and amount of vegetative cover. Canyon soils are shallow, but may be cultivated where adjacent to deeper soils. This soil unit is partially hydric. Approximately 188 acres of this soil unit are present in the MEA.

Valent and Dwyer Group Soils

The Valent and Dwyer soil group consists of intermingled areas of Valent series and Dwyer series soils. Both Valent and Dwyer soils are deep, excessively drained soils that formed in eolian sands on uplands and stream terraces. Both soils have rapid permeability and low available water capacity. Natural fertility and organic matter content of both soils are low. Runoff is slow because both soils absorb water rapidly. Dwyer soils have lime higher in the profile than Valent soils, but are otherwise very similar. These soils are best suited for rangeland grasses, but not for dryland farming. Some irrigated alfalfa is grown in these soils. Both Valent and Dwyer soil units present within the MEA are partially hydric. These soils comprise approximately 23 percent of the MEA. Valent and Dwyer group soils are mapped as composite unit 1882 on **Figure 3.3-17** and include the following units:

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1881 – Valent and Dwyer loamy fine sands, 0 to 3 percent slopes

This map unit occurs in areas as large as 200 acres on uplands and stream terraces, either of which may be hummocky. Soil component distribution varies, and some areas consist almost entirely of either soil series or may have both. Dwyer soils may have pebbles on the surface and throughout the profile. Soil blowing is a hazard in cultivated areas. Approximately 284 acres of this soil unit are present in the MEA.

1882 – Valent and Dwyer loamy fine sands, 3 to 20 percent slopes

This map unit occurs in areas as large as 1,000 acres on uplands. It is very similar to map unit 1881, but occurs on steeper slopes. Wind erosion is a very severe hazard if grass is removed, and blowouts occur in some areas. Approximately 786 acres of this soil unit are present in the MEA.

Vetal and Bayard Group Soils

The Vetal and Bayard soil group consists of intermingled areas of Vetal series and Bayard series soils. Both Vetal and Bayard soils are deep, well drained soils that formed in sandy alluvium and colluvium on foot slopes. Vetal soils are found on upland swales, and Bayard soils may be found on stream terraces as well as foot slopes. Both soils have moderately rapid permeability and moderate available water capacity. Natural fertility and organic matter content of both soils are moderate. Bayer soils have a thinner surface horizon than Vetal soils. Both soils are suited for dryfarmed and irrigated crops such as wheat, oats, and alfalfa. These soils are prime farmland if irrigated. Vetal and Bayard group soils comprise approximately 2.4 percent of the MEA and include the following map unit:

5070 – Vetal and Bayard soils, 1 to 6 percent slopes

This map unit occurs in areas as large as 300 acres on foot slopes and stream terraces. Vetal soils make up 55 to 75 percent of the map unit and Bayard soils make up 25 to 45 percent. Areas may be dominated by a single component or may have both present. Soil blowing is a hazard in cultivated areas, and runoff is slow due to rapid absorption of rainfall. Approximately 111 acres of this soil unit are present in the MEA.

Alliance Series Soils

The Alliance series consists of deep, well drained soils that formed in material weathered from sandstone on uplands. Permeability is moderate, and available water capacity is high. Natural fertility is medium, and organic matter content is moderate. These soils are generally suited for dryfarmed and irrigated crops and are prime farmland if irrigated. All Alliance series soils present within the MEA are partially hydric. Alliance series soils comprise approximately 8 percent of the MEA. Alliance series soils are mapped as composite unit 5105 on **Figure 3.3-17** and include the following map units:

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5105 – Alliance silt loam, 1 to 3 percent slopes

This map unit occurs in areas as large as 500 acres on smooth upland areas. This map unit is similar to other Alliance series soils but may have lime present below a depth of 30 inches. Small areas of Rosebud, Dwyer, and Richfield series soils may be present. Soil blowing and water erosion are a moderate hazard if the soil surface is not protected. Runoff is slow. Most crops are dryfarmed, and wheat is the primary crop, with lesser amounts of oats and alfalfa. Corn is the main crop in irrigated areas. Approximately 242 acres of this soil unit are present in the MEA.

5106 – Alliance silt loam, 3 to 9 percent slopes

This map unit occurs in areas as large as 300 acres on uplands. The soil profile of this map unit is similar to other Alliance series soils, but has a slightly thinner surface layer. This soil is partially hydric. Water erosion and soil blowing are hazards in cultivated areas. Runoff is medium. This soil is used primarily for rangeland or native grass hay. It is suited for cultivation, but effective management practices and cropping systems are needed to help control erosion. Approximately 88 acres of this soil unit are present in the MEA.

5107 – Alliance silt loam, 3 to 9 percent slopes, eroded

This map unit is similar to unit 5106, but has a surface layer thinner than 7 inches which has been at least partially removed by erosion. Lime may be present at the surface, and the subsoil may be thinner than other Alliance series soils. Slope steepness limits irrigation development. Approximately 29 acres of this soil unit are present in the MEA.

Busher and Tassel Complex Soils

The Busher and Tassel soil complex consists of intricately adjoining areas of Busher series and Tassel series soils on uplands. Busher soils are found on the middle and lower portions of slopes, and Tassel soils are on ridgetops, knolls, and sides of small drainages. This soil unit is not hydric. Busher and Tassel soils are described more completely in this section. Busher and Tassel complex soils comprise approximately 4 percent of the MEA and include the following map unit:

5118 – Busher and Tassel loamy very fine sands, 6 to 20 percent slopes

This map unit occurs in areas as large as 100 acres on uplands. Slopes are mostly from 9 to 20 percent, but may be as low as 6 percent. Busher loamy very fine sand makes up about 60 percent of this unit, and Tassel loamy very fine sand makes up about 40 percent. Areas of shallower soils are present where bedrock is at a depth of 20 to 36 inches. Soil blowing and water erosion are serious hazards if the native grass cover is removed. Runoff is medium. Most of this soil unit is used for native grass rangeland. Approximately 185 acres of this soil unit are present in the MEA.

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Busher Series Soils

The Busher series consists of deep, well drained to somewhat excessively drained soils that formed in material weathered from sandstone on uplands. Permeability is moderately rapid, and available water capacity is moderate. Natural fertility is medium to low, and organic matter content is moderate. Soil blowing and water erosion are serious hazards on all Busher series soils if the protective vegetation cover is removed. Where slopes are less than 9 percent, these soils are suited for cultivation and irrigation. Areas with slopes less than 6 percent (map units 5123 and 5124 below) are considered Farmland of Statewide Importance. No other Busher soils are considered prime farmland. Soil units 5123, 5124, and 5128 are partially hydric, but unit 5126 is not. Busher series soils comprise approximately 15 percent of the MEA. Busher series soils are mapped as composite unit 5136 on **Figure 3.3-17** and include the following map units:

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5123 – Busher loamy very fine sand, 1 to 6 percent slopes

This map unit occurs in areas as large as 100 acres on uplands. This unit is similar to other Busher series soils, but may have a surface layer consisting of very fine sandy loam or sandy loam, a transitional layer of loam or very fine sandy loam, or areas of shallower soil where bedrock is at a depth of 20 to 40 inches. Areas of Bridget, Jayem, Vetal, and Tassel soils may be present and make up as much as 15 percent of this unit. Management concerns include conserving soil moisture and maintaining soil fertility. This soil unit typically occurs in areas of native grass. Approximately 142 acres of this soil unit are present in the MEA.

5124 – Busher loamy very fine sand, 1 to 6 percent slopes, eroded

This map unit is similar to unit 5123, but occurs in areas as large as 200 acres and typically has a thinner (4 to 7 inches) surface layer due to erosion. This soil unit typically occurs in areas cultivated for dryfarmed wheat, alfalfa, and oats. Approximately 131 acres of this soil unit are present in the MEA.

5126 – Busher loamy very fine sand, 6 to 9 percent slopes

This map unit occurs in areas as large as 250 acres on uplands. This unit is similar to other Busher series soils, but may have a surface layer thinner than 7 inches and may have lime at a depth of 12 to 18 inches. Areas of Bridget, Jayem, Vetal, and Tassel soils are present and make up as much as 15 percent of this unit. This soil unit typically occurs in areas of native grass. Approximately 162 acres of this soil unit are present in the MEA.

5128 – Busher loamy very fine sand, 6 to 9 percent slopes, eroded

This map unit is similar to unit 5126, but occurs in areas as large as 100 acres and has a surface layer that is 4 to 7 inches thick. Bedrock may be present in areas of shallow soils at a depth of 20 to 36 inches. Small areas of rock outcrop may be present within this unit. This soil is somewhat droughty and typically occurs in areas cultivated for dryfarmed wheat, alfalfa, and oats. Approximately 135 acres of this soil unit are present in the MEA.

5129 – Busher loamy very fine sand, 9 to 20 percent slopes

This map unit occurs in areas as large as 200 acres on uplands. This unit is similar to other Busher series soils, but has a surface layer that is 4 to 7 inches thick and lime at a depth of 10 to 18 inches in places. Bedrock may be present in areas of shallow soils at a depth of 20 to 36 inches. Conserving soil moisture is a major management concern in this soil. Runoff is medium. This unit occurs primarily in areas of native grass. Areas with flatter slopes are cultivated, but the steepness of this unit makes most areas unsuitable. Approximately 141 acres of this soil unit are present in the MEA.

Canyon Series Soils

The Canyon series consists of shallow, well drained soils that formed in material weathered from sandstone on ridges, knolls, and the sides of upland drainages. These soils are found only in the northern half of the MEA. Canyon soils are typically loams that are at 15 inches or shallower. Permeability is moderate, and available water capacity is low. Natural fertility and organic matter content are also low. Because Canyon soils are steep and shallow, cultivation is limited to areas where they are adjacent to deeper, more suitable soils. These soils are not hydric. Canyon series soils comprise approximately 12 percent of the MEA. Canyon series soils are mapped as composite unit 5153 on **Figure 3.3-17** and include the following map units:

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5152 – Canyon soils, 3 to 30 percent slopes

This map unit occurs in areas as large as 500 acres. This unit is similar to other Canyon series soils, but has a surface layer that may be silt loam or very fine sandy loam. Bedrock may be present at depths of less than 10 inches. Areas of Bridget, Rosebud, Oglala, and Tassel series soils make up less than 20 percent of this unit. Water erosion and soil blowing are very severe hazards if the soil surface is unprotected. These soils are droughty due to low available water capacity and shallow root zones. Conserving soil moisture is a management concern. Runoff is medium until soils are saturated, and then becomes rapid. This unit is typically found in areas of native grass used for grazing. Approximately 13 acres of this soil unit are present in the MEA.

5153 – Canyon soils, 30 to 50 percent slopes

This map unit occurs in areas as large as 500 acres on the sides of upland drainages. These soils are similar to map unit 5152, but occur in areas of steeper slopes that may also contain rock outcroppings.

Very steep slopes, shallowness, and rock outcrops limit the use of these soils to range, woodland, and wildlife habitat. Runoff is very rapid. Approximately 537 acres of this soil unit are present in the MEA.

Oglala Series Soils

The Oglala series consists of deep, well drained soils that formed in material weathered from fine-grained sandstone on the middle and lower parts of side slopes in uplands. These soils are found only in the northern half of the MEA. Oglala soils typically have a loam surface layer overlying a silt loam subsoil. Permeability is moderate, and available water capacity is high. Natural fertility and organic matter content are moderate. In general, these soils are better suited to native grass than cultivation due to steep slopes. These soils are not hydric. Oglala series soils comprise less than 1 percent of the MEA and include the following map unit:

5200 – Oglala loam, 9 to 30 percent slopes

This map unit occurs in areas as large as 200 acres on hillsides. The surface horizon of this unit may be thinner (3 to 6 inches) in areas and lime may be present at depths of less than 20 inches. Areas of Bridget, Canyon, Rosebud, and Ulysses soils may be present and make up less than 15 percent of this unit. Water erosion and soil blowing are hazards if the soil surface is not protected. Runoff is medium to rapid, depending on slope steepness and type and amount of vegetative cover. Most of this unit is used for livestock grazing on native grass. Approximately 2 acres of this soil unit are present in the MEA.

Oglala-Canyon Complex Soils

The Oglala-Canyon soil complex consists of intricately adjoining areas of Oglala series and Canyon series soils on side slopes, ridges, and knolls in the northern portion of the MEA. Oglala soils are found on the middle and lower part of side slopes, and Canyon soils are on ridgetops and knolls. These soils are not hydric. The Oglala-Canyon complex comprises approximately 5 percent of the MEA and includes the following map unit:

5211 – Oglala-Canyon loams, 9 to 20 percent slopes

This map unit is found in areas as large as 1,000 acres. Oglala soils make up approximately 60 to 75 percent of this unit, and Canyon soils approximately 25 to 40 percent. Areas of Bridget, Duroc, Keith, Rosebud, and Ulysses soils may be present and make up 25 percent or less of this unit. Fragments of sandstone may be present at the surface in some areas. Water erosion is a hazard if the soil surface is not protected. Runoff is medium to rapid, depending on slope steepness and the kind and amount of vegetative cover. This unit is not suited for cultivation and is typically found in areas of native grass. Approximately 236 acres of this soil unit are present in the MEA.

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Schamber Series Soils

The Schamber series consists of shallow, somewhat excessively drained soils that occur on escarpments of stream terraces along tributaries of the Niobrara River in the southern portion of the MEA. Schamber series soils typically have a gravelly, very fine sandy loam surface layer and subsoil overlying coarse sandstone gravel at a depth of approximately 12 inches. Permeability is rapid to very rapid, and available water capacity is very low. Natural fertility and organic matter content are low. These soils are not well suited for cultivation and are not hydric. Schamber series soils comprise less than 1 percent of the MEA and include the following map unit:

5254 – Schamber soils, 3 to 30 percent slopes

This map unit is found in areas as large as 50 acres. The surface layer of this unit may be gravelly loam in areas. Areas of deeper soil exist where gravel is present at a depth of 20 to 40 inches. Areas of Keith, Mitchell, and Pierre series soils are present at lower elevations and may comprise up to 15 percent of this unit. Soil blowing and water erosion are hazards if the soil surface is not protected. Runoff is medium to rapid. These soils are typically found in areas of native grass used for grazing. The substrate of these soils may be a useful source of gravel for construction activities. Approximately 13 acres of this soil unit are present in the MEA.

Haverson Series Soils

The Haverson series consists of deep, well drained soils that formed in stratified silty and loamy alluvium on bottom lands and low stream terraces. Areas on very low bottom lands are subject to occasional to frequent flooding. Haverson soils are found only in the northern portion of the MEA. Permeability is moderate to moderately slow, and the available water capacity is high. Natural fertility is medium to low, and organic matter content is low. These soils are rich in lime, which typically occurs at the surface, and are suited for grass and irrigated crops. Haverson soils comprise approximately 1 percent of the MEA and include the following map unit:

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5640 – Haverson loam, frequently flooded

This map unit is found in areas of irregular size and shape on low bottom lands and low stream terraces. Flooding frequently occurs due to their low position on the landscape. Areas of Glenberg soils may be included in higher elevation portions of this unit. Flooding is the main hazard and management concern in this unit. Soil blowing can also be a hazard if the soil surface is unprotected. Runoff is slow. Alfalfa is the main crop (where cultivated) and is suited for irrigation if flooding can be controlled. This soil unit is partially hydric. Approximately 50 acres of this soil unit are present in the MEA.

Tripp Series Soils

The Tripp series consists of deep, well drained soils that formed in silty and loamy alluvium on stream terraces along major drainages. Permeability is moderate in the upper part of the subsoil and decreases with depth where lime has accumulated. Available water capacity is high, natural fertility is medium, and organic matter content is moderate. These soils are suited for dryfarming and irrigation. Tripp soils comprise less than 1 percent of the MEA and include the following map unit:

5871 – Tripp silt loam, 1 to 3 percent slopes

This map unit occurs in areas as large as 200 acres on stream terraces in the north-central portion of the MEA. This unit is similar to other Tripp soils, but may be thinner and may have lime at shallower depths. This map unit may include areas of Bayard and Bridget soils at high elevations and Duroc and Halverson soils at low elevations. Soil blowing and water erosion are hazards if the soil surface is not protected. Runoff is slow. If irrigated, this soil is categorized as prime farmland; however, it is mostly used for dryfarming of alfalfa, wheat, and oats. This soil unit is partially hydric. Approximately 20 acres of this soil unit are present in the MEA.

Duroc Series Soils

The Duroc series consists of deep, well drained soils that formed in colluvium and alluvium derived from loess and weathered sandstone. Permeability is moderate, and available water capacity is high. Natural fertility and organic matter content are moderate. These soils are well suited to cultivation and irrigation.

Duroc soils are primarily found as minor components of other soil map units within the MEA. Areas mapped as Duroc soils comprise less than 1 percent of the MEA and include the following map unit:

5947 – Duroc very fine sandy loam, 1 to 3 percent slopes

This map unit occurs on the northern boundary of the MEA on a stream terrace. It occurs in areas as large as 300 acres elsewhere in Dawes County. Alliance, Bridget, Keith, Richfield, and Rosebud soils may be associated with this unit at higher elevations. This soil is partially hydric. Runoff is slow. This unit is suited to irrigation but is mostly dryfarmed for wheat, oats, and alfalfa. This soil is prime farmland if irrigated. Less than 1 acre of this soil unit is present in the MEA.

Jayem Series Soils

The Jayem series consists of deep, well drained to somewhat excessively drained soils that formed in eolian sands on uplands. Permeability is moderately rapid, and available water capacity is moderate. Natural fertility and organic matter content are moderate. These soils are suited to both dryfarmed and irrigated crops. Jayem soils comprise less than 1 percent of the MEA and include the following map unit:

5978 – Jayem loamy very fine sand, 1 to 6 percent slopes

This map unit is found in areas as large as 200 acres on uplands. The surface horizon may consist of very fine sandy loam, and lime occurs at a depth of 10 to 26 inches. Areas of Keith, Sarben, and Vetal soils make up less than 15 percent of this unit. Soil blowing is a hazard if the soil surface is unprotected. Runoff is slow due to moderately rapid infiltration of rainfall. This unit is primarily found in areas of native grass used for grazing or hay, but is well suited for irrigation. This unit is considered to be Farmland of Statewide Importance. Wheat and alfalfa are the most commonly cultivated crops. This soil unit is partially hydric. Approximately 11 acres of this soil unit are present in the central portion of the MEA.

Tassel Series Soils

The Tassel series consists of shallow, well drained soils that formed in material weathered from fine grained sandstone on uplands. The surface horizon and subsoil of Tassel soils are typically composed of loamy very fine sand. Permeability is moderately rapid, and available water capacity is very low. Natural fertility and organic matter content are low. The shallow nature of these soils makes them poorly suited for commonly cultivated crops and better suited for range and wildlife habitat. Lime is typically present at the surface of Tassel series soils. These soils are not hydric. Tassel soils comprise approximately 8 percent of the MEA and include the following map unit:

6028 – Tassel soils, 3 to 30 percent slopes

This map unit is found in areas as large as 500 acres on ridges, knolls, and the sides of upland drainages in the northern and central portions of the MEA. Areas of shallow soils where sandstone occurs at depths of 4 to 10 inches and areas of deeper soils where sandstone occurs at depths of 20 to 40 inches are present within this unit. Small outcrops of sandstone are also included in this unit. Areas of Bayard, Busher, Canyon, Jayem, and Sarben soil comprise up to 20 percent of this unit. Soil blowing is a hazard if the grass cover is removed or damaged. These soils are often droughty, and conserving moisture is a management concern. Runoff is slow to rapid, depending on the slope steepness and type and amount of vegetative cover. This unit is primarily found in areas of native grass used for grazing. Because shallowness and steep slopes make this unit unsuitable for cultivation, it is typically only cultivated where adjacent to deeper soils. Approximately 346 acres of this soil unit are present in the MEA.

Tassel-Ponderosa-Rock Outcrop Association

The Tassel-Ponderosa-Rock outcrop soil association consists of well drained soils mapped together in steep upland areas. Tassel series soils are described above and are found on ridges. Ponderosa series soils are deep, well drained, very fine sandy loams that formed from residuum weathered from fine grained sandstone on side slopes. Available water capacity of Ponderosa soils is moderate, and permeability is high (SSS 2011). Rock outcrops are very shallow, excessively drained weathered sandstone that occur on ridges. These soils are not hydric. This soil association comprises less than 1 percent of the project area and includes the following map unit:

6043 – Tassel-Ponderosa-Rock outcrop association, 9 to 70 percent slopes

This map unit occurs along the western margin of the MEA in areas smaller than 10 acres. These soils have a very high potential for wind and water erosion. Runoff is medium to rapid, depending on the slope steepness, type and amount of cover, and presence of rock outcrops. This association is unsuited for cultivation due to steep slopes and shallow soils. Approximately 1 acre of this soil unit is present in the MEA.

Sarben Series Soils

The Sarben series consists of deep, well drained soils that formed in eolian sands on uplands. Permeability is moderately rapid, and available water capacity is moderate. Natural fertility is medium to low, and organic matter content is low. Lime occurs at a depth of 24 inches. These soils are suited to dryfarming and irrigation and are considered prime farmland if irrigated. Sarben series soils present within the MEA are not hydric. Sarben soils comprise less than 1 percent of the MEA and include the following map unit:

6091 – Sarben fine sandy loam, 1 to 6 percent slopes

This map unit occurs in areas as large as 100 acres on gently rolling uplands in the south-central portion of the MEA. This unit is similar to other Sarben soils, but has lime deeper in the profile and may be deeper than other variations. Soil blowing and water erosion, to a lesser extent, are hazards if vegetative cover is removed. These soils are moderately droughty, and conserving moisture and improving fertility are management concerns. Runoff is slow. Dryfarmed wheat, alfalfa, and oats are the main uses of this unit, but grass for grazing and hay is also cultivated. Approximately 19 acres of this soil unit are present in the MEA.

3.4 Water Resources

3.4.1 Water Use

3.4.1.1 Dawes County

Every 5 years since 1950, the USGS is scheduled to assess U.S. water use (USGS 2005) and includes water use estimates for the State of Nebraska. The latest study examined usage in 2005. The USGS works in cooperation with local, state, and federal environmental agencies to collect and distribute water-use information. For Nebraska water use data, the USGS works in cooperation with the NDNR. The USGS's National Water-Use Information Program is responsible for compiling and disseminating the nation's water-use data (USGS 2013). Every 5 years, the USGS compiles these data at the county level to produce water-use information aggregated at the county, state, and national levels. The next report was scheduled to be issued in 2010, but due to delays, the next report completion and data availability is not expected until 2014 (USGS 2013). The State of Nebraska does not update the data in the above referenced USGS

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reports, so any more recent data listed in **Table 3.4-1** will not be available until the USGS issues its water-use report in 2014. **Table 3.4-2** was updated to reflected information on non-abandoned registered water wells for Dawes County as of April 8, 2013.

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Estimated water use in 2005 for Dawes County, Nebraska is presented in **Table 3.4-1** (USGS 2005). The total 2005 population for Dawes County was 8,636 people, with public supply groundwater and surface water use totaling 2,590,000 gpd. Irrigation using groundwater and surface water accounted for a total of 24,550,000 gpd to irrigate an estimated 13,000 acres. Essentially all of the rural residents of Dawes County use groundwater for their domestic supply.

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A summary of the number and types of registered non-abandoned water wells located in Dawes County as of April 8, 2013 is presented in **Table 3.4-2.** Note that this table refers to registered wells. Under current Nebraska law, water supply wells used solely for domestic purposes and completed prior to September 09, 1993 do not have to be registered (NRS 2008). Therefore, there are a number of domestic/agricultural and agricultural unregistered wells located in Dawes County. CBR identifies such wells through interviews with landowners and local drillers.

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There are a total of 5,828 registered water wells in Dawes County used for a variety of purposes, as described in **Table 3.4-2**. According to the NDNR, there are a total of 251 domestic and 232 livestock wells located in Dawes County (NDNR 2013a). There are 36 public water supply wells located in Dawes County. Livestock water wells make up the majority of the wells identified in the MEA.

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3.4.1.2 Marsland Expansion Area Project Area

The town nearest to the MEA project site is Marsland, Nebraska, which is located approximately 4 miles (6.4 km) southwest of the nearest MEA license boundary. There is no public water supply system for Marsland. The residential homes scattered throughout the MEA area are supplied with domestic water from private wells. Private well use is discussed in more detail below.

In general, groundwater supplies in the vicinity of the MEA are limited due to topography and shallow geology (University of Nebraska-Lincoln 1986). Groundwater quality in the vicinity near the MEA is generally poor (Engberg and Spalding 1978). Locally, groundwater is obtained from the Arikaree and Brule Formations. The primary groundwater supply is the Brule Formation, typically encountered at depths from approximately 50 to 350 feet bgs. In general, the static water level for Brule Formation wells in the MEA ranges from 50 to 150 feet bgs, depending on local topography (**Figures 3.3-3a** through 3.3-3n and **1.4-1**).

Groundwater from the underlying basal sandstone of the Chadron Formation is not used as a domestic supply within the MEA because of the greater depth (800 to 1,150 feet bgs) and inferior water quality. Gosselin et al. (1996) state that: (1) "*the sands near the bottom of the Chadron Formation yield sodium-sulphate water with high total dissolved solids,*" and (2) in proximity to "*uranium deposits in the Crawford area, groundwater from the Chadron Formation is not suitable for domestic or livestock purposes because of high radium concentrations.*" In addition, it is economically impractical to install water supply wells into the deeper basal sandstone of the Chadron Formation in the vicinity of the MEA, in contrast to the vicinity of the NTEA, where most basal sandstone of the Chadron Formation wells either flow at the surface or have water levels very close to surface elevation because of artesian pressure.

Based on the American Water Works Association Research Foundation (AWWARF), the average household water use annually (including outdoor) is approximately 350 gpd (Mayer et al. 1999). This suggests a daily indoor per capita water use of 69.3 gallons. Because there is only one occupied residence located within the proposed MEA (NW¼ SW¼ section 7, T29N R50W), water use would be expected at an average of approximately 350 gpd. Eight occupied residences have been identified within the 2.25-mile (3.62 km) AOR. Therefore, water use would be expected to average at about 2,800 gpd for the entire area.

CBR conducted an updated water user survey in 2010 and 2011 to identify and locate all private water supply wells within the 2.25-mile (3.62 km) AOR of the proposed MEA. The water user survey targeted the location, depth, casing size, depth to water, and flowrate of all wells within the area that were (or potentially could be) used as domestic, agricultural, or livestock water supply. **Table 3.4.3** and **Appendix A** list the active and abandoned water supply wells within the MEA and AOR. The locations of all active and abandoned water supply wells are depicted on **Figures 3.4-6 and 3.4-7**. Available NDNR water well registrations within the AOR are presented in **Appendix E-1**, and available well abandonment records in the AOR are provided in **Appendix D-2**. The NDNR's water well retrieval database was reviewed on April 9, 2013 (NDNR 2013b), and no additional private water supply wells were identified to be installed within a 1-mile radius of the site since the ER was submitted to the NRC by letter dated May 16, 2012.

There are a total of 95 active private water supply wells within the AOR and outside of the licensed boundary (**Table 3.4-3**). Within this grouping of active private wells, 11 wells are classified as solely agricultural use, four wells are classified as domestic use (13 wells – domestic/livestock, two wells – domestic/garden, one well – domestic/agricultural, and one well domestic/livestock/agricultural), three wells are classified as garden use, with two with other uses, 62 wells are classified as solely livestock use, and one well has an unknown well use. It should be noted that 18 of these wells have multiple or mixed well use classifications. In terms of aquifer assignments, four wells are assigned to the Arikaree Formation, 35 wells are assigned to the Arikaree/Brule, 28 wells are assigned to the Brule Formation, and 28 wells are unassigned.

Within the MEA, there are a total of 11 active private water supply wells (**Table 3.4-3**). Within this grouping of active private wells, one well is classified as domestic use, eight wells are classified as livestock use, and two wells have an "other" well use. In terms of aquifer assignments, three wells are assigned to the Arikaree Formation, two wells are assigned to the Arikaree/Brule, three wells are assigned to the Brule Formation, and three wells are unassigned. Four wells within the MEA are designated as inactive.

For all of the active private wells described above that remain unassigned to a formation, information provided by the well owner and from nearby wells was insufficient to accurately determine the well completion depth. However, based on discussions with landowners and known completion depths of private water supply wells in the area, these wells have suggested well completions within the Arikaree or Brule Formations (**Table 3.4-3**). Well construction and water quality information for these wells is not available in the NDNR water well data retrieval database (NDNR 2011) or known by the well owner. Based on available information, all water supply wells within the MEA and AOR are completed in the relatively shallow Arikaree and Brule Formations, with no domestic or agricultural use of groundwater from the basal sandstone of the Chadron Formation (**Figure 3.4-6** and **Table 3.4-3**).

Active private wells within the license boundary and 2 km radius of the license boundary have been sampled quarterly as part of the preoperational/preconstruction monitoring program (PPMP). There are currently 11 active private wells within the license boundary and an additional 41 active private wells

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within the 2 km radius of the license boundary (**Figures 3.4.-6** and **3.4-7** and **Table 3.4-3**). The preoperational baseline groundwater sampling and analyses program for the private wells is discussed in Section 6.1.2.1. Sampling of wells is dependent upon landowner approval of access to the wells and condition of the wells.

Based on population projections, future water use within the MEA and AOR will be a continuation of present use (see Section 2.3). There is one irrigation crop circle with a center pivot that extends into the license boundary (SE ¼ section of section 18, T29N R50W; **Figure 7.3-2**). The nearest MUs to the crop circle are MU B and MU C, which are located (at the nearest points) 0.37 and 0.28 mile from the crop circle, respectively. This crop circle located within the license boundary may continue to be operated by the landowner, but the pivot will not be operated inside any MEA monitor well ring. There are no other lands within the license boundary that are irrigated, and no additional irrigation within the license boundary will occur during MEA operations. Irrigation within the MEA AOR is anticipated to be consistent with the past. Any further development would be expected to be limited due to limited water supplies, topography, and climate. It is anticipated that the residents of Marsland and surrounding area will continue to use water supplied exclusively by private wells.

In Nebraska, groundwater is subject to a combination of case law and statutory provisions administered by the Upper Niobrara White Natural Resource District and when necessary, the courts (Kelly 2010). Case law has adopted the "rule of reasonable use" in combination with a correlative rights doctrine for allocation among groundwater users in times of shortage. In essence, the owner of land is entitled to groundwater under his land, but the owner may not extract groundwater in excess of reasonable and beneficial use upon the land, especially if such use impacts others who use the same groundwater. If the supply is insufficient for all owners, each is entitled to a reasonable proportion. Because there are no nearby users of basal sandstone of the Chadron Formation groundwater, conflict is unlikely.

3.4.1.3 Wellhead Protection Area

The nearest town to the MEA project site is Marsland, Nebraska. It is located approximately 4 miles (6.4 km) southwest of the nearest MEA license boundary. Marsland is an unincorporated community, with the only business being a U.S. Post Office. There are scattered homesites in the area, with domestic water being supplied by private wells. Approximately eight households and ten people can be found in the immediate area of Marsland (Key to the City 2011). There is no public water supply system; therefore, there is no wellhead protection plan. The other nearest communities to the proposed MEA are the Town of Hemingford and City of Crawford, Nebraska, which are located approximately 12 miles (19.3 km to the southeast) and 11.5 miles (18.5 km to the northwest), respectively, from the nearest license boundary of the MEA. The City of Crawford and Town of Hemingford have well protection plans in place (NE IDs NE3101303 and NE3104505, respectively). However, these communities are located at a distance from the MEA that precludes any potential impacts from the MEA operations. A horizontal distance of 1,000 feet is the minimum required separation of a city water supply well (used for domestic, irrigation, stock, or heat pump purposes) from potential sources of contamination (NDHHS 2010). The minimum horizontal distances required for additional potential sources of contamination range from 10 to 1,000 feet and are provided in **Table 3.4-4**.

3.4.2 Surface Water

3.4.2.1 Rivers, Creeks, and Drainages

The USGS maintains a hierarchical HUC system that divides the United States into 21 regions, 222 sub-regions, 352 accounting units, and 2,149 cataloging units based on surface hydrologic features or

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drainages (USGS 2011a). The smallest USGS unit, the 8-digit HUC (or 4th level HUC), averages about 448,000 acres, and is usually the level referred to as an HUC. The Hydrologic Unit system is a standardized watershed classification system. The State of Nebraska's major river basins are shown on **Figure 3.4-1**.

Below the cataloging units, the surface hydrologic features or drainages are further broken down into watersheds and subwatersheds. The MEA project site is located in the following HUC classification system (USGS 2011b):

Region:	Missouri (10)
Sub Region:	Niobrara River: The Niobrara River Basin and the Ponca Creek Basin [Nebraska South Dakota: Wyoming] (1015)
Accounting Unit:	Niobrara River [Nebraska: South Dakota: Wyoming] (101500)
Cataloging Unit:	Niobrara Headwaters [Nebraska: Wyoming] (10150002)
Basin:	Niobrara River (**Figure 3.4-2, Table 3.4-5** [NDEQ 2011a])
Subbasin:	Subbasin N14 (**Figure 3.4-3** [NDEQ 2011a])

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The Niobrara Accounting Unit and Niobrara Headwaters Cataloging Unit occupy areas of 13,900 mi^2 (36,001 km^2) and 1,460 mi^2 (3,781.4 km^2), respectively (USGS 2011b). The Niobrara River Basin, with the majority located in Dawes County and the adjacent Sheridan County, is composed of a watershed area of approximately 11,870 mi^2 (30,743.3 km^2) (NDEQ 2005).

There are 25 segments within the Niobrara River Subbasin N14 (**Figure 3.4-3**). The MEA is located within the Niobrara River Subbasin N14, with the southernmost permit boundary being located approximately 0.25 mile (0.4 km) from the Niobrara River in Segment 4000 (**Figure 3.4-3**).

The Niobrara River originates near Mansville, Niobrara County, eastern Wyoming and flows in an east-southeast direction into western Nebraska (**Figure 3.4-4**). The river flows across Sioux County in Nebraska, east through the Agate Fossil Beds National Monument, past Marsland to the south of the proposed MEA project site, and through Box Butte Reservoir. From the reservoir, the river flows east across northern Nebraska, and joins the Snake River approximately 13 miles (20.9 km) southwest of Valentine. The Niobrara River joins the Keya Paha River approximately 6 miles (9.7 km) west of Butte, Nebraska. The river eventually joins the Missouri River northwest of Niobrara, Nebraska in northern Knox County.

Water flow and water quality information on sampling points on the Upper Niobrara River are presented in Sections 6.1.3.1, 6.1.3.2, and 6.1.3.4.

3.4.2.2 Surface Impoundments

Based on available maps and site investigations conducted by CBR, no surface water impoundments, lakes, or surface ponds have been identified within the MEA. Rainfall runoff occasionally creates temporary small pools in a few places on the MEA site, but there is no evidence of persistent stream flow in recent times (HWA 2012).

Box Butte Reservoir is located approximately 3 miles (4.8 km) to the east of the southeast corner of the MEA permit boundary (**Figure 3.4-4**). Box Butte Reservoir Dam is located within Segment 4000 of Subbasin N14. The primary purpose of the reservoir is for irrigation with secondary benefits for recreation, fish, and wildlife (USBR 2008). The Box Butte Reservoir Dam has altered the hydrology of the Niobrara River by diverting water for irrigation (Alexander et al. 2010). The reservoir is part of the Mirage Flats Irrigation Project, which consists of the Box Butte Reservoir, the Dunlap Diversion Dam and associated canal, and laterals to irrigate 11,662 acres (**Figure 3.4-5**; USBR 2008). Dunlap Diversion Dam is located approximately 10 miles (16.1 km) downstream of the Box Butte Reservoir Dam. Average flows below the Box Butte Reservoir Dam are reduced by 90 percent relative to inflow to Box Butte Reservoir, but the river gains significant flow downstream from the Dunlap Diversion Dam, mainly due to groundwater seepage (Bentall and Shaffer 1979).

The Box Butte Reservoir was constructed between 1941 and 1946 and is under the control of the U.S. Bureau of Reclamation (USBR). The total storage capacity of the Box Butte Reservoir is 29,161 acre-feet (USBR 2008) and the pool elevation is 3,997.6 feet. The reservoir occupies approximately 1,600 surface acres with 14 miles (22.5 km) of shoreline. The reservoir has stabilized the agricultural economy of the area that has resulted in larger farm populations and increased employment in related industries. The lake is well suited for recreation activities (aquatic and outdoor sports). Recreation at the reservoir is managed for the USBR by the Nebraska Game and Parks Commission (NGPC).

There are no direct drainages from the MEA project site to the reservoir. Any discharges from the MEA site that could enter the Niobrara River could commingle with river water flowing into Box Butte Reservoir.

The storage capacity of the Box Butte Reservoir is discussed in Section 6.1.3.3.

3.4.3 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 MEA). The discussion is based on information from investigations performed within the MEA, data presented in previous applications/reports for the current CPF where ISR mining is being conducted, the proposed NTEA and TCEA, and the geologic information presented in Section 3.3. In this regard, the hydrogeology of the MEA is expected to be similar in many respects to that encountered in the CPF, NTEA, and TCEA. Groundwater monitoring results and discussions are presented in Section 6.1.2.

The hydrostratigraphic section of interest for MEA 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 sandstone of the Chadron Formation (Mining Unit)
- Pierre Shale (Lower Confining Unit)

With regard to the CPF, NTEA, TCEA, and MEA in particular, two groundwater sources are of interest in the Crow Butte and surrounding area. These are the Brule Formation sand and the basal sandstone of the Chadron Formation. The basal sandstone of the Chadron Formation contains the uranium mineralization at the CPF, NTEA, TCEA, and MEA.

3.4.3.1 Groundwater Occurrence and Flow Direction

In the vicinity of the MEA, the alluvium, Arikaree Formation, Brule Formation, and basal sandstone of the Chadron Formation are considered water-bearing intervals. The alluvial deposits and Arikaree Formation are not typically considered to be reliable water sources. Sandy siltstones, overbank sheet sandstones, and occasional thick channelized sandstones that occur throughout the Orella Member of the Brule Formation may be locally water-bearing units. These sandstone and siltstone units are difficult to correlate over any large distance and are discontinuous lenses rather than laterally continuous strata. Although the Brule Formation is a local water-bearing unit, it does not always produce usable amounts of water. Despite this characteristic, the Brule Formation has historically been considered the shallowest aquifer above the basal sandstone of the Chadron Formation, and water supply wells have been completed in this unit.

Locations of all groundwater monitoring wells in the vicinity of the MEA are shown on **Figure 3.4-6**. There are nine active monitoring wells screened in the Brule Formation (BOW-2010-1, BOW-2010-2, BOW-2010-3, BOW-2010-4, BOW-2010-4A, BOW-2010-5, BOW-2010-6, BOW-2010-7, and BOW-2010-8). The Walters Drillers Pond-720 and Walters Drillers Pond-721 wells are also employed as monitoring wells for the Brule Formation. Well BOW-2010-4 is not being used for baseline water quality monitoring, and plans are to abandon this well in the future. During reaming of this well for casing, the driller lost a bit that he was unable to retrieve. Unsuccessful attempts made to convert the well to a shallow monitor well resulted in the well being considered unacceptable for baseline monitoring. A new replacement well (BOW-2010-4A) was drilled nearby. Well completion records for these monitoring wells are included in **Appendix E-2**.

Thirteen active monitoring wells are screened in the basal sandstone of the Chadron Formation (CPW-2010-1, CPW-2010-1A, Monitor-1, Monitor-2, Monitor-3, Monitor-4A, Monitor-5, Monitor-6, Monitor-7, Monitor-8, Monitor-9, Monitor-10, and Monitor-11; **Figure 3.4-6**). Well completion reports for these monitoring wells are included in **Appendix E-2**.

Water level measurements and water quality results for groundwater monitor wells are presented in Section 6.1.2.

3.4.3.2 Aquifer Testing and Hydraulic Parameter Identification Information

Prior to initiation of ISR mining activities, the NDEQ regulations require hydrologic testing and baseline water quality sampling. During the initial permitting and development activities within the MEA, an aquifer pumping test was performed between May 16 and May 20, 2011. The final report on pumping test activities in the MEA (Marsland Regional Hydrologic Testing Report – Test #8; Aqui-Ver 2011) is included in **Appendix F**. The pumping test was performed in accordance with the NDEQ approved Regional Pumping Test Plan dated September 27, 2010 (Worley Parsons 2010) and subsequent approved changes to the Regional Pumping Test Plan dated March 16, 2011 (Snowhite 2011). Testing activities and findings from pumping tests in the MEA are summarized below.

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Prior to testing activities, CBR installed 14 monitoring wells in the basal sandstone of the Chadron Formation (CPW-2010-1, CPW-2010-1A, Monitor-1, Monitor-2, Monitor-3, Monitor-4, Monitor 4A, Monitor-5, Monitor-6, Monitor-7, Monitor-8, Monitor-9, Monitor-10, and Monitor-11) and nine wells in the Brule Formation (BOW-2010-1, BOW-2010-2, BOW-2010-3, BOW-2010-4, BOW-2010-4A, BOW-2010-5, BOW-2010-6, BOW-2010-7, and BOW-2010-8; **Figure 3.4-6**). Well information for wells used during the 2011 pumping test is summarized in **Table 3.4-6**. Monitor-4 and BOW-2010-4 were

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abandoned prior to pumping test activities. To assess pre-test baseline water level fluctuations, water level data and barometric pressure data were recorded prior to the pumping period starting on May 6, 2011 for 7 days before initiating the pumping test. The locations of wells used during pumping test #8 are shown on **Figure 3.4-8**.

Static water levels were collected from all 12 wells in the monitoring network on November 12, 2010 from the Brule Formation and the basal sandstone of the Chadron Formation. Water levels ranged from approximately 4,134 to 4,213 feet amsl in the Brule Formation and 3,709 to 3,714 feet amsl in the basal sandstone of the Chadron Formation (**Table 3.4-6**).

As part of the NRC License Amendment Application to conduct ISR operations in the MEA, the 2011 regional groundwater pumping test was designed to accomplish the following:

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

The 2011 pumping test was conducted while pumping at CPW-2010-1A at an average discharge rate of 27.08 gpm for 103 hours (4.29 days). Based on the drawdown response observed at the most distant observation well locations (Monitor 2 and Monitor 8), the radius of influence (ROI) during the pumping test was estimated to be in excess of approximately 8,800 feet. More than 0.8 foot of drawdown was achieved during testing in all observation wells completed in the basal sandstone of the Chadron Formation in the observation well network, with a maximum drawdown of 23.40 feet observed in CPW-2010-1A (pumping well) during the test.

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

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

Estimated hydraulic parameters for individual well locations for the 2011 pumping test are summarized in **Table 3.4-7**. Results of the 2011 pumping test within the basal sandstone of the Chadron Formation indicate a mean hydraulic conductivity of 25 feet per day (ft/day) (ranging from 7 to 62 ft/day) or 8.82 x 10^{-3} centimeters per second (cm/sec) based on an average net sand thickness of 40 feet and a mean transmissivity of 1,012 square feet per day (ft^2/day; ranging from 230 to 2,469 ft^2/day). Based on both the drawdown and recovery analyses, hydraulic conductivities of the aquifer materials in the vicinity of the pumping well (CPW-2010-1A, CPW-2010-1, and Monitor-3) were approximately three to nine times greater than hydraulic conductivities estimated for other observation wells in the pumping test area.

An apparent higher conductivity boundary condition effect in these wells was indicated by a flattening of drawdown and recovery curves. Transmissivities for the recovery data were slightly higher than for the drawdown data and are considered more representative of the aquifer properties due to the slight variability in the discharge rate during the drawdown phase of the test. The mean storativity was 2.56 x 10^{-4} (ranging from 1.7 x 10^{-3} to 8.32 x 10^{-5}). Storativity units are a measure of the volumes of water that a permeable unit will absorb or expel from the storage unit per unit of surface area per unit of change in head. Storativity is a dimensionless quantity.

The hydrologic parameters observed at the MEA are consistent with, although slightly higher than, the aquifer properties determined for the areas of the CPF, TCEA, and NTEA (**Table 3.4-8**). No water level changes of concern were observed in any of the overlying wells during testing. The pumping test results demonstrate the following important conclusions:

- The pumping well and all observation wells completed in the basal sandstone of the Chadron Formation exhibited significant and predictable drawdown during the test, demonstrating that the production zone has hydraulic continuity throughout the MEA test area.
- The average transmissivity of the basal sandstone of the Chadron Formation within the portion of the MEA investigated during the test is significantly higher than the areas investigated within the TCEA, NTEA, and existing Crow Butte operations.
- A zone of relatively lower permeability is apparent in the vicinity of the pumping well (CPW-2010-1A) and observation wells CPW-2010-1 and Monitor-3, with significantly higher transmissivity noted elsewhere within the ROI of the test.
- Adequate confinement exists between the overlying Brule Formation and the basal sandstone of the Chadron Formation, as evidenced by no discernible drawdown in the Brule Formation observation wells.
- The hydrologic properties of the basal sandstone of the Chadron Formation have been adequately characterized within the majority of the proposed MEA to proceed with Class III UIC permitting and Nan NRC License Amendment Application for the MEA.

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These conclusions indicate that, though variance in thickness and hydraulic conductivity may impact mining operations (e.g., well spacing, completion interval, and injection/production rates), it is not anticipated to impact regulatory issues.

3.4.3.3 Hydrologic Conceptual Model for the Marsland Expansion Area

Tables 3.3-1 and 3.3-2 present the regional and local stratigraphic columns in the vicinity of MEA. The water-bearing units within the stratigraphic section present at the MEA include alluvial deposits (rarely), permeable intervals of the Arikaree Formation, permeable intervals in the Orella Member of the shallow Brule Formation, and the deeper confined basal sandstone of the Chadron Formation. The upper and lower confining units and the hydrologic conditions for the water-bearing intervals present at the MEA are discussed below.

<u>Confining Layers</u>

Upper confinement for the basal sandstone of the Chadron Formation within the MEA is represented by 430 to 940 feet of smectite-rich mudstone and claystones of the upper Chadron and middle Chadron (**Figures 3.3-3a** through **3.3-3n, 3.3-7, and 3.3-8**). Particle grain size analyses of four core samples from the upper confining layer within the MEA indicate that all samples were clayey siltstone (**Appendix G**). XRD analyses indicate that compositions of mudstone and claystone intervals of core samples from the middle Chadron are highly similar to the Pierre Shale (e.g., predominantly mixed-layered illite/smectite or montmorillonite with quartz), which would be expected if the Pierre Shale was a source of materials for the overlying middle Chadron (**Appendix G**). Significant water-bearing sandstones of the upper/middle Chadron are not present within the MEA. As a result, the Brule Formation is vertically and hydraulically isolated from the underlying aquifer proposed for exemption.

Lower confinement for the basal sandstone of the Chadron Formation in the vicinity of the MEA is represented by approximately 750 to more than 1,000 feet of black marine shale deposits of the Pierre Shale. Additional low permeability confining units are represented by the underlying Niobrara Formation, Carlile Shale, Greenhorn Limestone, and Graneros Shale. Together with the Pierre Shale, these underlying low permeability units hydraulically isolate the basal sandstone of the Chadron Formation from the underlying "D", "G", and "J" sandstones of the Dakota Group by more than 1,000 vertical feet (**Table 3.3-1**).

The Pierre Shale is not a water-bearing unit, exhibits very low permeability, and is considered a regional aquiclude. Regional estimates of hydraulic conductivity for the Pierre Shale range from 10^{-7} to 10^{-12} cm/sec (Neuzil and Bredehoeft 1980; Neuzil et al. 1982; Neuzil 1993). The Pierre Shale has a measured vertical hydraulic conductivity at the CPF of less than 1×10^{-10} cm/sec (Wyoming Fuel Company 1983), which is consistent with other studies in the region. Particle grain size analyses of two samples collected from the Pierre Shale within the MEA indicate low permeability silty clay compositions. Regional studies also indicate that there is no observed transmissivity between vertical fractures in the Pierre Shale, which appear to be short and not interconnected (Neuzil et al. 1982).

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Estimates of hydraulic conductivity were developed using particle grain size distribution data from the four core samples collected from within the upper Chadron and middle Chadron. Results of the particle size distribution analyses indicate sediments dominated by silts and clays. Hydraulic conductivity estimates were developed using the Kozeny-Carman equation, which is appropriate for sands and silts, but not for cohesive clayey soils with a high degree of plasticity. Estimated hydraulic conductivities of the two core samples collected within the upper Chadron ranged from 5.4×10^{-5} to 5.9×10^{-5} cm/sec. Estimated hydraulic conductivities of the two core samples collected within the middle Chadron ranged from 1.7×10^{-5} to 2.9×10^{-5} cm/sec. Hydraulic conductivities for the two core samples collected within the Pierre Shale were not estimated by the Kozeny-Carman method due to significant levels of clay. The vertical hydraulic conductivity across the upper and lower confining layers is likely to be even lower due to vertical anisotropy. Additionally, hydraulic resistance to vertical flow is expected to be low due to the significant thickness of the upper confining zone within the MEA, which ranges between 430 and 940 ft.

Hydrologic Conditions

A potentiometric map and cross-sections of the basal sandstone of the Chadron Formation indicate confined groundwater flow (**Figures 3.3-3a** through **3.3-3n** and **6.1-4**). Elevations of the potentiometric surface of the basal sandstone of the Chadron Formation indicate that the recharge zone must be located above a minimum elevation of 3,715 feet amsl. Confined conditions exist at the MEA as a result of an elevated recharge zone most likely located west or southwest of the MEA. The top of the basal sandstone of the Chadron Formation occurs at much lower elevations within the MEA, ranging from approximately 3,360 to 3,480 feet amsl (**Figures 3.3-3a** through **3.3-3n**).

In the vicinity of the MEA, groundwater flow in the basal sandstone of the Chadron Formation is predominantly to the northwest toward the White River drainage at a lateral hydraulic gradient of 0.0004 ft/ft (Aqui-Ver 2011). Regional water level information for the basal sandstone of the Chadron Formation is currently only available in the vicinity of the current production facility and the NTEA, but suggest a discharge point at an elevation of at least 3,700 feet amsl (or below) located east of Crawford, presumably at a location where the basal sandstone of the Chadron Formation is exposed.

Regional water level information for the Brule Formation is currently only available in the vicinity of the current production facility. However, within the MEA, groundwater generally flows to the southeast across the entire MEA toward the Niobrara River at a lateral hydraulic gradient of 0.011 ft/ft (Aqui-Ver 2011). Though the Brule Formation is the primary groundwater supply in the vicinity of the MEA, low production rates indicate that the discontinuous sandstone lenses of the Orella Member may not be hydraulically well connected. Recharge to this unit likely occurs directly within the MEA, as the unit is unconformably overlain by 50 to 210 feet of overlying Arikaree Formation and 0 to 30 feet of unconsolidated alluvial and colluvial deposits (depending on local topography). Monitoring wells will be installed in the Brule Formation between the license boundary and the Niobrara River to monitor water quality in the event of failure of an injection well or production well, and to prevent potential communication of mining fluids with surface water (see Section 6.2.2.2 for a more detailed discussion). Installation of such monitoring wells is required under the Class III injection well permit. Alluvial deposits along the margins of the Niobrara River may offer limited groundwater storage depending on river levels.

The Brule Formation and basal sandstone of the Chadron Formation within the MEA have distinct and differing water level elevations (**Figures 3.3-3a** through **3.3-3n** and **Table 6.1-7**). See discussions of water level measurements for CBR monitor wells in Section 6.1.2.2. The available water level data suggest hydrologic isolation of the basal sandstone of the Chadron Formation with respect to the overlying water-bearing intervals in the MEA. This inference is further supported by the difference in geochemical groundwater characteristics between the basal sandstone of the Chadron Formation and the Brule Formation (see Section 6.1.2.3; **Tables 6.1-4**, **6.1-8**, **6.1-9**, **6.1-10** and **6.1-11**).

In summary, the following multiple lines of evidence indicate adequate hydrologic confinement of the basal sandstone of the Chadron Formation within the MEA.

- Results of the May 2011 aquifer pumping test demonstrate no discernible drawdown in the overlying Brule Formation observation wells screened throughout the MEA (see Section 3.4.3.2).
- Large differences in observed hydraulic head (330 to 500 feet) between the Brule Formation and the basal sandstone of the Chadron Formation indicate strong vertically downward gradients and minimal risk of naturally occurring impacts to the overlying Brule Formation (see Section 3.4.3.1).
- Significant historical differences exist in geochemical groundwater characteristics between the basal sandstone of the Chadron Formation and the Brule Formation (Section 6.1.2.3).
- Site-specific XRD analyses, particle grain size distribution analyses, and geophysical logging confirm the presence of a thick (up to 940 feet), laterally continuous upper confining layer consisting of low permeability mudstone and claystone, and a thick (more than 750 feet),

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regionally extensive lower confining layer composed of very low permeability black marine shale.

- Analyses of particle size distribution results suggest a maximum estimated hydraulic conductivity of 10^{-5} cm/sec for core samples from the upper confining layer.
- Hydraulic resistance to vertical flow is expected to be low due to the significant thickness of the upper confining zone within the MEA.
- The vertical hydraulic conductivity across the upper and lower confining layers is likely to be even lower than 10^{-5} cm/sec due to vertical anisotropy.

3.4.3.4 Description of the Proposed Mining Operation and Relationship to Site Geology and Hydrology

The basal sandstone of the Chadron Formation is currently mined using ISR techniques within the MUs of the current Crow Butte operations and represents the production zone and target of solution mining in the MEA. Ore-grade uranium deposits underlying the MEA are located in the basal sandstone of the Chadron Formation (**Figure 1.3-1**). The ore body located within the MEA is a stacked roll front system, which occurs at the boundary between the up-dip and oxidized part of a sandstone body and the deeper down-dip and reduced part of the sandstone body. Stratigraphic thickness of the unit within the MEA ranges from approximately 20 to 110 feet, with an average thickness of approximately 55 feet. The unit occurs at depths ranging from about 817 to 1,130 feet bgs within the MEA (**Figures 3.3-3a** through **3.3-3n**). A competent upper confining layer consists of the overlying middle Chadron and upper Chadron, which consist predominantly of clay, claystone, and siltstone.

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Based on extensive exploration hole data collected to date (more than 1,650 drill locations), the thickness of the upper confining layers in the MEA ranges from 430 to 940 feet (**Figures 3.3-3a** through **3.3-3n**). Estimated hydraulic conductivities based on particle grain size distribution analyses for site-specific core samples collected within the upper confining layer are on the order of 10^{-5} cm/sec (see Confining Layers above). Geophysical logs from nearby oil and gas wells indicate that the thickness of the Pierre Shale lower confining layer ranges from approximately 750 to more than 1,000 feet (see White River Group in Section 3.3.1.1). The full thickness of the Pierre Shale is not depicted on **Figures 3.3-3a** through **3.3-3n**, as the required scale would obscure stratigraphic details of the overlying White River Group. The Pierre Shale exhibits very low permeabilities on the order of 0.01 millidarcies (md; less than 1 x 10^{-10} cm/sec; Wyoming Fuel Company 1983).

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Based on similar regional deposition, the MEA ore body is expected to be similar mineralogically and geochemically to the CPF. The ore bodies in the two areas are within the same geologic unit (i.e., basal sandstone of the Chadron Formation) and have the same mineralization source (see Section 3.3.1.2). 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 3.31.2). 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 current Crow Butte mineralized zone are presumed to be representative of the MEA. **Tables 3.4-9** through **3.4-11** are the Baseline and Restoration Values for MUs 1 through 3 in the current Crow Butte operations area. The values in these tables are expected to be representative of the geochemical characteristics of the MEA ore body. The MEA ore body, the outline of which is provided on **Figure 1.3-1**, 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 concentrations of these parameters outside of the production zone (e.g., **Tables 6.1-4, 6.1-8** and **6.1-10**).

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During the course of mining, the water quality is expected to change as outlined in **Table 3.4-12**. The chemicals used in the mining and recovery process will include $NaHCO_3$, an oxidizer such as O_2, and CO_2. 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 IX 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 the MEA are similar to that of the current Crow Butte site, so it is probable the change in water quality at the MEA will be similar to that experienced at the current Crow Butte site. Historical restoration activities at the current Crow Butte site have demonstrated the ability to successfully restore groundwater to established restoration standards. Groundwater restoration is discussed in detail in Sections 5.4.1.3 and 5.4.1.4.

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The site-specific ISR mining process for the MEA is described in Section 1.3.2.

Net withdrawal within the wellfield must be maintained in order to capture injected mining solutions (see discussion below). Under NDEQ Title 122, Chapter 19, Section 002.02, injection of mining solutions shall not exceed the formation fracture pressure, but must be significant enough to overcome existing pressure heads within the confined aquifer while assuring that the pressure in the injection zone during injection does not cause migration of injection fluids into an underground source of drinking water. From an operations standpoint, procedures must be in place for responding to leaking well casings or well valves. Mechanical integrity testing is conducted following installation of all wells and subsequently every 5 years after a well begins operation. In addition, all wells that have had rig work completed with the drill string entering the well casing will be tested for mechanical integrity before being returned to service. Water quality is sampled bi-weekly at all monitoring well locations, which would detect an excursion (i.e., presence of mining solutions). Contingency plans in the event of well failure are discussed in Section 4.12.3, which may either include identifying and patching the leaking well casing or abandoning the well if the leak cannot be repaired. Well plugging and abandonment procedures are discussed in Section 5.1.3.1.

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Maintenance of hydraulic control will be demonstrated by exterior monitoring wells surrounding each wellfield. Planned procedures for monitoring the capture of injected mining solutions are discussed in Sections 1.3.2.6 and 6.2.2.1. These procedures include routine water level measurements in the production zone and overlying water-bearing zones and water quality sampling at monitoring wells every 2 weeks. Any changes in water levels or water quality within the production zone will be evaluated after sample collection to ensure that the system is operating properly and successfully. The proposed procedures will also allow for flowrate adjustments to ensure capture of mining fluids. ISR mining at the MEA will be undertaken via a recirculation system with a close mass balance resulting from the over-production (or bleed) rates. Within the wellfield and its vicinity, there will be local changes in head and flow direction. However, beyond the MEA permit boundary, the magnitude of regional groundwater flow will not be meaningfully affected and will resume to regional flow conditions within a few hundred feet outside the permit boundary. The monitoring procedures proposed in Section 6.2.2.1 are considered an adequate trigger for hydraulic adjustments to the production system in response to increases in pumping by private wells screened in basal sandstone of the Chadron Formation.

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The hydrologic properties of the basal sandstone of the Chadron Formation must be known to formulate the best injection/extraction well arrays and for appropriate containment. Based on the pumping rate, test duration, and formation characteristics, the ROI (i.e., the area over which drawdown occurs) can also be determined for a given test. **Tables 3.4-7** and **3.4-8** present relevant hydrologic information based on an aquifer test performed in the MEA in May 2011, compared with the same properties in the CPF, NTEA, and TCEA. These data indicate that mean transmissivity and hydraulic conductivity at the MEA are more than adequate to successfully develop the MEA for ISR mining activities.

3.4.3.5 Lateral and Vertical Extent of the Proposed Exempt Aquifer

The lateral extent of the area requested being requested by CBR for an aquifer exemption under a separate application to the NDEQ, is shown on **Figure 1.3-1**. The lateral extent of the proposed aquifer exemption is equivalent to the proposed NDEQ Class III UIC Application permit boundary.

The vertical extent of the requested exemption is the full thickness of the basal sandstone of the Chadron Formation, which extends from the top of the Pierre Shale to the base of the middle Chadron (**Table 3.3-2; Figures 3.3-3a** through **3.3-3n**). This vertical extent is slightly different than the vertical extent requested and received in the 1983 Aquifer Exemption Petition for the current Crow Butte operations, which includes the middle Chadron and upper/middle Chadron, but it is similar to the vertical extent requested for the NTEA and TCEA.

3.5 Ecological Resources

This section describes the existing ecological resources within the MEA. The potential impacts associated with the proposed project and mitigation measures that would offset such impacts are discussed in Section 4. The analysis consisted of a review of documents, databases, and reports in conjunction with biological field surveys to determine the potential impacts, if any, to special-status plant and wildlife species and their habitats in the proposed expansion area. Pre-existing baseline ecological studies, including field observations, agency contacts, and literature searches, have been conducted for several other uranium ISR projects in the general area of the MEA, including CBR's main processing facility and for the proposed NTEA and TCEA uranium ISR satellite facilities. Baseline studies date from 1982 through 2008 for these project sites. These studies are discussed in more detail in this section. The purpose of the consultations and associated correspondence was to help identify biological issues and potential occurrences and distribution of special-status plants and wildlife and their habitats.

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3.5.1 Regional Setting

The project area occurs within the Western High Plains Level III ecoregion and is characterized by a semiarid to arid climate, with annual precipitation ranging from 13 to 20 inches. Higher and drier than the Central Great Plains to the east, much of the Western High Plains comprises a smooth to slightly irregular plain having a high percentage of dryland agriculture. Potential natural vegetation in the Western High Plains ecoregion is dominated by drought-tolerant short-grass prairie and large areas of mixed-grass prairie in the northwest portion of the state. The northern portion of the project area occurs within the Pine Ridge Escarpment Level IV ecoregion, with Ponderosa pine (*Pinus ponderosa*) woodlands associated with mixed-grass prairie on ridge tops and north-facing and east-facing slopes. The southern portion of the project area, predominantly rangelands, is made up of mixed-grass prairie with areas of moderate relief and is characteristic of the Sandy and Silty Tablelands Level IV ecoregion (Chapman et al. 2001).

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3.5.2 Local Setting - Marsland Expansion Area

The proposed MEA is located in southwest Dawes County, Nebraska within sections 26, 35, 36 T30N:R51W; sections 1, 2, 11, 12, 13 T29N:R51W; and sections 7, 18, 19, 20, 29, 30, T29:R50W. The project area occupies 4,622.3 acres approximately 4 miles (6.4 km) northeast of Marsland, Nebraska (**Figures 1.1-2 and 1.1-3**). Land ownership is primarily private within the project area and the 2.5-mile (4.0 km) radius area referred to as the Ecological Study Area (ESA). There is a total of one section of State Trust Land located in the AOR, with a ¼ of this section located in the MEA license boundary. The northern portion of the buffer intersects with the administrative boundary of the Nebraska National Forest-Pine Ridge Ranger District. However, the administrative boundary was proclaimed by Congress mainly for the purposes of limiting the area in which land swaps and acquisitions could be undertaken, and the boundary itself provides no jurisdiction on nonfederal parcels.

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3.5.3 Climate

The proposed MEA is located in a semiarid or steppe climate. The area is characterized by abundant sunshine, low relative humidity, and sustained winds which lead to high evaporative demand. There are also large diurnal and annual variations in temperature. The region has cold, harsh winters; hot, dry summers; and relatively warm, moist springs and autumns. Temperature extremes range from roughly -25° F in the winter to 100° F in the summer. The "last freeze" occurs during late May and the "first freeze" in mid to late September. The area has a growing season of approximately 120 days (NOAA and University of Nebraska-Lincoln 2011).

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Historical average minimum and maximum meteorological data (i.e., temperature, precipitation, and snowfall) typical of the Scottsbluff area are presented in **Table 3.5-1** (NOAA and University of Nebraska-Lincoln 2011). Scottsbluff is located approximately 45 miles (72.4 km) to the southwest of the MEA. A detailed discussion of more recent and expanded meteorological data (2010 through 2011) considered representative of the MEA project site is provided in Section 3.6.

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3.5.4 Pre-existing Baseline Data

Ecological studies have been conducted for several other mines in the general area of the MEA, including the CBR Crow Butte Uranium Project (Radioactive Source Materials License SUA-1534) and the TCEA. The first baseline study was conducted for the Crow Butte Mine in 1982 (Wyoming Fuel Company 1983), and additional baseline data were collected in 1987, 1995, 1996, 1997, and 2004 (CBR 2007). Baseline data, including field observations, agency contacts, and literature searches, were conducted for the TCEA in 2005 and 2008 (CBR 2010).

3.5.5 Terrestrial Ecology

The information presented in this report summarizes the baseline data collected for the Crow Butte Mine and TCEA between 1982 and 2008, and from field observations, surveys, and mapping conducted for the MEA in 2011.

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3.5.5.1 Methods

Baseline studies were performed during 2011 to determine presence or absence of federally or state-listed species of plants and animals as well as regional species of concern deemed by the state. Surveys were conducted in accordance with approved protocols established by state and federal agencies for: (1) winter bald eagle (*Haliaeetus leucocephalus*) roosts, (2) raptor nests, (3) burrowing owl (*Athene cunicularia*) nests, (4) black-tailed prairie dog (*Cynomys ludovicianus*) colonies, (5) swift fox (*Vulpes velox*), (6) threatened and endangered fish species, and (7) wetland habitat. In addition, amphibian breeding habitat was opportunistically documented, as well as all other wildlife species observed within or near the project area.

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The goal was to document and summarize the ecological resources not only within the project area, but also the surrounding ESA. The 2.5-mile (4.0 km) ESA area overlaps the 2.25-mile (3.62 km) AOR buffer. Aerial surveys conducted included the entire ESA area, but groundwork was almost entirely restricted to the project area due to limited access to private lands. Thus, certain ecological resources within the ESA were identified using aerial surveys, documented from public roads, and/or mapped using National Agriculture Imagery Program (NAIP) imagery (e.g., prairie dog colonies). When possible, these resources were later verified and mapped from the ground if landowner permission was granted.

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Information was also gleaned from recent field surveys conducted for the TCEA in 2005 and 2008, and from the baseline surveys conducted for the Crow Butte Mine in 1982. In 2005, primary floral and faunal species were identified through observation to determine the distribution and composition of vegetation communities that occurred within the project area. Raptor surveys were also conducted and compiled with past ecological data collected during 2008.

3.5.5.2 Existing Disturbance

Human expansion into the region was prompted by the development of the transcontinental railroad by the Union Pacific Railroad during the late 1800s. As a result of this expansion, the region became a regional railroad trade hub and eventually a source for agriculture, intensive rangeland, mining, and human development. Disturbance within the project area is limited to one small residence (i.e., farmhouse), farming and ranching activity, watering sites for cattle (e.g., windmills, water tanks), improved gravel and unimproved two-track roads, and one small gravel pit.

3.5.5.3 Vegetation and Land Cover Types

Vegetation classifications were applied to the MEA through heads-up digitizing of NAIP imagery and categorized into eight vegetation communities similar to the definitions in the TCEA Technical Report (**Figure 3.5-1**). These communities include mixed-grass prairie, degraded rangeland, mixed conifer, cultivated, drainage, structure biotope, range-rehabilitation, and deciduous streambank forest. The mixed-conifer vegetation type was not defined in the TCEA Technical Report, but was present in the MEA. The degraded rangeland class was added following field observations. Vegetation types were ground-truthed, and species composition of each type was recorded. Vegetation types represent a variety of species compositions and relative abundances. **Table 3.5-2** summarizes the abundance of vegetation types within the MEA.

The Chadron State College herbarium contains 468 plant species from Dawes County (Wyoming Fuel Company 1983). In addition, the Institute of Agriculture and Natural Resources lists 603 native and 123 introduced plant species that occur in Dawes County. During the 1982 baseline study (Wyoming Fuel Company 1983), more than 400 species of plants were collected (**Appendix H-1**).

Mixed-Grass Prairie

The most common vegetation type present in the MEA is mixed-grass prairie, comprising 65 percent of the area (**Table 3.5-2**). Common species observed in this vegetation type include the following grasses: needle-and-thread grass (*Hesperostipa comata*), junegrass (*Koeleria macrantha*), Sandberg bluegrass (*Poa secunda*), and threadleaf sedge (*Carex filifolia*). The non-native species cheatgrass (*Bromus tectorum*) and Kentucky bluegrass (*Poa pratensis*) were also abundant in this vegetation type. Common forbs observed included white sagebrush (*Artemisia ludoviciana*), fringed sagebrush (*A. frigida*), phlox (*Phlox sp.*), locoweed (*Oxytropis sp.*), lupine (*Lupinus sp.*), pussytoes (*Antennaria sp.*), and yucca (*Yucca*

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glauca). This vegetation type is the most common in the northern portion of the project area, and is quite variable in composition (**Figure 3.5-1**).

Degraded Rangeland

Areas where non-native species, predominantly cheatgrass, have overtaken the landscape are classified as degraded rangeland. Considerable portions of the southern half of the project area were observed to have larges patches dominated by cheatgrass and Kentucky bluegrass. The southernmost portion of the project area has large patches dominated by smooth brome (*Bromus inermus*). Overall biodiversity in these areas is lower than in areas of mixed-grass prairie. While non-native grasses are common throughout the project area, sections of the southern portion of the project area were particularly dominated by these species. The degraded rangeland vegetation type comprises 13.7 percent of the project area (**Table 3.5-2**; **Figure 3.5-1**).

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Mixed Conifer

Mixed-conifer forests are concentrated along drainages in the northern third of the project area, often expanding out onto nearby hills and plains (**Figure 3.5-1**). This vegetation type is dominated by Ponderosa pine, with chokecherry (*Prunus virginiana*), skunkbush sumac (*Rhus trilobata*), and snowberry (*Symphoricarpus albus*) common in the understory. A combination of native and non-native grasses were common, with smooth brome being particularly abundant in low-lying areas. Pussytoes was a commonly observed forb. Mixed-conifer forests comprise 8.3 percent of the project area, making this the most common of the forested vegetation types (**Table 3.5-2**).

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Cultivated

Cultivated fields make up approximately 6.3 percent of the project area and include crops such as alfalfa (*Medicago sativa*), wheat (*Triticum* spp.), oats (*Avena* spp.), corn (*Zea mays*), barley (*Hordeum* spp.), and rye (*Secale cereale*). In an environment not altered by humans, areas occupied by this vegetation type would most likely be occupied by mixed-grass prairie.

Drainages

Drainages in the south end of the project area are well drained and usually dry, covering 2.9 percent of the project area (**Table 3.5-2**; **Figure 3.5-1**). The vegetation composition in these intermittent tributaries to the Niobrara River is similar to that of surrounding grassland, though the vegetation is generally more robust. Meadow death camas (*Zigadenus venenosus*), wild onion (*Allium sp.*), and monkeyflower (*Mimulus sp.*) were observed in these areas. In the north side of the project area, conifers dominate the overstory of drainages with smooth brome in the understory. Standing water was only observed in the northern portion of the survey area, mostly in the area mapped as deciduous streambank forest. The weed houndstongue (*Cynoglossum officinale*) was observed in low densities.

Deciduous Streambank Forest

Deciduous stands found along ephemeral streams make up a very small portion of the project area, totaling less than 1 percent (**Table 3.5-2**; **Figure 3.5-1**). The most common overstory species observed within this habitat type include eastern cottonwood (*Populus deltoides*), boxelder (*Acer negundo*), and willow (*Salix sp.*). Snowberry was the dominant shrub, with Kentucky bluegrass, smallwing sedge (*Carex microptera*), *Rumex sp.*, and annual mustards (*Brassicaceae sp.*) common in the understory.

Structure Biotopes

The term "structure biotopes" refers to man-made features, with the exception of cultivated land. Common examples include roads, highways, buildings, farmlands, cities, and industry infrastructure. This cover type comprises 1.4 percent of the project area (**Table 3.5-2**; **Figure 3.5-1**). Dominant plant species in these areas are often non-native weedy species, including smooth brome, cheatgrass, white sweetclover (*Melilotus alba*), yellow sweetclover (*Melilotus officinalis*), and mustard species.

Range Rehabilitation

Previously cultivated fields are defined as range rehabilitation areas and are generally heavily grazed. Seasonal haying is also an important component of these areas. Vegetation of this habitat type is variable, with weedy species being more prevalent in areas with greater disturbance from cattle. Crested wheatgrass (*Agropyron cristatum*) was the dominant grass species observed, while fringed sagebrush was also common. This habitat type comprises less than 1.4 percent of the project area (**Table 3.5-2**; **Figure 3.5-1**).

3.5.6 Mammals

Information concerning current and historical mammal observations and distribution within and near the MEA were obtained from a variety of sources including the NGPC and the Nebraska Natural Heritage Program (NNHP). The NNHP is a primary repository for wildlife information in the State of Nebraska and contains records of wildlife observations for birds, mammals, herptiles, fish, and species at risk in the state. Wildlife information for the MEA was supplemented with survey data collected by Hayden-Wing Associates during spring/summer 2011 as part of the baseline and monitoring data requirements. A list of known and expected mammal species for Dawes County is provided in **Appendix H-2**.

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3.5.6.1 Big Game

Six big game species occur or potentially occur in the vicinity of the MEA, including pronghorn (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), white-tailed deer (*Odocoileus virginianus*), elk (*Cervus elaphus*), bighorn sheep (*Ovis canadensis*), and bison (*Bison bison*). Big game populations are managed by the NGPC. Population objectives are set annually based on multiple factors including, but not limited to, the carrying capacity of the habitat, herd production and health, and weather (e.g., drought).

Pronghorn

Pronghorn typically inhabit grasslands and semi-desert shrublands of the western and southwestern United States. This species is most abundant in short- and mixed-grass habitats and is less abundant in more xeric habitats. Home ranges for pronghorn can vary between 400 and 5,600 acres, according to several factors including season, habitat quality, population characteristics, and local livestock occurrence. Typically, daily movement does not exceed 6 miles (9.7 km). Some pronghorn make seasonal migrations between summer and winter habitats, but these migrations are often triggered by availability of succulent plants and not local weather conditions (Fitzgerald et al. 1994). Pronghorn occur mainly in the western half of Nebraska, with the highest densities occurring in Sioux and Dawes Counties. In Nebraska, this species primarily inhabits short-grass prairies and badlands (NGPC 2011a).

The project area is located in the Box Butte Antelope Hunt Unit, which extends from the Wyoming/Nebraska border, north from the North Platte River, east to Nebraska Highway 250, and south from the Pine Ridge Escarpment. In 2007 and 2008, 34 and 32 pronghorn, respectively, were harvested within this hunt unit (NGPC 2008a). In 2009, 36 pronghorn were harvested (NGPC 2010): and in 2010, 48 pronghorn were harvested (NGPC 2011b). Pronghorn populations in Nebraska are increasing, and harvest is at a 25-year high (NGPC 2011b). Pronghorn were observed regularly throughout the project area in 2011, and they appear to be relatively common year-round.

Mule Deer

Mule deer occur throughout western North America from central Mexico to northern Canada. Mule deer are found throughout Nebraska, but are more common in the western half of the state (NGPC 2011a). They inhabit a wide variety of habitats (e.g., sagebrush-steppe, grasslands, foothills) and feed on succulent grasses, forbs, shrubs, and agricultural crops. Mule deer tend to follow elevational migrations, moving from uplands during the warmer months to lowlands in the winter where denser, taller vegetation cover allows for manageable snow levels for foraging (Fitzgerald et al. 1994). Mule deer fawn mortality is typically due to predation or starvation. Adult mortality often occurs from hunting, winter starvation, and automobile collisions. Typical mule deer predators may include coyotes, bobcats, golden eagles, mountain lions, bears, and domestic dogs (Fitzgerald et al. 1994).

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The MEA is located within the Pine Ridge Mule Deer Hunt Unit, which occupies areas of Box Butte, Dawes, Sheridan and Sioux Counties north of the Niobrara River and west of Nebraska Highway 27. Due to concerns with harvest of buck deer, the NGPC conducted a study (based on aged sample projected by total kill) of adult bucks 2.5 years or older during the 1987, 1992, and 1997 regular firearm hunting seasons. Adult mule deer buck harvests in the Pine Ridge unit for 1987, 1992, and 1997 were 202, 446, and 385, respectively (NGPC 2011c). The adult mule deer buck harvest for the Pine Ridge unit was 735 in 2008 (NGPC 2008a) and 922 in 2009 (NGPC 2010). In 2010, 10,709 mule deer were harvested in Nebraska; 957 of these were adult bucks harvested in the Pine Ridge Unit (NGPC 2011b). Mule deer were seen within the project area during field_work in 2011 but not in high numbers, though higher numbers are likely during winter.

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White-tailed Deer

White-tailed deer occur throughout North America from the southern United States to Hudson Bay in Canada. Across much of its range, this species inhabits forests, swamps, brushy areas, and nearby open fields. In Nebraska, white-tailed deer are found throughout the state, but have higher densities in the eastern half. They are typically concentrated in riparian woodlands, mixed-shrub riparian areas, and irrigated agricultural lands, and are generally absent from dry grasslands and coniferous forests (NGPC 2011a). White-tailed deer have a diverse diet, capitalizing on the most nutritious plant matter available at any time. In addition to native browse, grass, and forbs, this species often relies on agricultural crops, fruits, acorns, and other nuts. Mortality of white-tailed deer is typically related to hunting, winter starvation, collisions with automobiles, and predation. Predators may include coyotes; mountain lions; wolves; and occasionally bears, bobcats, and eagles (Fitzgerald et al. 1994).

White-tailed deer hunting in the region occupies the same unit as previously described for mule deer. Results of the white-tailed deer buck harvest for the Pine Ridge area were 186, 318, and 363 in 1987, 1992, and 1997, respectively (NGPC 2011c). In 2008 and 2009, the white-tailed deer adult buck harvests for the Pine Ridge unit were 824 (NGPC 2008a) and 1,053 (NGPC 2010), respectively. In 2010, the white tailed deer adult buck harvest for the Pine Ridge Unit was 1,252 (NGPC 2011b). According to the NGPC (2011a), the fall white-tailed deer population in Nebraska is estimated to be between 150,000 and 180,000 animals. Currently, the NGPC has a goal of reducing white-tailed deer populations in eastern

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Nebraska by increasing harvest numbers. In 2010, a record 77,028 white-tailed deer were harvested in the state (NGPC 2011d).

Within the MEA, white-tailed deer were commonly seen during the 2011 survey around the agricultural and riparian habitats, but they were also seen in the higher elevations and in the forested areas.

Elk

Elk formerly ranged over much of central and western North America from the southern Canadian Provinces and Alaska south to the southern United States, and eastward into the deciduous forests. In Nebraska, this species occurs primarily in the northwestern region in a variety of habitats, including coniferous forests, meadows, short- and mixed-grass prairies, and sagebrush and other shrub lands. Similar to other members of the deer family, this species relies on a combination of browse, grasses, and forbs, depending on their availability throughout the seasons. Elk tend to be migratory, moving between summer and winter ranges. Typically, mortality is a result of predation on calves, hunting, and winter starvation. Predators may include coyotes, mountain lions, bobcats, bears, and golden eagles (Fitzgerald et al. 1994).

NGPC estimates the state elk population at approximately 2,300 individuals, and most of the population inhabits the Pine Ridge area (NGPC 2011e). The MEA Project Area is located in the Pine Ridge area, within the Ash Creek Elk Unit, specifically located east of Nebraska Highway 2, north of Spur L7E and west of U.S. Highway 385. The 2008 elk harvest was 73 individuals in the Pine Ridge area, and 10 individuals in the Ash Creek Elk Unit (NGPC 2008a). The 2009 elk harvest was 85 individuals in the Pine Ridge area, and 17 individuals in the Ash Creek Elk Unit (NGPC 2010). In 2010, elk harvest in the Pine Ridge included 114 individuals (17 in the Ash Creek Elk Unit) with an estimated 1,000 to 1,200 individuals comprising the population (NGPC 2011b).

Relatively large numbers of elk are known to occur year-round within the project area. During the fall and winter, the elk occupy many of the agricultural fields and lower elevation upland habitat. Although still found in the lower elevations during the spring and summer, the majority of the herd appears to move north to higher elevations in the forested portions of the Pine Ridge during the warmer portions of the year.

Bighorn Sheep

Prior to the 1900s, the Audubon bighorn sheep (*O. canadensis auduboni*) inhabited parts of western Nebraska including the Wildcat Hills, the Pine Ridge, along the North Platte River to eastern Lincoln County, and along the Niobrara River. It is thought that the Audubon bighorn probably became extinct in the early 1900s, with its last stronghold being the South Dakota badlands (NGPC 2011a).

Bighorn sheep were reintroduced into Nebraska in the early 1980s; the current population is estimated at 300 sheep, divided between two populations in the Pine Ridge and Wildcat Hills (NGPC 2011b). The reintroduction project began in 1981, when 12 bighorn sheep were first released in Fort Robinson State Park. Between 1988 and 1993, a total of 44 sheep were released in the state park. Twenty-two sheep were released in the Wildcat Hills south of Gering, Nebraska in 2001, and in 2005, an additional 49 were released into the Pine Ridge area. The most recent reintroduction occurred in 2007, with 51 bighorn sheep from Montana released in the Wildcat Hills south of McGrew, Nebraska (NGPC 2011f). As a result of disease, herd growth is limited; consequently, only a single lottery and a single auction permit were authorized for bighorn sheep hunting in 2011 (NGPC 2011b). Appropriate escape terrain habitat is

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not present within the MEA, and it is therefore extremely unlikely that bighorn sheep would occur within the project area.

Bison

Fort Robinson State Park currently manages a herd of 200 bison. These bison are contained in a compound and do not occur within the project area boundary.

3.5.6.2 Carnivores

The following species of carnivores have been documented or are expected to be present within the MEA: coyotes (*Canis latrans*) and red foxes (*Vulpes vulpes*) typically occupy grassland, shrub-steppe, and agricultural habitats; long-tailed weasels (*Mustela frenata*) are habitat generalists and can be found in a wide variety of habitats; bobcats (*Lynx rufus*) tend to occupy woodland and shrubland habitat; badgers (*Taxidea taxus*) inhabit areas with loose soils that are suitable for digging burrows which frequently includes roadsides, prairie dog colonies, and areas near surface disturbance; and mountain lions (*Puma concolor*) prey upon mule and white-tailed deer and tend to occupy wooded habitats. Coyotes are considered non-game species, and residents do not need a permit to harvest this species. Mountain lion permits are not available, and lions cannot be trapped or hunted in Nebraska. Badger, bobcat, long-tailed weasel, raccoon (*Procyon lotor*), red fox, and striped skunk (*Mephitis mephitis*) are open to hunting and trapping with appropriate permits.

Using infrared-triggered remote trail cameras, which were deployed for documenting the presence/absence of swift fox (see Section 3.5.11), Hayden-Wing Associates documented the presence of coyotes and badgers within the project area (HWA 2011). Several other carnivore species are expected to be present, such as red fox, bobcat, raccoon, striped skunk, and long-tailed weasel, even though they were not detected by the cameras.

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3.5.6.3 Small Mammals

Small mammals occupy a wide variety of habitats within the region, but most are considered common and widespread. Species known to occur or that are potentially present in the MEA include the deer mouse (*Peromyscus maniculatus*), white-footed mouse (*Peromyscus leucopus*), thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), meadow jumping mouse (*Zapus hudsonius*), plains pocket gopher (*Geomys bursarius*), least chipmunk (*Tamias minimus*), and meadow vole (*Microtus pennsylvanicus*). Muskrat (*Ondatra zibethicus*) and beaver (*Castor canadensis*) are known to occur in or near the project area, especially near the Niobrara River along the southern edge of the project area. Porcupine (*Erethizon dorsatum*) occurs in the wooded areas of the project area, as does the eastern fox squirrel (*Sciurus niger*). Four rabbit species are known or suspected to occur within the project area, including the white-tailed jackrabbit (*Lepus townsendii*), black-tailed jackrabbit (*Lepus californicus*), eastern cottontail (*Sylvilagus floridanus*), and desert cottontail (*Sylvilagus audubonii*) (HWA 2011).

Two bat species have been recorded within a few miles of the MEA: the fringe-tailed myotis (*Myotis thysanodes pahasapensis*) and the long-legged myotis (*Myotis volans*). Both bat species are listed at Tier I At-Risk species by Nebraska Natural Legacy Project (NNLP), and the fringe-tailed myotis is listed as Sensitive in the nearby Pine Ridge Ranger District by the U.S. Forest Service (USFS) Nebraska National Forest. According to the USFS (Abegglen, pers. comm. 2011), the fringe-tailed myotis is known to occur in the Ponderosa pine habitat near the MEA. Both species may be present in the project area if suitable hibernacula exist (e.g., caves, mines, buildings, cliff crevices, hollows in snags, or hollow areas under the bark of trees). Also, it is likely that these and other bat species use the project area for foraging, but no formal bat surveys were conducted by Hayden-Wing Associates in 2011.

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Black-tailed prairie dogs, which are listed as Sensitive in the Pine Ridge Ranger District by the USFS, are known to occur in the vicinity of the project area. Four colonies were found during aerial surveys; two are situated along the project area border, and two are located within the 2.5-mile (4.0 km) ESA (HWA 2011). All four are occupied with prairie dogs. The smallest is only 0.63 acre in size, which is located just east of the project boundary in section 7, T29N:R50W. The other colony that borders the project area is approximately 20 acres in size and is located in section 30, T29N:R50W. The current boundaries of both of these colonies were mapped on foot in 2011.

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The two colonies in the ESA were much larger; one south of the project area measured 47 acres and one east of the project area measured 151 acres in size. The southernmost colony (section 36, T29N:R51W and sections 2 and 3, T28N:R51W) was mapped entirely using NAIP 2010 imagery due to a lack of access, but the colony to the east (sections 16 and 21, T29N:R50W) was partly mapped from the ground (i.e., portion in section 21), and the remaining portion was mapped using NAIP imagery due to a lack of landowner access permission. Prairie dogs, groundhogs (*Marmota monax*), and porcupine are considered non-game species in Nebraska, and residents do not need a permit to harvest these species. Prairie dog colonies, however, provide habitat for several other at-risk or sensitive species, such as swift foxes, long-billed curlews (*Numenius americanus*), ferruginous hawks (*Buteo regalis*), and burrowing owls. Therefore, avoidance of prairie dog colonies is recommended by the U.S. Fish Wildlife Service (USFWS) and NGPC for projects involving ground disturbance activity.

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3.5.7 Birds

The Nebraska Ornithologists Union lists 291 bird species occurring in Dawes County (**Appendix H-3**) and 455 species recorded in the state (NOU 2011). Of the 455 species in the state, 329 occur regularly (reported 9 out of the past 10 years); 78 are accidental (occurring less than two times in the past 10 years); 42 are casual (occurring between four and seven times in the past 10 years); four are extirpated, and two are extinct (NOU 2011). During a survey conducted in 1982, 201 bird species were documented in an area just north of the MEA (CBR 2010). Although formal point count bird surveys were not performed for the project area, a total of 73 bird species were documented in and around the project area in 2011, the majority of which are believed to breed locally (HWA 2011). Of the 73 species, 68 were documented during the 1982 baseline survey, four were listed as "reported by knowledgeable individual" in previous ecological surveys (blue jay [*Cyanocitta cristata*], eastern bluebird [*Sialia sialis*], northern mockingbird [*Mimus polyglottos*], and peregrine falcon [*Falco peregrinus*]), and one was new for the list of species (Eurasian collared-dove [*Streptopelia decaocto*]).

3.5.7.1 Passerines

Many species of passerines (perching birds, including songbirds) use the MEA for breeding, feeding, migration, wintering, and as year-round habitats. All habitats throughout the project area are likely used to some degree by various species. The Migratory Bird Treaty Act (MBTA; 16 USC, §703 *et seq.)* protects 836 migratory bird species (to date) and their eggs, feathers, and nests from disturbances (USFWS 2011a). See **Appendix H-3** for a list of known or expected bird species for the project area and surrounding ESA.

The Crawford Breeding Bird Survey (BBS) route passes within 4 miles (6.4 km) of the MEA to the north. In an analysis of data collected along this BBS route from 1966 to 2007, the five most abundant species were western meadowlark (*Sturnella neglecta*; 181.1 birds per route), mourning dove (*Zenaida macroura*; 56.1 birds per route); American robin (*Turdus migratorius*; 18.1 birds per route); American crow (*Corvus brachyrhynchos*; 16.4 birds per route); and lark sparrow (*Chondestes grammacus*; 16.3 birds per route) (Sauer et al. 2011).

3.5.7.2 Upland Game Birds

Wild turkey (*Meleagris gallopavo*), ring-necked pheasant (*Phasianus colchicus*), gray partridge (*Perdix perdix*), and sharp-tailed grouse (*Tympanuchus phasianellus*) occur in the MEA. The site is located in the Panhandle hunting region for upland game birds and is managed by the NGPC. Wild turkeys in the Pine Ridge area use habitats in the foothills, plateaus, forest habitats, and riparian draws and are likely to be distributed throughout the project area. Ring-necked pheasants often use open grasslands and agricultural areas and are fairly common. Gray partridge, which are introduced and uncommon, are often located in areas near dense shrub cover. Sharp-tailed grouse inhabit open grassland and steppe habitats with scattered trees and shrubs. The scattering of trees and shrubs plays an important role in their life cycle for food and cover, and this species is known to occur in the project area in low numbers. Upland game birds designated as migratory that are confirmed or potentially present in the project area include mourning dove, Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), and Wilson's snipe (*Gallinago delicata*). Mourning doves occupy a wide variety of habitats including sagebrush, grasslands, shrubland, and riparian areas. Sora and Virginia rail typically occupy areas near wetlands, and snipe are frequently found in flooded fields and ditches (HWA 2011).

3.5.7.3 Raptors

Several raptor species are known or expected to occur in or around the MEA. Grasslands, shrublands, and scattered trees provide suitable nest substrates for a variety of species for breeding, hunting, and wintering. The Niobrara River drainage immediately south of the site provides habitat for tree-nesting species and provides potential roosting sites for wintering raptors (e.g., bald eagle, rough-legged hawk [*Buteo lagopus*]). All raptors and their nests are protected from "take" or disturbance under the MBTA (16 USC, §703 *et seq.*; USFWS 2011a). Golden eagles and bald eagles also are afforded additional protection under the Bald and Golden Eagle Protection Act, amended in 1973 (16 USC, §669 *et seq.*). In addition, several raptor species are considered at-risk or sensitive by NNLP and/or Nebraska National Forest-Pine Ridge Ranger District.

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Aerial surveys were conducted for documenting raptor nests throughout the MEA and the ESA on April 28 and May 13, 2011. A ground survey for confirming nest locations, determining nest status, and searching for new nests was conducted from May 10 to 12, 2011. The ground survey was limited to the project area and areas adjacent to public roads in the ESA due to minimal access to private lands. Additional ground surveys for determining productivity of known nests, including nests in the ESA found during the aerial surveys, were conducted from June 7 to 8 and July 7 to 8, 2011 (HWA 2011).

A total of seven raptor nests were documented within the MEA during 2011, including two active red-tailed hawk (*Buteo jamaicensis*) nests, two active burrowing owl nests, one active great horned owl (*Bubo virginianus*) nest, and two inactive stick nests of unknown species (**Figure 3.5-2**). An additional 19 nests were documented within the ESA, including five active red-tailed hawk nests, two active great horned owl nests, nine active burrowing owl nests, one active Swainson's hawk (*Buteo swainsoni*) nest, one active ferruginous hawk nest, and one inactive stick nest of an unknown species. One additional active great horned owl nest was located just outside the ESA (HWA 2011). Of the five species documented nesting in and around the MEA, two (ferruginous hawk and burrowing owl) are designated by the NNLP as Tier I At-Risk species. All but one of the burrowing owl nests were found in active prairie dog colonies.

Of the five active nests in the MEA, only one great horned owl nest (nest #13) and one red-tailed hawk nest (nest #20) were confirmed to be productive (i.e., at least one fledged chick) at the time of the last survey. Both great horned owl nests in the ESA had large chicks during the first ground survey and both likely fledged young, and red-tailed hawk nest #12 in the ESA was confirmed productive during the last survey. The remaining active nests still had young to medium-aged nestlings when surveyed last or, in the case of the burrowing owl nests, production could not be determined due to chicks remaining underground or the burrow entrances being too obscured by vegetation to observe chicks during the final ground survey (HWA 2011).

Several additional raptor species were observed in and around the project area during the spring surveys, including Cooper's hawk (*Accipiter cooperii*), northern harrier (*Circus cyaneus*), golden eagle (*Aquila chrysaetos*), American kestrel (*Falco sparverius*), and peregrine falcon (HWA 2011).

With the exception of peregrine falcons, for which little nesting habitat exists within the project area, all the other species are possible breeders in and around the project area. Other species documented within 10 miles (16.1 km) of the MEA and that have the potential to occur and breed within the MEA include bald eagle, osprey (*Pandion haliaetus*), merlin (*Falco columbarius*), prairie falcon (*Falco mexicanus*), sharp-shinned hawk (*Accipiter striatus*), northern goshawk (*Accipiter gentilis*), short-eared owl (*Asio flammeus*), long-eared owl (*Asio otus*), barn owl (*Tyto alba*), northern saw-whet owl (*Aegolius acadicus*), and eastern screech owl (*Megascops asio*). Rough-legged hawks are common within the MEA during the winter, and other species that have the potential to occur during migration or winter include broad-winged hawk (*Buteo platypterus*), red-shouldered hawk (*Buteo lineatus*), gyrfalcon (*Falco rusticolus*), and snowy owl (*Bubo scandiacus*).

Northern goshawk, Cooper's hawk, and sharp-shinned hawk are typically forest-nesting raptors. Potential nesting habitat includes scattered, mixed-conifer forests located in the northern portion of the project area and in the ESA. These forests may also provide nesting habitat for red-tailed hawks, osprey, merlins, American kestrels, and long-eared owls. Owls and falcons with only a few exceptions are dependent on other species for the availability of nests. Long-eared owls and merlins are secondary stick nesters (they use stick nests of other species, such as magpies and crows), and the smaller owls and kestrels are secondary cavity nesters (they use tree cavities established by other species, such as woodpeckers). Ferruginous hawks are found primarily in mixed-grass prairie and sagebrush steppe habitats during the spring, summer, and fall. They generally build nests on the ground, rock outcrops, cliff ledges, or small isolated trees. The one ferruginous hawk nest documented in the ESA is in a small isolated tree. Swainson's hawks typically nest in small trees or large shrubs along water features (e.g., irrigation ditches, streams), frequently near agricultural areas. Within the project area, the majority of *Buteo* nests are located in the deciduous trees along the Niobrara River, shelterbelts, trees around farmhouses and old homesteads, and the Ponderosa pine trees in the northern portion of the project area. Golden eagles commonly nest on cliffs and in large trees. Although cliff habitat is limited within the project area, golden eagle nests are known to occur just north of the project area, and suitable nesting habitat (i.e., large trees) occurs within the MEA and the ESA. Prairie falcons and peregrine falcons are strictly cliff-nesting species, and although they have been documented near the project area, cliff habitat within the project area is limited and nests are unlikely (HWA 2011).

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Wintering Bald Eagles

All potential bald eagle roosting habitat within the ESA was surveyed on three separate occasions during the 2010/2011 winter (HWA 2011). Potential roosting habitat was defined as any medium or large deciduous or coniferous tree or group of trees. All potential habitat was identified and delineated using NAIP imagery from 2010. Aerial surveys were conducted using a Cessna 172 fixed-winged aircraft. Survey dates included December 14, 2010, January 12 and February 8, 2011, and all surveys were conducted between 30 minutes pre-sunrise to 1 hour post-sunrise or between 1 hour pre-sunset to 30 minutes post-sunset. Large blocks of potential habitat (i.e., conifer forest) were flown using north-south transects spaced by 0.5 mile (0.8 km). Linear habitat (i.e., riparian habitat) was flown by flying parallel to the habitat type. Information recorded for each eagle sighting included number of adults, number of subadults, behavior, and perch type.

During the winter surveys, no bald eagles were seen within the MEA, and one adult bald eagle was seen on one occasion (Dec. 14, 2010) in the ESA. The results suggest that bald eagles are present in the vicinity of the MEA during the winter and likely use the surrounding habitat for feeding and roosting, but apparently, regularly attended roost locations are not present even though suitable roosting habitat exists in the area (HWA 2011).

3.5.7.4 Waterfowl

During spring and fall migration, some waterfowl species may use the area for feeding, nesting, or resting, specifically those areas along the Niobrara River which occur within the ESA of the MEA, but little open water exists within the project area. Box Butte Reservoir is likely used heavily during migration; however, this waterway is just outside the ESA. The baseline study in 1982 documented 24 species of waterfowl (CBR 2010). A complete list of waterfowl species that may potentially occur in the project area is included in **Appendix H-3**.

3.5.8 Reptiles and Amphibians

The baseline study in 1982 documented 13 species of reptiles and amphibians (CBR 2010). Though formal surveys were not conducted for the MEA, several species of herptiles were documented opportunistically, including: plains spadefoot toad (larval stage) (*Spea bombifrons*), northern leopard frog (*Rana pipiens*), and common snapping turtle (*Chelydra serpentina*). Only the spadefoot toads were found within the project area; the other two species were found along the Niobrara River corridor near the project area. The spadefoot toad tadpoles were found in a small ephemeral wetland in NW section 13, T29N:R51W. Identification of the tadpoles to species was aided by D. Ferraro, Extension Associate Professor and Herpetologist, School of Natural Resources, University of Nebraska-Lincoln (Ferraro, pers. comm. 2011). A complete list of known or expected herptiles for Dawes and Box Butte Counties is provided in **Appendix H-4** (Fogell 2010).

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3.5.9 Threatened, Endangered, or Candidate Species

Under the Federal Endangered Species Act (FESA) of 1973 and the Nongame and Endangered Species Conservation Act (Neb. Rev. Stat. §37-430 *et seq.*) several species receive unique protections due largely to their rarity, population declines, and/or habitat loss. A summary of potentially occurring threatened and endangered species within the MEA is presented in **Table 3.5-3** (also see **Appendix H-7** for range maps in Nebraska). Consultations were held between Hayden-Wing Associates and the NGPC, which consisted of emails and phone conversations (NGPC 2011). The NGPC provided a written response to Hayden-Wing Associates (NGPC 2011; **Appendix V**).

Black-footed Ferret

The black-footed ferret (*Mustela nigripes*) is listed by the USFWS as endangered and is considered the most endangered mammal species in the United States. Several factors have contributed to declines in ferret populations, including eradication of prairie dogs by humans and disease outbreaks (i.e., sylvatic plague and canine distemper). Distributions of black-footed ferrets closely correspond to those of prairie dogs. Black-footed ferrets depend heavily on prairie dogs for food and they also use prairie dog burrows for shelter, parturition, and raising young. Black-tailed prairie dog colonies occur in the project area. However, no known ferret populations occur in Nebraska (NGPC 2011a); therefore, the likelihood of black-footed ferrets occurring within the project area is minimal.

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Whooping Crane

The whooping crane (*Grus americana*) is North America's tallest bird, with males close to 5 feet tall. The species is listed as endangered by USFWS and NGPC, and according to USFWS they have the potential to occur in Dawes County (USFWS 2011b). Whooping cranes migrate through central Nebraska during spring and fall, and primarily stop over along the Platte River Valley (NGPC 2011a). Whooping cranes use a variety of habitats during the non-breeding season, including wetland mosaics, cropland, and riverine habitat in Nebraska. They depend on seasonally and semi-permanently flooded wetlands for roosting. Such habitat is limited or absent in the MEA. The USFWS maintains a database of confirmed whooping crane sightings within the known migration corridor for this species. According to this database, there has been one confirmed whooping crane sighting in Dawes County in the last 50 years: a sighting of one individual adult whooping crane in 1991, approximately 17 miles (27.4 km) north of the MEA (USFWS 2011c). It is unlikely that whooping cranes would occur within or near the project area due to the lack of suitable habitat.

Gray Wolf

Gray wolves were first listed as endangered in the lower 48 states in 1967. After decades of intensive management, including reintroductions in Idaho and Wyoming, the species was delisted in the Northern Rocky Mountain Distinct Population Segment (DPS) except Wyoming on May 5, 2011 (USFWS 2011d). There are no known populations of wolves in Nebraska. However, dispersing individuals from either Montana or Wyoming into the state would be afforded full protection under the FESA as an endangered species. Wolves are capable of dispersing significant distances, but it is extremely unlikely that wolves would occur in or near the project area.

Swift Fox

The swift fox is a state-listed endangered species that inhabits short-grass and mixed-grass prairies over most of the Great Plains. It appears to prefer flat to gently rolling terrain. Swift foxes feed primarily on lagomorphs, but arthropods and birds are also included in their diets. They mate between late December and February. A mating pair can bear two to five pups in late March to early May, and pups emerge from the den in June. Dens are generally located along slopes or ridges that offer good views of the surrounding area (Fitzgerald et al. 1994). In a study completed in southeastern Colorado, the home range size of an adult swift fox was approximately 3.6 mi^2 (9.4 square km^2) at night, and their day ranges are typically much smaller (Schauster et al. 2002).

The swift fox is found in native short-grass prairies in northwestern Nebraska. Unlike coyotes or red fox, the swift fox uses dens in the ground year-round. Some characteristics of swift fox dens differentiate them from other dens. Swift fox den entrances measure about 8 inches in diameter, similar to the size of a badger den. However, swift fox usually have more than one entrance, whereas badgers and most other animals have only one. Swift fox tend to spread excavated soil over a larger area than most other animals, resulting in a less prominent mound near the burrow's entrance. Dens are located on relatively flat ground away from human activity. Where coyotes are abundant, predation by coyotes is a significant cause of mortality for swift fox, and den availability is an important aspect of swift fox survival (Schauster et al. 2002).

Numerous natural and anthropocentric factors influence swift fox populations. Natural factors include fluctuating prey availability, interspecies competition, disease, and landscape physiography. Anthropogenic factors include habitat loss from agricultural, industrial, and urban conversion; land uses on remaining habitat, including hydrocarbon production, military training, and grazing; and pesticide use. Competition with coyotes and red foxes may currently be the most significant threat to swift fox populations, though habitat loss is also a major threat (Stephens and Anderson 2005).

Presence of swift foxes has been confirmed by NGPC in Dawes, Box Butte, and Sioux Counties (NGPC 2009), and potentially suitable habitat occurs in and around the project area; thus, the presence of swift fox within the MEA is possible. However, much of the habitat within the project area appears to be marginal, and previous site-specific surveys in the area have failed to detect the species. Grass height in particular appears to create unsuitable conditions throughout the majority of the project area, where dense fields of cheatgrass exceed 14 inches in many areas during summer (HWA 2011).

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As general surveillance for carnivore species in the project area, and with a focus on sampling areas most suitable for swift fox, Hayden-Wing Associates deployed remote infrared trail cameras throughout mixed-grassland portions of the project area in 2011. Cameras were used instead of the conventional track station methods because of time and budget constraints. Hayden-Wing Associates used Reconyx© HyperFire™ HC600 passive infrared (no glow illuminator) remote trail cameras for the monitoring. Four cameras were deployed simultaneously among eight locations throughout the southern half of the project area. Cameras were deployed continuously from June 6 to July 7, 2011. The number of sampling days per location was largely determined by the timing of other field surveys, but cameras were deployed for 9 to 22 days per location. Cameras were positioned along fencelines and other likely travel corridors and baited with a combination of skunk scent (to act as a long-distance lure) and fish oil. Camera locations were deliberately selected based on quality of habitat, proximity to prairie dog colonies, and presence of cattle (to protect cameras).

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No swift fox were detected using the remote cameras during 2011. Only two species of carnivores were detected: coyote and badger. Other species detected by the cameras included pronghorn, white-tailed deer, elk, cottontail *sp.*, jackrabbit *sp.*, cattle, and a lark bunting (*Calamospiza melanocorys*) (HWA 2011).

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Fish

Three species of state-listed fish are found in the Niobrara River system and may potentially be impacted by a reduction in river flow or impairment of stream quality (**Table 3.5-3**).

The blacknose shiner (*Notropis heterolepis*), a state-listed endangered species that was once commonly distributed throughout the state, is now restricted to three main areas along the Niobrara and Snake Rivers (NGPC 2009). This species typically inhabits cool weedy creeks, rivers, and lakes, usually with a sand substrate (NatureServe 2010). Reductions in stream flows and/or quality are important considerations for this species, as it resides downstream from the project area.

The northern redbelly dace (*Phoxinus eos*) and finescale dace (*Phoxinus neogaeus*) are state-listed threatened species. These species are both found in pools and beaver ponds in the headwaters of creeks and small rivers, usually in areas with a silty substrate (NatureServe 2010). Both of these species are downstream residents from the project area and could be impacted by reductions in water quantity and/or quality.

3.5.10 Aquatic Ecology

The MEA is located within the Niobrara River Basin. Annual flows within the Niobrara River basin are regulated mainly by snowmelt, precipitation, and groundwater discharge. No perennial streams occur within the MEA. The Niobrara River, located just south of the project area, is the prominent drainage in the vicinity of the MEA and flows into Box Butte Reservoir. Other small drainages include Dooley Spring, Willow Creek, and other small unnamed drainages, but all are dry and re-vegetated. All lack distinct stream channels and banks. Occasional runoff may create small pools in a few places, but there is no evidence of persistent stream flows in recent times (HWA 2011). Based on existing land uses, intensive grazing and agricultural practices are likely the largest factors influencing water quality in the area.

3.5.10.1 Fish

The 1982 and 1996 studies for the Crow Butte Mine recorded 21 species of fish throughout various streams and the White River (CBR 2010; **Appendix H-5**). Game fish collected included rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta*), and white sucker (*Catostomus commersonii*). Minnow species included longnose dace (*Rhinichthys cataractae*), common shiner (*Luxilus cornutus*), fathead minnow (*Pimephales promelas*), and creek chub (*Semotilus atromaculatus*). Many of the same species are thought to occur, or to have formerly occurred, in the Niobrara River. According to a local landowner (Troester, pers. comm. 2011), trout previously occurred in the Niobrara River just south of the MEA. However, a combination of drought and northern pike (*Esox lucius*) becoming more numerous upstream from Box Butte Reservoir during the past 10 years may have altered the fish community dramatically because pike are major predators of minnows and small trout (NPS 2002).

The local fish population was sampled at three sites along the Niobrara River during early June and mid-September, 2011 (HWA 2011). The goal was to collect baseline information on the species composition and general abundance upstream and downstream of the proposed project for comparison with future monitoring efforts. The sampling was intended also as surveillance for the state-listed species (black-nose shiner, northern redbelly dace, and finescale dace) known to occur in the Niobrara River. Sampling methods involved mainly electroshocking techniques, but seine nets were also used. Methods complied with the U.S. Environmental Protection Agency's Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers (Barbour et al. 1999).

During the June sampling effort, only two species were detected: northern pike and white sucker. Green sunfish (*Lepomis cyanellus*) and red shiner (*Cyprinella lutrensis*) were also detected during the training period. None of the state-listed species were detected (HWA 2011).

During the September sampling effort, eight species were detected: northern pike, white sucker, common carp (*Cyprinus carpio*), largemouth bass (*Micropterus salmoides*), yellow perch (*Perca flavescens*), bluegill (*Lepomis macrochirus*), pumpkinseed sunfish (*Lepomis gibbosus*), and central stoneroller (*Campostoma anomalum*). Again, no state-listed species were detected (HWA 2011).

3.5.10.2 Macroinvertebrates

Macroinvertebrates were also sampled during the baseline study in 1982, and results suggested that streams in the Crow Butte area were stressed, with low water quality and degraded stream habitats (CBR 2010; **Appendix H-6**). Aquatic conditions within the MEA may be similar, but macroinvertebrates were not sampled directly, although crayfish (unknown species) were commonly found during the fish sampling in the Niobrara River (HWA 2011).

3.5.10.3 Wetlands

The MEA was surveyed for areas that qualify as wetlands as defined by the U.S. Army Corps of Engineers (USACE 2008). All locations within the MEA identified in the National Wetlands Inventory (NWI) as wetlands or potential mesic sites were assessed as well (USFWS 2011e). Because ground-disturbing activity is not planned for wetland areas, only wetland habitat was surveyed and delineated. All drainages and low-lying areas were surveyed by all-terrain vehicle (ATV) or on foot. Three types of indicators were used for assessing whether a site qualified as a wetland, including hydric soil, hydrophytic vegetation, and hydrology. Sites containing all three indicators of hydric conditions were classified and delineated as wetlands.

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A total of four sites were evaluated as potential wetlands within the MEA (**Figure 3.5-1**):

- Site #1 – location identified in the NWI as "freshwater emergent wetland." Low-lying depression in a grassy field with ephemeral open water created by runoff and rainwater. Tadpoles were present. Location had appropriate hydric soil, vegetation, and hydrology. Qualifies as wetland.
- Site #2 – representative location in bottom of dry drainage. Wetland-like conditions not present, but location assessed in order to compare dry drainages to mesic locations. Does not qualify as wetland or mesic.
- Site #3 – location identified in the NWI as "freshwater emergent wetland." Site satisfied the vegetation and hydrology indicators for a wetland, but hydric soils were absent. Does not qualify as wetland, but mesic conditions exist.
- Site #4 – location not identified in the NWI, but found during ground surveys. Site satisfied the vegetation and hydrology indicators for a wetland, but hydric soils were absent. Does not qualify as wetland, but mesic conditions exist.

3.6 Climate, Meteorology, and Air Quality

3.6.1 Introduction

The proposed MEA is located in a semiarid or steppe climate. The area is characterized by abundant sunshine, low relative humidity, and sustained winds which lead to high evaporative demand. There are also large diurnal and annual variations in temperature. The region has cold, harsh winters; hot, dry summers; and relatively warm, moist springs and autumns. Temperature extremes range from roughly -25° F in the winter to 100° F in the summer. The "last freeze" occurs during late May and the "first freeze" in mid to late September. The area has a growing season of approximately 120 days (NOAA and University of Nebraska-Lincoln 2010).

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Yearly precipitation totals typically range from 13 to 16 inches. Migratory storm systems that originate in the Pacific Ocean release a majority of their moisture over the Rocky or Cascade Mountains. Major precipitation events can occur when these systems regain moisture already present in the area or moisture advected from the Gulf of Mexico. The region is prone to severe thunderstorm events throughout the spring and early summer months and much of the precipitation is attributed to these events. In a typical year, the area will experience four or five severe thunderstorm events (as defined by NWS criteria) and 40 to 50 thunderstorm days. Autumn stratiform rain events also contribute to precipitation totals, but to a lesser degree. Snow frequents the region throughout winter months (30 to 50 inches per year), but generally provides less moisture than rain events.

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Windy conditions are fairly common to the area. Roughly 3 percent of the time, hourly wind speed averages exceed 25 miles per hour (mph) (40.2 km). The predominant wind directions are north-northwesterly and northwesterly, with the wind blowing from those directions roughly 25 percent of the time. Surface wind speeds are relatively moderate at a year-round, hourly average of 10 to 11 mph. Higher average wind speeds are encountered during the winter months, while summer months experience lower average wind speeds.

For the regional analysis, meteorological data have been compiled for 21 sites surrounding the MEA. Data were acquired for these sites through the Western Regional Climate Center (NOAA and Desert Research Institute 2011) for Cooperative Observer Program (COOP) and Automated Surface Observation Stations (ASOS) operated by the NWS. Among these regional sites, the Scottsbluff Airport was selected as most representative of the MEA meteorology. Scottsbluff is less than 50 miles (80 km) south of the project site, with an elevation roughly 300 ft lower than the project area. It is also the closest NWS station to the project site that collects hourly wind and relative humidity data. Hourly data from Scottsbluff are available from the last 15 years.

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Hourly data for the Scottsbluff weather station were only available from NCDC in electronic form for years 1996 and later. In order to corroborate the conclusions drawn in the TR regarding temporal representativeness, hourly data from the Chadron airport have been compiled and analyzed. Only 12 years of NCDC hourly data were available for Chadron in electronic form, spanning the period from January 1, 2001 through December 31, 2012. The results of the Chadron data analysis are attached to this report as **Appendix S**. In addition, **Appendix S** presents the regression analyses for both Scottsbluff and Chadron, with associated p-values. For both sites, the conclusion reached is that the consistently low p-values render the high coefficients of determination (near 1.0) statistically significant. The strong correlation implied between wind characteristics during the baseline monitoring year and wind characteristics over a longer period is real at both the Scottsbluff and the Chadron sites. One may infer a similar relationship at the project site, some 30 miles southwest of Chadron and 48 miles north of Scottsbluff. This justifies the conclusion that the baseline year's wind data represent the long term.

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For the site-specific analysis, meteorological data from the MEA meteorological station were used. These data were collected during the 1-year baseline monitoring period extending from August 24, 2010 through August 29, 2011. **Table 3.6-1** provides the station ID, coordinates, and periods of operation for the regional and site-specific meteorological stations. The locations of the regional and MEA meteorological station are shown on **Figure 3.6-1**.

These sites have been analyzed collectively to evaluate regional climatic temperature and precipitation in the proposed project area. The NWS sites have also been incorporated into the snowfall discussion. The nearest available long-term monitoring site that continuously records all weather parameters is the Scottsbluff Airport. This site was analyzed for the regional wind summaries. At the project site, hourly average meteorological data include wind speed, wind direction, sigma theta, temperature, relative humidity, precipitation, and solar radiation. Evapotranspiration (ET) rates were calculated for both the

Scottsbluff site and project site by applying Penman's equation to available solar radiation, wind speed, temperature, and relative humidity data. As solar radiation data were not available from the Scottsbluff data set, estimated monthly averages for solar radiation were obtained for the Scottsbluff area from the U.S. Department of Energy's National Renewable Energy Laboratory (NREL 1990).

In the information that follows, a regional overview is presented first. This section includes a discussion of the maximum and minimum temperatures and relative humidities, annual precipitation including snowfall estimates, a brief wind speed and direction summary, and a discussion of ET rates. A combination of monitoring stations is analyzed for the regional overview of temperature, snowfall, and total precipitation.

A site-specific analysis follows the regional overview. Most of this analysis is based on the onsite monitoring. An in-depth wind analysis summarizes average wind speeds and directions, wind roses, wind speed frequency distributions, and a joint (wind speed and direction) frequency distribution to characterize the wind data for the MEA by atmospheric stability class. A discussion of monthly and seasonal data is included for the temperature, precipitation, ET, and wind parameters. General upper atmosphere data from the NWS station at Rapid City, South Dakota represent the project site.

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The site-specific analysis includes a justification for using wind data from the baseline monitoring year to predict meteorological conditions over the long term. This is necessary to validate air sampling locations and MILDOS dispersion modeling inputs. The short-and long-term wind data from the Scottsbluff site are correlated for this purpose.

3.6.2 Regional

3.6.2.1 Temperature

The annual average temperature for the region is approximately 48° F (8.9° C). Temperatures at the Scottsbluff Airport meteorological station are considered to be representative of the region.

Figure 3.6-2 shows monthly average temperatures for the Scottsbluff Airport site, along with the monthly maximum and minimum temperatures over the last 15 years. July has the highest average monthly temperature (74.5° F), followed by August. December records the lowest average temperatures for the year (26.0° F), followed by January. **Table 3.6-2** shows average, minimum, and maximum monthly temperatures for the Scottsbluff Airport site. Low temperatures in the region can drop to nearly -30° F, while high temperatures can reach 107° F.

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Large diurnal temperature variations occur in the region due in large part to its high altitude and low humidity. **Figure 3.6-3** depicts the monthly diurnal temperature variation for the Scottsbluff Airport site from 1996 through August 2011. Spring and summer daily variations of 30° F are common with maximum temperature variations exceeding 40° F during extremely dry periods. Less daily variation is observed during the cooler portions of the year, as fall and winter have average variations of roughly 20° F. This can be attributed to the more stable atmospheric conditions in the region during the fall and winter months. Stable periods have much lower mixing heights and accompanying lapse rates, allowing for less temperature variation.

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On a year-round basis, daily maximum temperatures in the project region average approximately 60° F, and daily minimum temperatures average approximately 33° F. July has the highest maximum temperatures, with averages near 90° F, while the lowest minimum temperatures are observed in January with averages near 10° F (NCDC 2011). Annual average minimum and maximum temperatures are shown on **Figures 3.6-4** and **3.6-5**, respectively.

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3.6.2.2 Relative Humidity

The Scottsbluff Airport site records relative humidity (dew point) data. The graph on **Figure 3.6-6** charts monthly average relative humidity values for this site. The Scottsbluff Airport data are from 1996 through August 2011. These data indicate that July has the driest air, with relative humidity averaging around 58 percent. The winter months of December, January, and February make up the most humid part of the year, with average relative humidity approaching 70 percent. The overall average relative humidity is 63 percent at Scottsbluff Airport.

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Relative humidity is a temperature-based calculation which reflects the fraction of moisture present relative to the amount of moisture for saturated air at that temperature. Warmer air holds more moisture at saturation than colder air. Therefore, for a given amount of moisture in the air, relative humidity maximum values occur more frequently in the early mornings, while minimum values typically occur during the mid-afternoon hours. The summer months exhibit a much greater variation in relative humidity between morning and afternoon values due to greater temperature variations (**Figure 3.6-7**).

3.6.2.3 Precipitation

The region is characterized by moderately dry conditions. The Scottsbluff Airport received measurable (>0.01 in) precipitation on an average of 82 days per year between 1996 and 2011. Average annual precipitation during that period was 15.2 inches per year. In general, the project region has an annual average from 14 to 23 inches (**Figure 3.6-12**). Spring showers and thunderstorms produce nearly half of the precipitation at Scottsbluff Airport (**Figure 3.6-8**). May and June are typically the wettest months of the year; with most of the region receiving an average greater than 2 inches for each of those months (**Figure 3.6-9**). The region receives less precipitation in January than in any other month, averaging generally 0.5 inch or less. The winter months (December through February) typically account for less than 10 percent of the yearly precipitation totals. Only moderate precipitation occurs in late summer, when atmospheric conditions are more stable and the absence of convective activity limits storm development.

Severe weather does arise throughout the region, but is limited on average to five or six severe events per year. These severe events are generally split between hail and damaging wind events. Tornadoes can occur but are rare in western Nebraska.

Average annual snowfall varies throughout the region. Major snowstorms (more than 5 in/day) are relatively infrequent in the region. The region experiences fewer than three major snowstorms per year. Hay Springs, Nebraska has the highest annual snowfall of the sites closest to the project, with an average of 52 inches, while Sidney, Nebraska has the lowest averages at 30.7 inches per year. The interpolated values (**Figure 3.6-13**) show average snowfall of 30 to 60 inches per year in the project region.

Snowfall at the Scottsbluff Airport site averaged 38.2 inches per year over the last 15 years. Monthly average snow amounts are depicted in **Figure 3.6-10**, which shows the highest amount of snowfall in March. Monthly snowfall amounts in the overall region follow a similar pattern (**Figure 3.6-11**).

3.6.2.4 Wind Patterns

Year-round wind speeds in the area average between 8 and 11 mph. **Table 3.6-3** shows monthly average wind speeds for the Scottsbluff Airport site. The overall average wind speed at this site was 8.9 mph for the 1996 to 2011 period analyzed in this study. Mean monthly average wind speeds are lowest in the summer months and highest in April at nearly 11 mph.

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Table 3.6-3 also shows monthly maximum hourly wind speeds for the Scottsbluff Airport. High wind events are fairly common in this region; wind data from this site show every month recording peak hourly wind speeds greater than 30 mph during the 15-year period analyzed.

Figure 3.6-14 graphs the Scottsbluff Airport 15-year monthly average and monthly maximum wind speeds listed in **Table 3.6-3.**

Figure 3.6-15 shows the 15-year wind rose for the Scottsbluff Airport site. Predominant winds are generally from the west-northwesterly or northwesterly directions. These winds, often associated with storm fronts, dominate the late fall, winter, and early spring seasons. A secondary mode occurs from the east-southeasterly or easterly directions. These winds are generally associated with the summer season when regional high pressure dominates. The highest wind speeds tend to occur from the northwesterly direction. **Table 3.6-4** provides the same information as the wind rose, but in tabular form.

Winds at the Scottsbluff Airport site and throughout the region exhibit a diurnal pattern. **Figure 3.6-16** shows the pattern at Scottsbluff for each season of the year. Wind speeds peak during the early afternoon for the winter and fall seasons. During spring and summer, wind speeds peak in late afternoon, largely due to longer daylight hours and the predominant effect of solar heating on wind patterns. **Figure 3.6-16** also shows that the highest average wind speeds occur during the spring season, when the atmosphere tends to be least stable and storm systems are the strongest. The lowest wind speeds occur during summer, when the atmosphere is generally stable and storm systems are weak.

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3.6.2.5 Heating, Cooling, and Growing Degree Days

Figure 3.6-17 summarizes the monthly cooling, heating, and growing degree days for Scottsbluff, Nebraska (NWS meteorological monitoring site 257665). The data are assumed to be indicative of the project area due to its proximity and comparable elevation.

The heating and cooling degree days are included to show deviation of the average daily temperature from a predefined base temperature. In this case, 50° F has been selected as the base temperature for computation of growing degree days. The base temperature for computing heating and cooling degree days is 65° F. The number of heating degree days is computed by taking the average of the high and low temperatures occurring that day and subtracting it from the base temperature. The calculation for growing and cooling degree days is the same, except that the base temperature is subtracted from the average of the high and low temperatures for the day. Negative values are disregarded for both calculations.

As expected, the graphs of heating degree days and cooling degree days are inversely related, and the growing and cooling degree days are directly related. The maximum number of heating degree days occurs in December and January, at roughly 1,200 degree days. This coincides with the months having the lowest minimum average temperatures. Conversely, July registers the most growing degree days with nearly 700, and the most cooling degree days at fewer than 300. This also corresponds to July having the highest average temperature.

3.6.2.6 Evapotranspiration

The project region is characterized by high evaporative demand during much of the year. This demand is related to dry air (low dew points), high daytime temperatures, and moderate wind speeds. **Figure 3.6-18** graphs monthly potential ET rates, in inches of water per month, at the Scottsbluff Airport site. Potential ET is an estimate only, calculated using the Penman Equation (Jensen et al. 1990). Meteorological inputs to this equation include wind speed, barometric pressure, solar radiation, and temperature and humidity extremes.

For the Scottsbluff site, barometric pressure was estimated based on the elevation. Because solar radiation data were not available at this site, estimated monthly averages for solar radiation were obtained for the Scottsbluff area from the NREL. A flat-plate collector at zero degrees incline from horizontal represents the global solar radiation available at a given location. Wind speed, temperature, and humidity data for the ET calculation were obtained from the Scottsbluff Airport hourly database.

Potential ET values are highest in July, at 10 inches, and lowest in December and January, at 2 inches. Annual ET for this area is projected at 68.6 inches per year.

3.6.3 Site-Specific Analysis

3.6.3.1 Introduction

The site-specific discussion of climate, meteorology, and air quality is limited to on-site meteorological data collected for the baseline monitoring period of August 2010 through August 2011. These on-site data are supplemented by meteorological data from the nearby Scottsbluff Airport site, collected during the 15-year period from 1996 through August 2011. The Scottsbluff site is included to incorporate wind monitoring results from a longer period of record and to demonstrate that, for this region, winds during the baseline monitoring period are representative of the longer term. The Scottsbluff site is located 48 miles (77.2 km) south of the MEA, with elevation and topographic features comparable to the project area. In both cases, the surrounding area is characterized by rolling hills and flat plains bordered by small ridges and breaks with ephemeral drainages. With the exception of cultivated land, the vegetation types are mainly confined to native grasses with some sage brush and wooded areas.

3.6.3.2 Temperature

The annual average project site temperature is similar to the regional average temperature at approximately 46° F. The maximum temperature for the baseline monitoring year was 99° F, and the minimum temperature was -28° F.

Figure 3.6-19 shows the monthly average, minimum, and maximum temperatures for the project site. **Table 3.6-5** provides the same data in tabular form. Daily average temperatures range from near 20° F in the winter months to above 70° in the summer months.

Table 3.6-6 provides a meteorological summary for the MEA site for the baseline monitoring year. The averages, maximums, and minimums are specified for each parameter recorded at the site along with the data recovery rate for each. The recovery rates are greater than 97 percent for all parameters.

3.6.3.3 Wind Patterns

Figure 3.6-20 presents a wind rose for the project site during the 12-month baseline monitoring period. **Table 3.6-7** presents the same information in tabular form. The predominant wind direction is north-

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northwesterly and northwesterly, with the highest wind speeds also coming from those directions. During periods of fair weather, particularly in late spring and summer, high pressure located over the northern plains produces moderate southeasterly winds in the project area. Synoptic weather systems generally interrupt this pattern, producing high north-northwesterly winds. **Figure 3.6-21** shows seasonal wind roses for the project area. Spring experiences the greatest variability in wind direction with secondary modes as a result of the synoptic scale transition period that occurs during this time. Low pressure regions develop on the lee side of the Rocky Mountain, bringing southeasterly winds during storm development. As the low pressure systems form and move off with the general atmospheric flow, winds switch to a north-northwesterly direction.

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Figure 3.6-22 presents a diurnal graph of wind speeds at the project site by season. For all seasons, wind speeds peak during the afternoon. Winds during the summer plateau at less than 12 mph, while the rest of the year experiences peak afternoon wind speeds averaging roughly 15 mph. Nighttime winds average 8 to 10 mph throughout the year.

Figure 3.6-23 shows the time distribution of wind speeds at the project site. Half of the time, wind speeds are less than 8 mph, while winds exceed 18 mph 10 percent of the time.

The average wind speed for the project site was 10.6 mph over the 12 months of monitoring, slightly higher than the 8.9 mph long-term average at Scottsbluff. The monthly average and maximum hourly wind speeds at the project site are summarized on **Figure 3.6-24.** The graph shows higher wind speeds in the winter and spring, peaking in April.

Table 3.6-8 provides a breakdown of wind speeds by wind direction. Wind speeds average near or above 12 mph when the wind blows from the northwest quadrant. A secondary maximum occurs for southerly winds, averaging more than 10 mph. For all other directions, wind speeds average less than 10 mph.

The Joint Frequency Distribution (JFD) provides more detail on wind speed distribution by wind direction and atmospheric stability class. The distribution shows the frequencies of hourly average wind speed for each direction based on stability class. **Table 3.6-9** lists the annual JFD for the MEA. **Tables 3.6-10** through **3.6-13** list the seasonal JFDs. A majority of the winds at the project site fall into stability class D, which represents near neutral to slightly unstable conditions. The light winds which accompany stable environments are reflected in the stability class F summary.

3.6.3.4 Precipitation

Figure 3.6-25 shows monthly precipitation at the project site during the baseline monitoring year. Total precipitation was 17 inches, although 10 inches fell during the abnormally wet month of May. Very little precipitation fell during the fall and winter months. Based on long-term records at other weather stations in the region, precipitation recorded during the baseline monitoring year at Marsland is probably not representative of the long term. An annual average precipitation of 15 inches is considered more likely.

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3.6.3.5 Evapotranspiration

Daily ET rates were calculated for the project site by applying Penman's equation to recorded solar radiation, wind speed, temperature, and relative humidity data. These calculations were then summed for each month. **Figure 3.6-26** shows projected monthly ET at the project site during the baseline monitoring period. From these calculations, annual ET is computed at approximately 60 inches. This compares favorably to the long-term, calculated average of 68 inches at the Scottsbluff Airport site.

3.6.3.6 Justification of Baseline Year as Representative of Long Term

The proposed project is situated in northwest Nebraska (Scottsbluff 15-year vs baseline year wind roses). The baseline meteorological monitoring period extended approximately 1 year, from August 24, 2010 through August 29, 2011. To demonstrate that this baseline year is representative of the longer-term wind conditions, the Scottsbluff Airport site was analyzed. Among the weather stations in this region, the Scottsbluff Airport was selected as most representative of the MEA meteorology. Scottsbluff is less than 50 miles (80 km) south of the project site, with an elevation roughly 300 ft lower than the project area. It is also the closest NWS station to the project site that logs hourly wind data. Available hourly data from Scottsbluff span from January 1, 1996 to the present and therefore represent the last 15 years.

Figure 3.6-27 shows wind roses for Scottsbluff (Scottsbluff 15-year vs baseline year wind roses). The wind rose on the left reflects 15 years of monitoring (1996 through August, 2011), while the one on the right reflects the MEA baseline monitoring period only. Wind speeds and directions are demonstrated to be very similar between the 15-year and 1-year monitoring periods.

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Figure 3.6-28 compares the wind direction frequency distributions between the 15-year and baseline periods at Scottsbluff. The percent of the time the wind blows from each of the 16 cardinal directions shown is quite similar for the two monitoring periods.

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Figure 3.6-29 compares the wind speed frequency distributions of the 15-year and baseline periods at Scottsbluff. The percent of the time the wind speed falls within each of the six wind speed classes shown is quite similar for the two monitoring periods.

In order to quantify this similarity, it is useful to isolate wind speed and wind direction variables in order to correlate short-term and long-term frequency distributions. IML Air Science has developed a statistical methodology for assessing the degree to which the distributions of wind speed class and wind direction frequencies from 1 year of monitoring at a particular location represent the long-term distributions at that same location.

For the joint frequency wind distribution used in the MILDOS-AREA model (NRC 1981), wind speeds are divided into six classifications ranging from mild (0 to 3 mph) to strong (> 24 mph), as illustrated in **Table 3.6-9** and on **Figure 3.6-29**. Likewise, wind directions are divided into 16 categories corresponding to the compass directions illustrated in the wind roses and on **Figure 3.6-28**.

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The percent of the time that winds occur in each of the six wind speed categories can be calculated to produce a wind speed frequency distribution. The percent of the time that winds blow from each of the 16 directions can be calculated to produce a wind direction frequency distribution. For each parameter, the 1-year and 15-year distributions can then be compared. Linear regression analysis provides a useful tool to assess the degree of correlation between short- and long-term distributions.

Figure 3.6-30 presents this correlation for the wind speed distributions at Scottsbluff. Each point represents one of the six wind speed classes. The x coordinate corresponds to the percent of the 1-year period during which the wind speed fell in a given class, while the y coordinate corresponds to the percent of the 15-year period during which the wind speed fell in that same class.

The regression line (red) on **Figure 3.6-30** represents the least-squares fit to the six data points. The corresponding R^2 value of 94.5 percent implies very strong linear correlation. The linear slope of 0.98

further implies that short- and long-term wind speed frequencies not only correlate, but are substantially equivalent in magnitude.

A similar analysis can be performed for wind direction frequencies. **Figure 3.6-31** presents this correlation, again for the Scottsbluff Airport site. Each point represents one of the 16 wind direction categories. The x coordinate corresponds to the percent of the 1-year period during which the wind blew from a given direction, while the y coordinate corresponds to the percent of the 15-year period during which the wind blew from that same direction.

The regression line (red) on **Figure 3.6-31** represents the least-squares fit to the 16 data points. The corresponding R^2 value of 97.2 percent implies very strong linear correlation. The linear slope of 1.02 further implies that short- and long-term wind speed frequencies not only correlate, but are substantially equivalent in magnitude.

Figures 3.6-30 and **3.6-31** offer conclusive evidence that the 2010-2011 baseline monitoring year adequately represents the last 15 years at Scottsbluff Airport. Because the 1-year wind data serve as reliable predictors of the long-term wind conditions at Scottsbluff, and because the MEA site experiences similar regional weather patterns, it is proposed here that the 1-year baseline monitoring represents long-term meteorological conditions at the MEA site.

3.6.3.7 On-Site Meteorological Instrument Specifications

Table 3.6-14 lists the meteorological instruments employed at the MEA meteorological monitoring station. The table shows instrument models, accuracy specifications, and instrument heights above the ground. An example of a calibration report for the meteorological instruments is contained in **Appendix B** to this document.

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Meteorological data collection, management, and reporting methods at the project site conform to NRC atmospheric dispersion modeling requirements for uranium milling operations, and meet the acceptance criteria established in the NRC's RG-1569. The onsite monitoring program was developed according to RG 3.63, "Onsite Meteorological Measurement Program for Uranium Recovery Facilities – Data Acquisition and Reporting." Hourly average values for wind speed, wind direction, sigma theta, temperature, relative humidity, precipitation, and solar radiation are generated by field instruments and recorded by continuous data loggers. Data recovery exceeded 97 percent for the 12-month monitoring period. All hourly data have been downloaded to a relational database for quality assurance, statistical analysis, and reporting purposes.

The meteorological instruments are located in the MEA in an area that represents as closely as possible the long-term meteorological characteristics of the area for which the measurements are being made. NRC RG 3.63 provides guidance acceptable to the NRC regarding the siting of meteorological instruments. The siting of the MEA meteorological instruments followed this NRC guidance and is discussed in **Appendix R** of this document. This appendix addresses the NRC's siting conditions identified as being necessary to achieve meteorological data representative of the proposed project site.

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3.6.3.8 Upper Atmosphere Characterization

Mixing height is the height of the atmosphere above the ground that is well mixed due either to mechanical turbulence or convective turbulence. The air layer above this height is stable. Higher mixing heights are associated with greater dispersion, all other parameters being the same. Stable periods have much lower mixing heights and accompanying lapse rates, allowing for less temperature variation. The MILDOS-AREA model uses mixing height, along with other wind parameters, to predict pollutant dispersion. Unstable air leads to more dispersion, which leads to lower predicted impacts on ambient air quality. The default mixing height used by MILDOS-AREA is 100 meters, a very conservative value given that typical mixing heights exceed 1,000 meters.

The nearest upper-air data available from the NWS are from Rapid City, South Dakota, approximately 108 miles (173.8 km) north of the project area. Average mixing heights were derived from the American Meteorological Society (AMS)/EPA Regulatory Model (AERMOD) calculations used for dispersion modeling, based on hourly data obtained from the NWS stations in Rapid City (upper air). The AERMOD calculation is based on a combination of mechanically and convectively driven boundary layer processes. The results of these calculations are provided for morning and afternoon in **Table 3.6-15**. The annual average mixing height is 1,110 meters.

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The mixing or inversion heights are entered as inputs to the MILDOS-AREA model for pollutant dispersion modeling. For the MEA project, the MILDOS default value of 100 meters was used for both morning and afternoon mixing heights. Argonne National Laboratory has used a default value of 100 meters for the annual average morning and afternoon atmospheric mixing heights (ANL 1998). Page 12 of the Guide states "Mixing Heights: annual average Morning and Afternoon atmospheric mixing height in meters. The default value is 100 m for both." Therefore, this default value was used for MILDOS modeling of the MEA site.

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Because this mixing height of 100 m is lower than the calculated mixing heights in **Table 3.6-15**, and lower mixing heights lead to less pollutant dispersion, the dosage concentrations calculated by the MILDOS model are conservatively high.

3.6.3.9 Bodies of Water and Special Terrain Features

The only significant body of water near the proposed MEA is the Niobrara River, which flows easterly through a point approximately 4 miles (6.4 km) south of the project site. The average flowrate at this location, however, is only 29 cubic ft/sec (USGS 2009). It is unlikely that the influence of such a small stream could be measured 4 miles (6.4 km) away with a standard humidity probe.

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The nearest mountain ranges to the project site are:

- The Laramie Mountains, approximately 100 miles (160.9 km) to the west
- The Black Hills, approximately 65 miles (104.6 km) to the north

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It is believed that, at these distances, the mountain ranges have minimal impact on meteorology in the project area. As discussed above, storms moving eastward from the Rocky Mountains generally relinquish moisture on the windward side of the mountains, creating a drier climate on the leeward side. This is mitigated, however, by occasional moist air masses moving into Nebraska and Wyoming from the Gulf of Mexico.

3.6.4 Conclusion

The proposed MEA near Crawford, Nebraska is located in a semiarid or steppe climate. The area is characterized by abundant sunshine, low relative humidity, and sustained winds which lead to high evaporative demand.

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Thirteen NWS meteorological stations were used to characterize regional weather patterns. The region experiences average daily maximum temperatures near 90° F in July, and average daily minimum temperatures around 15° F in January. There are large diurnal and annual variations in temperature. The region has cold, harsh winters; hot, dry summers; and relatively warm, moist springs and autumns. Temperature extremes range from roughly -25° F in the winter to 100° F in the summer. The site average temperature is expected to be 46° F with extremes of -30° to + 105° F. The region generally receives little precipitation, with annual averages between 13 and 16 inches. Spring and early summer precipitation events are responsible for the majority of the yearly average.

The region is characterized by annual average wind speeds of 9 to 12 mph. Winds at the project site are expected to average 10 to 11 mph annually, with summer averages dipping below 8 mph and winter averages exceeding 12 mph. The predominant wind directions are from the north-northwest and northwest.

The MEA meteorological station and the Scottsbluff Airport meteorological station were both analyzed in the site-specific analysis. The Scottsbluff site is included to validate the temporal representativeness of on-site wind data by incorporating wind monitoring results from a longer period of record. The Scottsbluff site is located 48 miles (77.2 km) south of the MEA, with elevation and topographic features comparable to the project area. The distribution of wind speeds and directions at Scottsbluff during the baseline monitoring period have been shown to closely represent long-term wind speeds and directions.

3.6.5 Air Quality

3.6.5.1 National Ambient Air Quality Standards

The NDEQ air quality regulations are based on federal and/or state law, with the primary source of the authority for air quality regulations being the Federal Clean Air Act (NDEQ 2003). The NDEQ adopts the majority of these federal regulations into Title 129 (Nebraska Air Quality of the Nebraska Administrative Code). The basic foundation of the NDEQ air program is the National Ambient Air Quality Standards (NAAQS), which are concentrations of pollutants the EPA has established (and adopted by the NDEQ) as being protective of human health and the environment. The standards are established for six "criteria" pollutants: particulate matter, sulfur dioxide (SO_2), nitrogen oxides, carbon monoxide, ozone, and lead (**Table 3.6-16**, EPA 2013). The State of Nebraska is required to keep areas in compliance with the standards and restore compliance in any areas out of compliance. The NDEQ has several ambient air monitors located throughout the state to measure the concentrations of pollutants in the ambient air (NDEQ 2011). An area may be classified as nonattainment if the concentration of one or more criteria pollutants in an area is found to exceed the regulated or "threshold" level for one or more of the NAAQS. Those areas with concentrations of criteria pollutants below the levels established by the NAAQS are considered in attainment or unclassifiable.

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The overall air quality in the State of Nebraska is considered to be good. Nebraska is located in a part of U.S. that is largely in attainment with NAAQS, thereby minimizing the impact of pollutant transport from other states on Nebraska air quality (NDEQ 2011). All areas within the state are in attainment with NAAQS (NDEQ 2011). The City of Omaha previously had a nonattainment designation for lead, but due to actions by Omaha Air Quality Control, NDEQ, EPA, and local industries, the area is now classified as attainment. The City of Omaha is located more than 375 miles (603.5 km) from the MEA area.

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On February 14, 2012, the EPA proposed thresholds for classifying nonattainment areas for the 2008 ozone NAAQS promulgated by the EPA on March 12, 2008 (EPA 2012). This proposal also addresses the timing of attainment dates for each classification and revokes the 1997 ozone NAAQS 1 year after the effective date of designations for the 2008 ozone NAAQS for transportation conformity purposes only. The February 14, 2012 proposal establishes a necessary step to implement the 2008 NAAQS for ground-level ozone. The EPA set those standards at 0.075 parts per million (ppm) on March 12, 2008.

There are no ambient air quality monitoring data for criteria pollutants in the proposed MEA license boundary or AOR. However, there are a limited number of state and federal monitoring sites in the region of the MEA that can be used as levels representative of the region for the monitored parameters. These monitoring sites are maintained for a variety of purposes, including for regional background purposes by the NDEQ, per Appendix D of 40 CFR Part 58. However, the parameters measured are limited to particulate and ozone monitoring.

Regional monitoring sites and parameters measured are presented in **Table 3.6-17**. The locations of the monitor sites in western Nebraska are shown on **Figure 3.6-32**. The data available at the time of preparation of this section are summarized in **Tables 3.6-18** through **3.6-25**. The results of this monitoring indicate that the regions being monitored, including the MEA area, are well within compliance of NAAQS standards.

3.6.5.2 Prevention of Significant Deterioration

In addition to the ambient air quality standards, there are national standards for the Prevention of Significant Deterioration (PSD) of air quality (40 CFR 51.166). The PSD program is administered by the States of Nebraska and South Dakota, with their programs designed to protect the air quality in area that are in attainment with the NAAQS and to prevent degradation of air quality in areas below the standard (designated as clean air areas). PSD differs from the NAAQS in that the NAAQS provides for maximum allowable concentrations of pollutants, while PSD requirements provide maximum allowable increases in concentrations of pollutants for areas already in compliance with the NAAQS. The PSD requirements establish allowable pollution "increments" that may be added to the air in each area while still protecting air quality. The increment is the maximum allowable deterioration of air quality. The maximum allowable increments applicable to Nebraska and South Dakota are shown in **Table 3.6-26.**

The allowable increments vary by location across the states. Those areas characterized as Class I (i.e., National Parks and Wilderness Areas) allow for less incremental pollution increase. Class III areas are planning areas set aside for industrial growth. The areas classified as Class II are essentially all other areas of the state not designated as Class I or Class III. There are no Class I National Park and Wilderness Areas in Nebraska. The Soldier Creek Wilderness Area, located north of Fort Robinson, is not designated as Class I. The State of South Dakota has two Class I Areas: Badlands and Wind Caves National Parks. The Wind Caves National Park is closer to the MEA, at a distance of approximately 75 miles (120.7 km).

No potential impacts to NAAQS parameters or PSD Class I, II, or III areas are expected to occur as the result of the MEA operations. The primary emissions from the proposed MEA will be tailpipe emissions of nitrogen oxides (NO_x), carbon monoxide (CO), SO_2, non-methane-ethane volatile organic compounds (VOCs), and particulate matter with a diameter less than ten microns (PM_{10}) resulting from vehicle traffic within the MEA. The majority of the emissions generated during construction will be fugitive dust and vehicle combustion emissions. Effects of air emissions and impacts associated with construction and operations are discussed in Section 4.6

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3.7 Noise

The MEA site and immediate area is predominantly rural and undeveloped, with a minimal number of residences (**Figure 3.1-2**). Such rural areas tend to be relatively quiet. Primary man-made noises that contribute to the background noise levels at the MEA would include the following:

- Farm and ranching activities in the area

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  The MEA is in an area of ranching and farming, so noise associated with farm and ranch equipment would contribute to seasonal background noise levels at the MEA.

- US/State Highways and county roads vehicle traffic

  Highway 20, SH 2/71, and various county roads are located nearby, and vehicle traffic would contribute to the background noise levels.

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- Train traffic

  The Burlington Northern Santa Fe (BNSF) Railroad tracks are located just to the west of the MEA, with numerous trains passing daily. This train traffic is one of the main sources of noise in the area of the MEA.

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Noise impacts associated with construction of the satellite facilities would be of short duration compared to the operations period. Noise levels during site construction are expected to increase due to increased vehicle traffic in support of construction on SH 2/71. Additionally, heavy equipment use during construction may include bulldozers, scrapers, graders, front-end loaders, cranes, and various trucks used for conveying personnel. Train usage would not increase as a result of construction. Noise from construction would not be generated during nighttime hours, and increases in noise levels would be intermittent and temporary.

Noise sources during operation are expected to increase due to increased vehicle traffic as increased numbers of employees traveling to and from the City of Crawford and area for work, and from resin transfer to the CPF. Processing equipment at the satellite facility would be minimal and is not expected to significantly add to existing noise sources. Increases due to operations are expected to be less than noise levels generated during construction. Therefore, it is expected that noise levels during operations would be barely perceptible over the existing ambient noise that is dominated by vehicle and BNSF railroad noise.

Noise impacts are discussed in Section 4.7.

3.8 Regional Historic, Archeological, Architectural, Scenic, and Natural Landmarks

3.8.1 Historic, Archeological, and Cultural Resources

There have been few cultural resources investigations on private land in southern Dawes County. Cultural resources investigations have been more numerous around the White River and the Cities of Chadron and Crawford about 10 miles (16.1 km) to 15 miles (24.1 km) to the north, and the results of those surveys can provide a cultural context for comparison to the MEA. Known resources in that area include indigenous people, artifact scatters, faunal kill and processing sites, and camps; fur trade and other contact period sites; the Sidney-Deadwood Trail; historic railroads; historic farming sites; Fort Robinson; and the Cities of Chadron and Crawford. In the mid-1800s, this region was occupied predominantly by bands of Lakota Sioux and Cheyenne. In the 1870s, the Red Cloud Indian Agency was located at Fort Robinson west of Crawford. By 1878, the tribes had officially been relocated to reservations, but sporadic Lakota

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and Cheyenne resistance continued through the 1880s. The MEA is south of the Pine Ridge Escarpment near the Niobrara River, and the nearby Town of Marsland is small in comparison to the Cities of Chadron and Crawford. The Town of Marsland is located along the Sidney-Deadwood Trail, along one of the historic railroad corridors that also passed through Crawford, and along a major river that would have attracted fur trappers. The fur trade in northwest Nebraska was centered along the White and Niobrara Rivers.

The proposed MEA is located on private lands east of SH 2/71 and north of the Niobrara River. An archaeological files search through the Archaeology Division of the Nebraska State Historical Society (NSHS) indicated that there have been no previous archaeological investigations within 1 mile (1.6 km) of the MEA, and that no archaeological sites have been previously reported. An architectural and structural properties search through the Nebraska State Historic Preservation Office (SHPO) indicated that four historic structures (DWOO-240, DWOO-241, DWOO-242, and DWOO-243) have been reported in the study area. Two of these structures are within the MEA, and the other two are close to the MEA.

A search of the BLM Public Land Patent Records indicates that nine patents were granted for lands in the MEA from 1891 to 1917. This is consistent with the completion of the Chicago, Burlington, and Quincy Railroad through Crawford in 1889, which made the land more accessible to homesteaders, and with a brief moist period in the region between 1910 and 1920. A search of the National Register of Historic Places (NRHP) online database for Dawes County yielded 11 sites in the northern portions of the county. None of these NRHP-listed sites is within 10 miles (16.1 km) of the MEA. Fort Robinson and the Red Cloud Indian Agency, about 15 miles (24.1 km) north-northwest of the MEA, are also listed as a National Historic Landmark.

ARCADIS completed an intensive pedestrian block cultural resources inventory of approximately 4,500 acres for the MEA during the period from November 2010 to February 2011 (Graves et al. 2011). The MEA was inventoried for the presence of euroamerican and indigenous peoples' properties (cultural resources that are listed or eligible for listing on the NRHP) and may be impacted by proposed mine development. Graves et al. (2011) recorded 15 newly discovered euroamerican historic sites and five euroamerican historic isolated finds, and updated the documentation on two of the previously recorded historic farmstead sites (DWOO-242 and DWOO-243).

ARCADIS submitted the "Cameco Resources Marsland Expansion Area Uranium Project Cultural Resource Inventory" report and associated Nebraska Archeological Site Survey Forms to the NHPS/SHPO on April 28, 2011 (Graves 2011), and SHPO concurrence was granted by the Deputy State Historic Preservation Officer on May 19, 2011. The SHPO approval was issued via a stamped concurrence on the April 28, 2011 submittal letter.

CBR requested that ARCADIS complete a field survey of an additional 160 acres in section 36 T30N R51W surveyed during the original field investigation but not documented in the original report. The 160 acres was field investigated by ARCADIS on February 19, 2011, and no new cultural resources were discovered. One historic bridge (25DW362) was identified in section 36 T30N R51W and reported within the original cultural resource inventory report. An addendum to the original cultural resources report was prepared to address the additional 160 acres (Graves and Graves 2012). Historic site 25DW362 was recommended not eligible for listing on the NRHP with SHPO concurrence.

The Nebraska SHPO concurred with the findings of the addendum to the cultural resources report that no archaeological, architectural, or historic context property resources will be affected by the proposed

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project (NSHS 2012). As stated in the SHPO concurrence letter, the SHPO's review does not constitute the opinions of any Native American Tribes that may have an interest in Traditional Cultural Properties potentially affected by this project.

No indigenous people sites or artifacts were found in the project area. Regardless, a process for tribal identification of Traditional Cultural Properties is being developed and will be implemented during review of the MEA Environmental Report to satisfy NEPA.

The newly recorded historic sites included six farmsteads (25DW359, 25DW360, 25DW361, 25DW365, 25DW366, and 25DW370), three artifact scatters (25DW357, 25DW363, and 25DW369), two cisterns (25DW358 and 25DW364), one corral and windmill (25DW367), one bridge (25DW362), one dugout depression and berm (25DW368), and one stone quarry (25DW371). All of these sites were recommended not eligible for the NRHP.

The previously recorded farmstead sites were recorded jointly by SHPO and NSHS as part of a historic building survey of Dawes County in 2005 as the B. Chapman House (DWOO-242; built about 1910); and an abandoned farmhouse (DWOO-243; built about 1890). Updated documentation was prepared for the two buildings in the survey area. This documentation included the completion of NSHS archaeological site survey forms that included documentation of associated artifacts and features in addition to the buildings. Updated documentation of the DWOO-242 included a concrete cistern, a storage shed, two modern propane tanks, and historic and modern artifacts. The house is well maintained and appears to be occupied. Site DWOO-243 is more extensive. This site includes two abandoned 1.5-story farmhouses; a smaller 1-story house; two storage sheds; one stock shelter; one foundation with a chicken coop gate; two metal grain bins; abandoned vehicles, wagons, and farm implements; a network of fenced enclosures; and a large pile of historic debris.

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All of the newly recorded historic sites were recommended not eligible for the NRHP and do not qualify as historic properties. Isolated finds are by definition not eligible for the NRHP. Historic farmstead DWOO-242 is recommended not eligible for the NRHP, but appears to be currently or recently occupied. Site DWOO-243 may have the potential to yield information important in history and may be potentially eligible for the NRHP. Avoidance of these two sites by project actions is recommended. If these recommendations are followed, the proposed project will have no adverse effect on historic properties, and no further cultural resource investigations are recommended.

Specific information included in cultural resources investigations falls under the confidentiality requirement for archaeological resources under Section 304 of the National Historic Preservation Act (NHPA; 16 U.S.C. 470w-3(a)). In addition, disclosure of such information is protected under Nebraska State Statute Section 84-712.05 (13 and 14). The cultural resources inventory report and Attachment A of that report have been marked "FOR OFFICIAL USE ONLY: DISCLOSURE OF SITE LOCATIONS IS PROHIBITED (43CFR 7.18). In compliance with Nebraska SHPO, NRC RG-1569 Section 24, and NDEQ Title 122 Ch. 11 Sections 006.07. These materials should be treated as confidential information for the purpose of public disclosure of this NRC license amendment. The cultural resources report will be submitted to the NRC and State of Nebraska SHPO under separate cover.

The NRC is responsible for the government-to-government NHPA Section 106 consultation for the Crow Butte project areas near Crawford, Nebraska. These project areas include the CBR current operation ISR facility license renewal and the proposed NTEA, TCEA, and MEA. As part of the NRC's ongoing efforts to identify historic properties of religious and cultural significance to Native American Tribes that could

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be affected by CBR's proposed projects, the NRC sent a letter, dated October 31, 2012, offering each consulting Tribe an opportunity to participate in a field study to identify potential places of religious and cultural significance at these sites (NRC 2013). In support of the NRC's offering, CBR offered to open each of the four project areas for field inspection during the period of November 14 through December 7, 2012.

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Two consulting Tribes accepted CBR's offer to open the CBR project areas during the November 14 through December 7, 2012 timeframe (NRC 2013). Tribal field crews inspected the four CBR project areas for zones thought to potentially contain places of Tribal religious and cultural significance. The Santee Sioux Nation submitted a Traditional Cultural Properties Survey report on the behalf of the Crow Tribe of Montana and the Santee Sioux Nation for the Crow Butte operations (Santee Sioux Nation 2013; **Appendix U**). A report for this survey was submitted to the NRC; the survey did not result in the recognition of any historic property of potential significance for NRHP listing.

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3.9 Scenic Resources

3.9.1 Introduction

The MEA is on private land that is not managed to protect scenic quality by any public agency. The MEA is located on generally level ground south of the Pine Ridge area of northwestern Nebraska, and may be visible from some public roads in the areas. The existing landscape and the visual effect of the proposed facilities have been inventoried and assessed for the proposed project using the BLM Visual Resource Management (VRM) system.

3.9.2 Methods

The VRM system is the basic tool used by the BLM to inventory and manage visual resources on public lands. The VRM inventory process involves rating the visual appeal of a tract of land, measuring public concern for scenic quality, and determining whether the tract of land is visible from travel routes or observation points.

The scenic quality inventory was based on methods provided in BLM Manual 8410 – Visual Resource Inventory (BLM 1986a). The key factors of landform, vegetation, water, color, influence of adjacent scenery, scarcity, and cultural modifications were evaluated according to the rating criteria, and provided with a score for each key factor (BLM 1986b). The criteria for each key factor ranged from high to low quality based on the variety of line, form, color, texture, and scale of the factor within the landscape. A score was associated with each rating criterion, with a higher score applied to greater complexity and variety for each factor in the landscape. The results of the inventory and the associated score for each key factor are summarized in **Table 3.9-1**. According to RG-1569; 2.4.3(7), if the visual resource evaluation rating is 19 or lower, no further evaluation is required. The total score of the scenic quality inventory is 13; however, an analysis was prepared to reflect the growing concern some residents may have for scenic resource, as Dawes County is expected to continue to develop tourism in the region.

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3.9.2.1 VRM Classes

The elements used to determine the visual resource inventory class are the scenic quality, sensitivity levels, variety classes, and distance zones. Each of the elements used to identify the VRM Class is defined below:

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Scenic Quality – Scenic quality is a measure of the visual appeal of a tract of land. In the visual resource inventory process, public lands are assigned an A, B, or C rating based on the apparent scenic quality, which is determined using seven key factors: landform, vegetation, water, color, adjacent scenery, scarcity, and cultural modifications. During the rating process, each of these factors is ranked comparatively against similar features within the physiographic province.

Sensitivity Level – A degree or measure of viewer interest in the scenic qualities of the landscape. Factors to consider include 1) type of users, 2) amount of use, 3) public interest, 4) adjacent land uses, and 5) special areas. Three levels of sensitivity have been defined:

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- Sensitivity Level 1 – The highest sensitivity level, referring to areas seen from travel routes and use areas with moderate to high use.
- Sensitivity Level 2 – An average sensitivity level, referring to areas seen from travel routes and use areas with low to moderate use.
- Sensitivity Level 3 – The lowest sensitivity level, referring to areas seen from travel routes and use areas with low use.

Distance Zones – Areas of landscapes denoted by specified distances from the observer, particularly on roads, trails, concentrated-use areas, rivers, and other locations. The three categories are foreground-middleground, background, and seldom seen.

- Foreground-Middleground – The area visible from a travel route, use area, or other observer position to a distance of 3 miles (4.8 km) to 5 miles (8.0 km). The outer boundary of this zone is defined as the point where the texture and form of individual plants are no longer apparent in the landscape, and vegetation is apparent only in pattern or outline.
- Background - The viewing area of a distance zone that lies beyond the foreground and middleground. This area usually measures from a minimum of 3 miles (4.8 km) to 5 miles (8.0 km) to a maximum of about 15 miles (24.1 km) from a travel route, use area, or other observer position. Atmospheric conditions in some areas may limit the maximum to about 8 miles (12.9 km) or increase it beyond 15 miles (24.1 km).
- Seldom Seen – The area is screened from view by landforms, buildings, other landscape elements, or distance.

The visual resource inventory classes are used to develop VRM classes, which are generally assigned by the BLM through the resource management plan process. VRM objectives are developed to protect scenic public lands, especially those that receive the greatest amount of public viewing. The following VRM classes are objectives that outline the amount of disturbance an area can tolerate before it no longer meets the visual quality of that class.

- Class I Objective: To preserve the existing character of the landscape. The level of change to the characteristic landscape should be very low and must not attract attention.
- Class II Objective: To retain the existing character of the landscape. The level of change to the characteristic landscape should be low.
- Class III Objective: To partially retain the existing character of the landscape. The level of change to the characteristic landscape should be moderate.

- Class IV Objective: To provide for management activities which require major modification of the existing character of the landscape. The level of change to the characteristic landscape can be high.

The Scenic Quality, Sensitivity Level, and Distance Zone inventory levels are combined to assign a VRM Class to inventoried lands as shown in **Table 3.9-2**.

3.9.2.2 Affected Environment

The MEA lies mostly in the Sandy and Silty Tableland ecoregion, with the northern portion of the MEA lying in the Pine Ridge Escarpment; both are sub-regions of the Western High Plains ecoregion. The physiography of the Pine Ridge Escarpment is characterized by alternating ridges and valleys with entrenched channels and rock outcrops, with elevations increasing from the northeast to the southeast. Vegetation includes ponderosa pine woodlands with Rocky Mountain juniper, western snowberry, skunkbush sumac, choke cherry, and Arkansas rose. Mixed-grass prairie is also found, containing little bluestem, western wheatgrass, prairie sandreed, needle-and-thread, blue grama, and threadleaf sedge. The physiography of the Sandy and Silty Table is characterized by tablelands with areas of moderate relief, with some areas of isolated sand dunes, and canyons along stream valleys. Vegetation includes mixed-grass prairie containing blue grama, little bluestem, threadleaf sedge, and needle-and-thread, and some scattered Sand Hills prairie with sand reed and little bluestem (EPA 2000).

The MEA landscape is rural and agricultural in character, and is composed primarily of scenery that is common for the ecoregion. Vegetation cover consists of grassy meadows and croplands interspersed with shrubby riparian growth along drainages. The landscape colors are dominated by tan, gold, and green vegetation. The colors and values (degrees of lightness and darkness) of soils and vegetation are similar, exhibiting little contrast during most of the year, although the dark greens of Ponderosa pine visible in the background from the MEA exhibit striking color contrasts throughout the year. The scenic quality of the MEA is enhanced by the backdrop of the slopes covered with Ponderosa pine in the Nebraska National Forest to the south.

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The characteristic landscape of the MEA consists of flat to rolling hills dissected by tributaries of the Niobrara River, which is located south of the MEA. The terrain becomes progressively higher in elevation to the north. The MEA is blocked from view along the entirety of SH 2/71 by low ridges located close to the highway. Portions of the MEA are visible from E. Belmont Road, Squaw Mound Road, Hollibaugh Road, and River Road.

The visual character of the landscape includes human modification from a variety of land uses, including open lands, cropland, roadways, rural residences, and utility corridors. Open land used for grazing activities is the dominant land use in the MEA. The northern portion of the MEA is accessible from E. Belmont Road, and the southern portion from River Road. Both are gravel-surfaced county roads, which in turn connects to SH 2/71, one of the primary north-south roadways through Dawes County. Human modifications to the natural landscape evident in the MEA include private roads, rural residences, agricultural implements, and electric distribution lines.

3.9.2.3 MEA Visual Inventory

Most of the MEA is characterized by the low, rolling plains and agricultural land uses characteristic of the area in northwestern Nebraska. The scenic quality of the MEA landscape is typical of the ecoregion, and is rated as Class B. There are no Class A landscapes visible from the MEA.

Sensitive Viewing Areas

Sensitive viewing areas in the MEA include E. Belmont Road, River Road, Squaw Mound Road, and Hollibaugh Road (the primary transportation routes through and adjacent to the MEA) and rural residences. In general, residents and other users of the region are accustomed to viewing human modification in the rural landscape, but could be sensitive to increased levels of development.

The characteristic landscape of the MEA as viewed from any of the roads and the residences consists of a broad expanse of mixed-grass prairie and cropland with scenic backdrops to the north. The MEA is located more than 3.5 miles (5.6 km) east of SH 2/71 at its nearest point, and is not visible from the highway. Public use of county and private roads within the MEA is relatively low, with motorists falling into the categories of local ranchers and residents.

The greatest number of viewers of the proposed facilities would be traveling on E. Belmont Road, River Road, Squaw Mound Road, or Hollibaugh Road. The majority of motorists on the road would be residents within and outside of the MEA. There is one occupied residence within the MEA. The MEA landscape is also within the view of five residences within the 2.25-mile (3.62 km) AOR.

The level of use on E. Belmont Road, River Road, Squaw Mound Road, or Hollibaugh Road and residences within or near to the MEA is low to moderate (Sensitivity Level 2) due to the fact that River Road is one of only three routes into Box Butte Reservoir State Recreation Area. Viewers at isolated rural residences with views of the project area are few.

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A potential sensitive viewing area is the Nebraska National Forest located north of the north boundary of the MEA. However, there are no developed campgrounds or other facilities within the National Forest that could view the MEA due to the topography of the area. Individuals hiking through the National Forest could view the MEA in the background. While the level of concern for scenic landscapes would be high for many park visitors, the MEA would not be visible from most of the National Forest.

VRM Class

Based on the project area Class B scenic quality, the Sensitivity Level 2 (Medium) as viewed from E. Belmont Road, River Road, Squaw Mound Road, Hollibaugh Road, and residences; and the location of the project area in the background distance zone as seen from the Nebraska National Forest, the MEA has been assigned Class III for both the visual resource inventory and the VRM objective.

3.10 Population Distribution

Information presented in this section concerns those demographic and social characteristics of the environment that may be affected by the proposed expansion of the Crow Butte Uranium Project to include operations in the MEA. Data were obtained through the 1980, 1990, and 2000 Decennial Census, with updates from the 2010 census; various State of Nebraska government agencies; and other publicity available sources.

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3.10.1 Demography

3.10.1.1 Regional Population

The area within a 50-mile (80 km) radius of the project site includes portions of six counties in northwestern Nebraska, two counties in southwestern South Dakota, and two counties in eastern

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Wyoming. Because the 50-mile (80 km) radius extends only slightly into two very rural portions of Garden County, Nebraska and Niobrara and Goshen Counties in Wyoming, these areas are not discussed in detail beyond data summarized in **Tables 3.10-1** through **3.10-3**. **Figure 3.10-1** depicts significant population centers within a 50-mile (80 km) radius of the proposed MEA.

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Historical and current population trends in the project area counties and communities are summarized in **Table 3.10-1**. Most counties have experienced a decline in population since either the 1970 or 1980 Decennial Census; the exceptions are Shannon County, South Dakota and Goshen County, Wyoming, which have both seen population increases. All of the Nebraska counties comprising the project area experienced slight growth or actual population decline between 1960 and 1980 and population decline between 1980 and 2010. The state experienced its fastest growth since the 1920s between 1990 and 2000. The total state population in 2010 was 1,826,000, which was a 6.7-percent increase over the 2000 population of 1,711,000. The Nebraska counties in the project area experienced little of the 15.7 percent growth spurt seen state-wide in the 1990 to 2010 period; only Scotts Bluff and Dawes Counties registered positive population growth in this time period, and that growth was less than 3 percent. In general, population trends for the past two decades show that the population in urban areas is increasing, while population in rural areas is declining. Areas within 50 miles (80 km) of the project site that are defined as urban (all territory, population, and housing units in urbanized areas and in places of more than 2,500 persons outside of urbanized areas) by the U.S. Census 2000 are the Cities of Chadron and Alliance, Nebraska (USCB 2003a).

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Dawes County grew slightly between 1990 and 2000, gaining 1.8 percent in population; this is attributed to growth in the City of Chadron, which more than offset the population declines in other communities in the county. This population growth has not offset the large loss of population that occurred in the 1980 to1990 time period; the population today remains below its 1980 level. The City of Chadron and the City of Crawford are the nearest large communities in Dawes County close to the project site. The City of Chadron is located approximately 25 miles (40 km) northeast of the project site; its 2010 population was recorded at 5,851; an increase of 3.9 percent from 2000 (USCB 2011). The City of Crawford, within 15 miles (24 km) of the site, had a 2010 population of 1997; an almost 10 percent decrease from 2000 (USCB 2011). The population declines in the City of Crawford were greater than the losses in most other communities and the county as a whole.

Sioux County has been losing population since the 1970 Decennial Census; the pace of these losses has fluctuated over the last 40 years, but has averaged approximately 10 percent per decade. The population decline was slowest in the 1990 to 2000 period due to a population increase of nearly 16 percent in the City of Harrison.

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Box Butte County experienced a significant gain in population in the 1970 to 1980 timeframe, but has been losing population ever since. The population decline has averaged approximately 6 percent per decade since the 1980 Census, with the county losing 7 percent of its population since the 2000 Census. The Village of Hemingford, the nearest significant community in Box Butte County to the project site, has seen fluctuating population levels since the 1970 Census, although the Village lost approximately 19 percent of its population in the past decade.

Similarly, Sheridan County saw a gain in population in the 1970 to 1980 timeframe, but has been steadily losing population at an average rate of approximately 10 percent per decade since. This decline in population has been seen in the county's larger communities of Hay Springs and Rushville, both of which have similar rates of decline in their populations since 1980.

Scotts Bluff and Morrill Counties have experienced less severe population losses over the 1980 to 2010 timeframe, with losses of 6 and 1.1 percent per decade, respectively. The communities of Scottsbluff and Minatare in Scotts Bluff County have experienced population growth of 0.7 and 2.1 percent, respectively, since the 2000 Census.

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Within South Dakota, portions of Fall River and Shannon Counties fall inside the 50-mile (80 km) study area. Fall River County experienced population growth in the 1970 to 1980 period, but has lost more than 16 percent of its population in the last 30 years despite a small positive growth rate in the 1990 to 2000 period. The county-wide trends in population growth and loss are mirrored in the community of Oelrichs, which has lost more than 21 percent of its population since 1980. Shannon County, on the other hand, has grown by an average of better than 15 percent per decade since 1970; this growth has been realized in significant swings, with 38 percent growth in the 1970 to 1980 period followed by a 12.5 percent decline in population over the 1980 to 1990 period, which was then followed by a decade of nearly 26 percent growth from 1990 to 2000 and then 9 percent growth from 2000 to 2010. Much of the growth occurred in the Pine Ridge and Oglala Census Designated Places, which are urban areas as defined by the U.S. Census but are not incorporated municipalities.

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The population declines in the counties within the 50-mile (80 km) radius reflect trends in the overall region, where population declines have been attributed to the declines in the rural farming-based economy and limited economic opportunities for youth. Persistent drought conditions have also contributed to the shrinking of the agriculture-based economy. Rural residents have been migrating to larger cities, depopulating the largely rural Great Plains states. Many of the people migrating out of the state are young adults and families, which results in fewer people of childbearing age, and therefore, fewer children. This trend also contributes to the increasing proportion of the elderly population in the state (UNRI 2008).

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3.10.1.2 Population Characteristics

2010 population by age and sex for counties within 50 miles (80 km) of the MEA is shown in **Table 3.10-2**. Overall, 74.5 percent of the population in the region is more than 18 years old. Fewer than 20 percent of the populations of Garden, Fall River, and Niobrara Counties are under the age of 18; Shannon County has the youngest population, with nearly 40 percent of its population under the age of 18. Females slightly outnumbered males in all but four counties, with an overall population of 50.6 percent female to 49.4 percent male (USCB 2011).

In 2010, 81.5 percent of the population of the 11 counties was classified as white. American Indians comprised the largest non-white classification. The largest American Indian population is found in Shannon County, South Dakota, where American Indians comprise 96 percent of the 13,586 people in the county (USCB 2011).

3.10.1.3 Population Projections

The projected population for selected years by county within the 50-mile (80 km) radius of the proposed MEA Project is shown in **Table 3.10-3**. The population is expected to decrease or hold steady in all 11 counties surrounding the project area. These counties are primarily rural, with agriculture-based economies. It is anticipated that the declining population trends of the last two decades will continue into the foreseeable future for these counties as populations shift to more urban counties (e.g., Douglas, Lancaster, Sarpy). The largest declines are projected for Dawes and Garden Counties, which are each expected to lose more than 20 percent of their current populations by the year 2030.

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3.10.1.4 Seasonal Population and Visitors

According to the Final Environmental Impact Statement for the Northern Great Plains Management Plans Revision (May 2001), the various state parks in northwest Nebraska, the Pine Ridge Ranger District, and the Oglala National Grassland are increasingly becoming regional tourist destinations.

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Approximately 345,923 people visited Fort Robinson State Park in 2010. This number represents a 25 percent decrease from 460,154 in 2007 and a 2 percent decrease from 356,352 in 1993 (NDED 2011). Approximately 50 percent of the visitors in 2002 were from other states, which is an increase in the number of out-of-state visitors from 1981, as the majority of 1981 visitors were Nebraskan families. It is likely that the decline of visitors from Nebraska has resulted from the overall decline of population in rural counties within a few hours commuting distance of the park.

There were 55,000 visitors to the Pine Ridge District of the Nebraska National Forest in 2001. Camping and motorized travel/sightseeing are the two most popular recreation categories within the Pine Ridge Ranger District and the Oglala National Grassland.

The forest provides a wide range of other undeveloped backcountry recreation opportunities such as hunting, hiking, backpacking, fishing, and wildlife observation. The district provides the greatest number of miles of mountain biking trails in the state. District trails also attract horseback riders and off-highway motorized vehicle use. The Pine Ridge is an important destination for deer hunting, and provides the most popular turkey hunting area in Nebraska.

One source of seasonal population in this region is Chadron State College, located approximately 21.6 miles (35 km) from the site. During the fall seasons of 2005, 2006, 2007, 2008, 2009, 2010, and 2011, the enrollment was 2,601, 2,767, 2,726, 2,769, 2,744, 2,759, and 2,609, respectively (CSC 2010a, 2010b, Haag 2012, and Universities.com 2010). The average enrollment from 1994 through 1999 was 2,944, with a range of 2,768 to 3,189 (NCCPE 2005). Enrollment from 2011 (2,609) versus this later average of 2,944 is a 0.11 percent reduction in student enrollment. A rising enrollment trend has been observed at the college since 2006, with the overall increase near 30 percent during the period (Haag 2012). Actual enrollment values presented in this paragraph may vary depending on the time of the year of the enrollment count.

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3.10.1.5 Schools

The City of Crawford is served by the City of Crawford Public School District. The Crawford High School and grade school are presently under capacity (Vogl, pers. comm. 2010). Enrollment for the 2010-2011 school year was 123 in the grade school and 115 in the high school; this represents a decline of about 9.5 percent in total enrollment for both schools from the 2007-2008 school year (NDE 2011a).

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The Village of Hemingford is served by the Hemingford Public Schools. Enrollment for the 2010-2011 school year was 232 in the grade school and 169 in the high school, an increase of more than 9 percent in total enrollment for both schools from the 2007-2008 school year (NDE 2011b). This enrollment level is lower than in past years, reflecting continuing pressures on population levels in the area.

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Families moving into the Crawford or Hemingford School Districts as a result of the proposed MEA operations would not stress the current school system.

3.10.1.6 Sectorial Population

Existing population, as determined for the original analysis in the CBR commercial license application prepared in 1987 for the 50-mile (80 km) radius was estimated for 16 compass sectors by concentric circles of 0.6, 1.2, 1.9, 2.5, 3.1, 6.2, 12.4, 18.6, 24.9, 31, 37.3, 43.5, and 50 miles (1, 2, 3, 4, 5, 10, 20, 30, 40, 50, 60, 70, and 80 km) from the site (a total of 208 sectors). 2010 US Census data were used; subtotals by sector and compass points as well as the total population are shown in **Table 3.10-4**.

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Population within the 50-mile (80 km) radius was estimated using the following techniques:

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- U.S. Census 2010 data were used to estimate the total population within a 50-mile (80 km) radius, measured from the center of the proposed MEA site. The data were created by Geographic Data Technology, Inc., a division of Earth Sciences and Research Institute (ESRI), from Census 2000 boundary and demographic information for block groups within the United States.
- ArcInfo GIS was used to extract data from U.S. Census 2000 population estimates for 40 Census Tract Block Groups located wholly or partially within the 50-mile (80 km) radius from the approximate center of the MEA site. Urban areas within each county were generally assigned their own block group.
- To assign a population to each sector, a percentage area of each sector within one or more block groups was calculated for all of the block groups.
- 2010 U.S. Census of population estimates for cities and counties in Nebraska, South Dakota, and Wyoming were used to determine total urban population.

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3.10.2 Local Socioeconomic Characteristics

3.10.2.1 Major Economic Sectors

In 2009, average annual unemployment rates in Dawes and Box Butte Counties decreased from the 2008 rates. **Table 3.10-5** summarizes unemployment rates and employment in the Nebraska project area counties, as well as the overall change in employment in economic sectors between 1994 and 2009. Dawes and Box Butte Counties exhibited unemployment rates at 4.4 percent in Dawes County and 6.8 percent in Box Butte County in 2009. The Dawes County unemployment rate was slightly lower than the statewide rate of 4.7 percent, whereas the Box Butte County rate was significantly higher (NDOL 2010).

The major economic sectors in the project area have changed little in recent years, although individual sectors have shifted in their relative proportion in the overall economy. The area continues to depend on trades, government, and services. Economic sectors in the City of Crawford area include farming, ranching, cattle feed lots, tourism, and retail sales.

Agriculture accounted for a significant portion (19.2 percent) of the total employed labor force in Dawes County in 2009. During the same time period, farm employment was 2.0 percent of total employment in Box Butte County. Retail trade accounted for 14.7 percent of total employment in Dawes County, followed by local government employment (12.6 percent), leisure and hospitality (11.1 percent), education and health services (9.8 percent), and state government (6.5 percent). Mining and construction accounted for 5.0 percent. In Box Butte County, the largest four non-farm employment sectors are local transportation, communication, and utility services (20.2 percent); local government (17.7 percent); production (8.6 percent); and leisure and hospitality (8.0 percent) (NDOL 2010).

While agriculture employment is not dominant, agriculture provides the economic base for the counties, as other economic sectors support the agricultural industry. Events that affect agriculture are generally felt throughout rural economies. According to the Nebraska Department of Economic Development (NDED 2010), farm employment in Nebraska is expected to decline by nearly 14,000 jobs (20 percent) between 2000 and 2045, while overall non-farm employment will increase by nearly 26 percent. The decrease in jobs in the agricultural sector could continue to fuel migration from rural counties to urban areas, resulting in overall declines in other sectors of the local economy as dollars spent from personal income and agricultural business expenditures move out of the counties.

Per capita personal income is the income that is received by persons from all sources, including wages and other income, over the course of 1 year. In 2010, personal income in Dawes County was $28,981, which was 74 percent of the state average of $39,332. The county ranks 87th out of 93 counties in the state (BEA 2011). In 2010, personal income in Box Butte County was $35,225, which was 89 percent of the state average of $39,332. Box Butte County ranks 58th out of 93 counties in the state.

3.10.2.2 Housing

Between 1970 and 1980, total housing units increased by 17 percent in Dawes County from 3,388 to 3,965 units (USCB 1990a). After a decline in total units during the 1980s, growth increased by 2.4 percent from 3,909 units in 1990 to 4,004 units in 2000, and then increased again by 6.2 percent to 4,252 units in 2010. The City of Chadron, the largest community in Dawes County and within 25 miles (40 km) of the project site, experienced a negligible increase (0.3 percent) in housing stock between 1980 and 1990, a 5 percent increase between 1990 and 2000, and a 4.4 percent increase to 2,559 units between 2000 and 2010. Between 1980 and 1990, the City of Crawford housing stock decreased by nearly 7 percent to 576 (USCB 2003a). The number of housing units continued to decline through 2010, when 567 units were reported.

Box Butte County, which borders Dawes County to the south, exhibited a 1 percent loss in total housing units between 1990 and 2000, when 5,488 units were counted in the 2000 Census; a similarly small loss of 10 units was reported in the following decade, with a total of 5,478 units reported in 2010. In the Village of Hemingford, 418 housing units were reported in 2010; this represents a slight decrease from the 438 units reported in 2000.

In 2000, Dawes and Box Butte Counties had homeowner vacancy rates of 1.7 and 1.4 percent, respectively. In 2010, these rates were 2.3 and 2.4 percent, respectively. As of June 2011, there were six single-family housing units for sale in the City of Crawford. Five of the units were listed at prices below $100,000. One unit was listed at a price higher than $250,000. Three new single-family housing units were constructed between 2006 and 2008 in the City of Crawford, and average new home construction costs were $70,000 (NPPD 2011); one permit was issued in 2009 for a home with a construction cost of $60,000. In Hemingford, one permit was issued in 2006 for a residence with a construction cost of $25,100. The median gross rent for the City of Crawford in 2009 was $440 per month; in the Village of Hemingford, the median gross rent was $344 (Advameg 2010).

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The demand for rental housing did not change significantly between 1990 and 2000, as rental vacancy rates were 11.8 percent in Dawes County and 15.4 percent in Box Butte County in 2000 (USCB 2003c) compared with 1990 rental vacancy rates of 12.6 percent and 14.9 percent, respectively (USCB 1990b). Similar rates continue to be seen: the rental vacancy rate in Dawes County is currently 10.2 percent, and 17.7 percent in Box Butte County (USCB 2011).

High interest rates and tax rates were the major deterrents for potential homebuyers in the project area in the past. Current deterrents are economic uncertainty and unemployment, as home mortgage interest rates have recently been at historic lows.

The majority of housing demand expected over the next two decades in Dawes County is most likely to occur in the City of Chadron, reflecting a continued shift from rural to more urbanized environments.

The purchase of homes by Crow Butte employees provides the City of Crawford with ad valorem property taxes. The City of Crawford levies taxes at a dollar per hundred of valuation. In 2010, the total levy was 0.424539, which would result in taxes on a $50,000 property of approximately $212 per year. The Village of Hemingford levies taxes at a dollar per hundred of valuation. In 2010, the total levy was 0.98062, which would result in taxes on a $50,000 property of approximately $490 per year (NE Revenue 2010).

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3.10.3 Environmental Justice

The 2010 Census provides population characteristics for Census Tracts, which contain Block Groups that are further divided into Blocks. The Blocks are the smallest Census areas that contain the race characteristics of the population in the MEA region. The MEA contains all or a portion of, or is adjacent to, 23 Blocks within Census Tract 9506 in Dawes County. Census Bureau-generated 2009 data on the poverty status of school district populations were used as a proxy.

The affected area selected for the Environmental Justice analysis includes the racial characteristics of the population within Census Tract Blocks within the MEA, and the poverty status of students enrolled in local school districts.

The State of Nebraska was selected to be the geographic area with which to compare the demographic data for the population in the affected Blocks. This determination was based on the need for a larger geographic area encompassing affected area Block Groups in which equivalent quantitative resource information is provided. The population characteristics of the MEA are compared with Nebraska population characteristics to determine whether there are concentrations of minority or low-income populations in the MEA relative to the state.

According to the 2010 Census, and summarized in **Table 3.10-6**, the combined population of the Census Block Groups within or adjacent to the MEA was 32. The entire population was white; with one individual identified as Hispanic. The next nearest minority populations reside within the City of Crawford, located approximately 15 miles (24.1 km) north-northwest of the MEA, and the Village of Hemingford, located approximately 15 miles (24.1 km) south-southeast. Races in the City of Crawford consist of white non-Hispanic (95.6%), American Indian (0.9%), Hispanic (1.0%), persons reporting two or more races (2.3%), and smaller percentages of other races. Races in the Village of Hemingford consist of white non-Hispanic (96.1%), American Indian (1.2%), Hispanic (4.6%), persons reporting two or more races (2.1%), and smaller percentages of other races. The total percentage is greater than 100 percent because Hispanics could be counted in other races.

No concentrations of minority populations were identified as residing in rural areas near the proposed MEA. There would be no disproportionate impact to any minority population from the construction and implementation of the MEA.

The schools located nearest the MEA are those in the City of Crawford (operated by Crawford Public Schools), the Village of Hemingford (operated by Hemingford Public Schools), and in the community of Marsland (the Pink Public School operated by the Sioux County Public Schools). 12.9 percent of all students aged 5 to 17 in the State of Nebraska are identified as living in families in poverty. This compares to 22.8 percent of students in the Crawford Public Schools, 13.8 percent in the Hemingford Public Schools, and 19.8 percent in the Sioux County Public Schools. These data indicate that more students in the vicinity of the MEA live in families in poverty than are found in the state as a whole. Lower income levels are characteristic of predominantly rural populations and small communities that serve as a local center of agricultural activity. No adverse environmental impacts would occur to the population within the MEA from proposed project activities; therefore, there would be no disproportionate adverse impact to populations living below the poverty level in these Block Groups.

3.11 Public and Occupational Health

3.11.1 Non-Radiological Impacts of the Current Operation

3.11.1.1 Chemical Impacts of the Current Operation

The current operation at the CPF involves the use of hazardous chemicals in the process in quantities that could present a hazard to workers and the environment. Specifically, CBR stores and uses hydrochloric acid, sodium hydroxide, H_2O_2, liquid O_2, and CO_2. The design of facilities and the storage and handling of these chemicals at CBR is performed in accordance with accepted codes and standards as recommended in RG/CR-6733. CBR is also subject to the requirements of the Occupational Safety and Health Administration (OSHA) set forth in the Process Safety Management Standard contained in 29 CFR §1910.119. As a result of these requirements and the management and administrative controls implemented by CBR, there has never been a serious incident involving hazardous chemicals at the CPF.

As part of CBR's SHEQMS 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 is located only at the CPF and will not be used at the satellite facility.

None of the hazardous chemicals used at the CPF are covered under the EPA's 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.

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3.11.1.2 Potential Declines in Groundwater Quality

Excursions at the current operation represent a potential effect on the adjacent groundwater. During production, injection of the lixiviant into the wellfield results in a temporary degradation of water quality in the exempted aquifer, compared to pre-mining conditions. Movement of this water out of the wellfield results in an excursion. Excursions of contaminated groundwater in a wellfield can result from: an improper balance between injection and recovery rates; undetected high permeability strata or geologic faults; improperly abandoned exploration drill holes; discontinuity and unsuitability of the confining units which allow movement of the lixiviant out of the ore zone; and poor well integrity. Hydrofracturing has not, and will not, be utilized at the CBR operations in Dawes County. To date, there have been several

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confirmed horizontal excursions in the Chadron sandstone in the CPF license area. These excursions were quickly detected and recovered through overproduction in the immediate vicinity of the excursion. In the majority of cases, the reported vertical excursions were actually due to natural seasonal fluctuations in Brule groundwater quality and very stringent upper control limits (UCLs). In no case did the excursions threaten the water quality of an underground source of drinking water (USDW) because the monitor wells are located well within the aquifer exemption area approved by the EPA and the NDEQ. **Table 3.11-1** provides a summary of excursions reported for the CPF license area.

3.11.2 Radiological Impacts of the Current Licensed Operation

CBR is currently licensed to operate the CPF at a maximum production flowrate of 9,000 gpm and a maximum annual production of 2,000,000 pounds U_3O_8. Because the project is an in-situ operation, the particulate emission sources normally associated with the ore crushing and grinding and tailings disposal at a conventional uranium mill are not present. A vacuum dryer is in use at the commercial operation. The vacuum dryer works on the principle that gases or particulates released into the system are collected in a liquid condenser and there is no release of particulates. The effluent collection efficiency for this dryer system is, therefore, 100 percent. The only routine radioactive emission is radon-222 gas.

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Radon is present in the ore body and is formed from the decay of radium-226. The radon dissolves in the lixiviant as it travels through the ore body to a production well, when the solution is brought to the surface, the radon is released.

In order to assess the radiological effect of radon on the environment, an estimate of the quantity released during the operation was made in the CPF License Renewal Application submitted to NRC in 2007. Meteorological data and MILDOS-AREA (June 1989) were used to predict the ground level air concentration at various points in the environment. The ingrowth of radon daughters is important, and their concentration in the soil, vegetation, and animals was calculated. Finally, the impact on humans from these concentrations of radionuclides in the environment was determined.

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Based on the MILDOS-AREA results for the current operation, the anticipated effects were not significantly above naturally occurring background levels. This background radiation, arising from cosmic and terrestrial sources, as well as naturally occurring radon, comprises the primary radiological impact to the environment in the region surrounding the project.

3.11.2.1 Exposures from Water Pathways

The solutions in the mining zone are controlled and adequately monitored to ensure that migration does not occur. The overlying aquifers will also be monitored.

Three commercial evaporation ponds located approximately 2,000 feet from the current CPF building have been constructed for commercial operation. There are also two R&D evaporation ponds located approximately 1,000 feet from the CPF building. The R&D evaporation ponds have a 34-mil Hypalon liner and a leak detection system. The commercial evaporation ponds are lined with double impermeable synthetic liners. The ponds, therefore, are not considered a source of liquid radioactive effluents. There is a leak detection system installed to provide a warning if the liner develops a leak.

The CPF is located on a curbed concrete pad to prevent any liquids from entering the environment. Solutions used to wash down equipment drain to a sump and are pumped to the ponds. The pad is of sufficient size to contain the contents of the largest tank in the event of its rupture.

Because there are no routine liquid discharges of process water from the CPF, there are no definable water-related pathways.

3.11.2.2 Exposures from Air Pathways

The only source of radioactive emissions from the current operation is radon released into the atmosphere through the plant ventilation systems or from the wellfield. This radon release results in radiation exposure via the inhalation, ingestion, and external exposure pathways. The TEDE to nearby residents in the region around the Crow Butte project was estimated in the 2007 License Renewal Application by using the computer simulation MILDOS-AREA. The joint frequency data compiled from a site-specific meteorological station were used to define the atmospheric conditions in the project area.

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Based on the site-specific data and method of estimation of the source term, the emission rate of radon-222 from the Crow Butte project was estimated at 5,937 Curies/yr for a flow of 5,000 gpm in the upflow IX columns in the existing CPF. In order to show compliance with the annual dose limit found in 10 CFR §20.1301, CBR demonstrated by calculation that the TEDE to the individual most likely to receive the highest dose from the current licensed operation was less than 100 mRem per year. The dose to the most effected resident was 23.2 mRem/yr (0.232 mSv/yr) or 23.2 percent of 100 mRem/yr dose constraint.

3.11.2.3 Exposure to Flora and Fauna

The exposure to flora and fauna was evaluated in the Environmental Report submitted in September of 1987, and the doses were found to be negligible.

The long-term impacts on groundwater quality should also be minimal, as restoration activities have been shown to be successful in returning the groundwater quality to background or class of use standards. Additionally, there is no mechanism in EPA or NDEQ regulations to "unexempt" an aquifer. Therefore, the groundwater in the immediate mining area will never be used as a USDW. The primary purpose for restoration is to ensure that post-mining conditions do not affect adjacent USDWs.

3.11.2.4 Occupational Safety

CBR has an exemplary safety record at the Crow Butte project. The company has been recognized on several occasions for this safety record including being named the recipient of the Governor's Safety Award and the Star Award, awarded by the Nebraska Safety Council. The Health and Safety Management System (HSMS) implemented at the project is designed to meet the Occupational Health and Safety Management System (OHSAS):18001 international HSMS standard.

3.12 Waste Management

The effluents of concern at the proposed satellite facility will include the release or potential release of radon-222, radionuclides in liquid process streams, and dried yellowcake. Yellowcake processing and drying operations are conducted nearby at the CPF. Loaded IX resin from the satellite facility will be transported to the CPF for elution, precipitation, drying, and packaging. Effluent control systems will be used at the satellite facility to control the release of radioactive materials to the atmosphere.

The yellowcake drying facilities at the CPF are composed 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 CBR CPF have been reviewed by NRC and approved in the current license.

3.12.1 Gaseous and Airborne Particulates

The principal radioactive airborne gaseous radiological effluent at the MEA will be radon-222 gas. Processing at the satellite facility will produce water-based solutions or wet slurry (no yellowcake processing or drying); therefore, airborne uranium concentrations are expected to be at or near local background levels. Airborne releases from uranium ISR facilities normally are radon-222 and its daughters from process fluids and particulates from yellowcake drying and packaging operations (NRC 2001). One process area at the proposed MEA where small quantities of airborne uranium particulates have the potential for occurring is the resin transfer station, where minor spills may occur. The loaded IX resin is transferred to a truck for transport to the CPF for completion of uranium recovery. Spills can occur during resin transfer, and this is where exposure to uranium particulates is possible. All spills will be cleaned up as soon as possible to prevent 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.

Maintenance activities on piping containing pregnant lixiviant could also result in the release of radon and uranium. Any spills or releases during maintenance of these potential sources would be cleaned up promptly to prevent drying of the material and creation of particulates subject to dispersion.

Radon-222 is found in the pregnant lixiviant that comes from the wellfield into the satellite facility. The uranium is then separated from the lixiviant by passing the solution through fixed- bed 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 the atmosphere outside the satellite facility 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, RO system operation during groundwater restoration, and maintenance activities. These are minimal, infrequent radon gas releases. The general building ventilation system in the satellite facility will further reduce employee exposure. The air in the satellite facility is sampled for radon daughters to ensure 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 are 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. All of the well releases would be outside of buildings and directly vented to the atmosphere. Some venting would also occur from the wellhouses to remove any radon releases from the building to the surrounding atmosphere. The exhaust fans are located in the wall directly opposite the entryway. Releases to the atmosphere from wells and wellhouses would result in radon emissions dispersing rapidly. Wellfield offgassing is not considered a significant source of radon or a safety issue. This statement is supported by MILDOS-AREA calculations (Section 4.12.2.3) and by monitoring at the current CPF.

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Employee radon daughter monitoring results and work area ventilation systems at the CPF are discussed in Section 5.7 of the MEA Technical Report.

3.12.2 Liquid Wastes

ISR mining will produce several sources of liquid waste. The potential wastewater sources that exist at the satellite facility include the following:

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3.12.2.1 Liquid Waste Generated

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 collected by vacuum trucks and discharged directly to the well workover fluid tank located in the satellite building. This tank, which will have a cone bottom to enhance the collection and concentration of solids, will feed a belt filter or other separation equipment to separate solids from water. Filtered water will be discharged to the DDW water supply tank for disposal in the onsite DDWs. Solids will be bagged for 11e.(2) byproduct disposal. This will allow treatment and disposal of the fluids without the accumulation of waste solids.

As a backup to this system, the well workover fluid would be transported to the CPF evaporation ponds. This option would only be used if there were equipment issues with the separation system at the MEA satellite building.

Deleted: the wastewater surge/equalization tanks that discharge to a DDW. Silt, fines, and other natural suspended matter collected during well development will settle out in the wastewater surge/equalization tanks. Well development water may also be treated with filtration and/or RO and used as plant make-up water or disposed of in the DDW. If required, well development water may be transported to the CPF site for disposal in the lined evaporation ponds.

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Purge Water from Baseline Monitor Well Sampling

Except where a baseline well is on excursion, purge water is released onto the ground surface, but is not discharged directly into a stream. When a baseline well is on excursion, the purge water is collected and disposed in the wastewater disposal system or taken to the evaporation ponds at the CPF. This is allowed by the NDEQ because the monitor wells are hydrologically separated from the confined basal sandstone of the Chadron Formation.

Liquid Process WasteThe operation of the satellite facility results in one primary source of liquid waste, a production bleed, as previously discussed in Section 1.3.2.6. This bleed will be routed to wastewater tanks housed in the satellite building and then pumped from the tanks to the DDWs.

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Waste Petroleum Products and Chemicals

Small quantities of waste petroleum products and chemicals typical of ISR facilities will be generated and will include items such as waste oil and out-of-date or partially used reagents/chemicals. All such wastes that are non-hazardous will be temporarily stored in appropriate sealed containers above ground prior to disposal by a contracted waste disposal entity at an approved waste disposal or recycling facility. Such wastes are not considered to be affiliated with the processing or generation of 11e.(2) byproduct material and will not be classified as Atomic Energy Act (AEA)-regulated waste. It is estimated that less than 50 gallons of waste petroleum products and chemicals will be disposed of annually. Any used oil that may be generated will be recycled by an approved commercial recycler, and such materials are not classified as a hazardous waste. Hazardous waste generation is discussed in Section 3.1.3.4.

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Aquifer Restoration Waste

Following mining operations, restoration of the affected aquifer 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

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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, being disposed of by deep well disposal. As has been the case with past operations at CBR, it is anticipated that, during restoration, groundwater at the MEA will be treated using IX and RO. Using this method, there would be no water consumption, and only the bleed has to be disposed, with the rest of the treated water being reinjected.

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Groundwater treatment activities involve the use of process equipment to lower the ion concentration of the groundwater in the affected mining area. An RO unit will be used to reduce the TDS in the groundwater. The RO unit produces clean water (permeate) and brine. The permeate is either injected into the formation or disposed of in the wastewater 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 NPDES permitting requirements for industrial facilities and construction activities. The NDEQ NPDES regulatory program contained in Title 119 (NDEQ 2010a) requires that procedural and engineering controls be implemented so that runoff will not pose a potential source of pollution. The design and engineering controls for the proposed MEA facilities will be such that any potentially contaminated stormwater runoff or snowmelt (e.g., any tankage diking or curbing outside of the satellite building) will be collected and disposed of in the DDW. Engineering and procedural controls contained in a SWPPP, in combination with the design of the project facilities, will ensure that stormwater runoff is not a potential source of pollution.

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Domestic Liquid Waste

Domestic liquid wastes from the restroom, toilets and lavatories and sink in the lunchroom/break area will be disposed of in an approved septic system that meets the requirements of the State of Nebraska. The septic system will be designed with a capacity sufficient to handle the projected number of employees, contractors, and visitors. CBR currently maintains a Class V UIC Permit issued by the NDEQ for operation of the septic system at the CPF. A similar permit will be required for the satellite facility.

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CBR will employ an estimated 10 to 12 employees at the proposed MEA satellite facility. Assuming 13 gpd for each employee (based on the estimate for industrial employees by EPA), a total of approximately 130 to 160 gpd of sanitary waste would be generated (EPA 2002). An assumed additional 50 gpd of miscellaneous sanitary wastewater (e.g., lavatories and sink in lunchroom/break area) would result in approximately 180 to 210 gpd of sanitary wastewater being discharged to the septic system.

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The number of temporary construction employees for the proposed satellite facility is estimated at 10 to 15 personnel. An assumed an average of five to 10 full-time employees during construction would result in a total of 15 to 25 employees on site for some periods. This would result in approximately 200 to 325 gpd of sanitary waste generation. During initial construction, portable sanitary units will be used, which will be provided and serviced by a third-party contractor.

The septic system will be designed, constructed, operated, and permitted as per applicable NDEQ Title 124 regulations.

Laboratory Waste

There will be no laboratory located in the satellite building.

Liquid Waste Disposal

Liquid waste disposal is discussed in Section 4.13.2.2.

CBR plans to use DDWs as the primary liquid waste disposal system at the MEA site. The DDWs will be operated without the need for surge tanks or surge/evaporation ponds.

The proposed DDWs at Marsland is the third project to be developed by CBR in Nebraska that uses underground injection wells to dispose of a non-hazardous waste stream associated with ISR Uranium mining operations from the basal sandstone of the Chadron Formation.

CBR currently operates two non-hazardous Class I injection wells in the CPF license area for disposal of wastewater under Permits #NE0206369 and #NE0210825 (DDW-1 and DDW-2, respectively). The wells are permitted under NDEQ regulations in Title 122 (NDEQ 2010b) and operated under a Class I UIC Permit. The permits for both wells allow unlimited flow and maximum operating pressure of 650 psi. To preserve optimum performance, Well #1 has typically been operated at up to 40 psi with a 200 gpm flow.

CBR has operated DDW-1 at the CPF license area for more than 10 years with excellent results and no serious compliance issues. DDW-2 was incorporated into the license by action of the CBR Safety and Environmental Review Panel on November 18, 2011, with the well started up on November 30, 2011. CBR expects that the liquid waste stream at the satellite facility will be chemically and radiologically similar to the waste disposed of in the current DDWs. Radiological data for the years 2008 through 2012 for DDW-1 injection stream are shown in **Table 3.12-1**, and radiological data for DDW-2 for the year 2012 in **Table 3.12-2**. The non-radiological data for DDW-1 and DDW-2 injection streams for 2012 are presented in **Table 3.12-3**.

CBR has submitted an application to the NDEQ for an Area Permit to install and operate Class I Non-hazardous Waste Injection Wells on private lands within the MEA license boundary. The purpose of establishing an Area Permit is to allow for multiple injection wells to be installed at the MEA site over the expected multi-year life of the project. This permit application is for the initial two Class I Non-hazardous Waste Injection Wells to be installed under the Area Permit. Cameco is aware that a permit modification would be required for any additional wells added to the Area Permit at a later date. The permit application was prepared in accordance with regulatory requirements presented in the NDEQ Assessment Section, Title 122 Rules and Regulations for Underground Injection and Mineral Production Wells (Effective April 2, 2002). The formation receiving the injected waste fluids shall be restricted to the Lower Dakota, Morrison, and Sundance Formations, which have been demonstrated to be located below the lowermost underground source of drinking water. In addition, the Lower Dakota, Morrison, and Sundance Formations exhibit water quality that is not considered under state and federal regulations to be underground sources of drinking water due to measured TDS concentrations.

CBR has found that permanent deep disposal is preferable to evaporation in ponds. The basic reasons for this position are as follows:

- The potential for human contact while using a DDW is lower because the waste is handled in enclosed systems.

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- The potential for emissions from the pond surface is higher than the enclosed DDW disposal system.
- Evaporation ponds carry the potential for leaks.

Use of evaporation ponds creates a larger amount of 11e(2) byproduct waste. The DDWs at Marsland will be located near the satellite building (**Figure 1.1-7**). All tankage, filtration, and process equipment will be located at the main operating satellite facility. Feed from the satellite facility will pass through a set of bag filters and will be pumped to the DDW located in a DDW wellhouse. At the DDW wellhead, there will be a set of filters, flowmeters, check valve, and annulus fluid tank. Per NDEQ permitting requirements, CBR will be required to continually monitor and record the injection pressure, injection flowrate and volume, and annual pressure. Any failure of the monitoring system requires that the DDW be shut down immediately until the potential for a release has been investigated.

Two dedicated storage tanks located in the satellite building will supply feed to the DDWs. One tank will serve as the primary DDW supply tank, with all makeup water to the DDW flowing to this tank (e.g., RO brine, wellfield bleed, plant sump, and filtered well workover fluid). At the CPF, a DDW water supply tank is operated using similar makeup water, and the primary DDW supply tank at the MEA site is expected to be operated in a similar fashion at the MEA. All flow to the DDWs will pass through a set of bag filters at the satellite building and the DDW wellhouse.

Current plans are to use the second tank for managing special wastewaters that are periodically generated, such as collecting filtered water from the well workover fluid tank, which is then sent to the primary DDW tank for disposal. This second tank would also be used for surge capacity for the DDW well system when needed (very infrequent based on CPF operations). Under normal operations, this tank will be operated with water levels sufficient to allow use for surge capacity. The surge capacity will be designed to only handle short-term flows and not for long-term periods when additional capacity is needed and/or the DDWs may not be available. In the event that capacity of the DDW tanks is insufficient to receive additional flows, such as during upset conditions, the commercial process will be immediately curtailed to reduce the wastewater generated until tank levels can return to norml. See Section 3.12.2.2 (MEA water balance) for discussions of actions that be taken to address long-term shutdown periods of the DDWs.

The size and detailed operations of the wastewater tanks will be defined in the detailed engineering phase of the project.

The DDW will be installed in sufficient time to be used for wastewater disposal allowed by the permit. Details of the DDW operations, controls, monitoring, waste management, and spill issues will be addressed in a future NDEQ permit application. No wastewaters will be discharged to the land surface or surface water of the State of Nebraska.

Radioactive liquids not referenced above will be disposed of as per NRC License SUA-1534.

In addition to the use of DDWs as a disposal method, the NDEQ has issued CBR an NPDES permit for the CPF license 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 satellite facility. It is expected that liquid waste generated in the MEA can be satisfactorily managed with deep disposal. If needed in an emergency situation, contaminated wastewater can be collected and trucked to the evaporation ponds at the CPF site or to an approved commercial disposal facility for disposal.

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Evaporation Ponds

No evaporation ponds will be used at the proposed MEA site. The alternate approach is the use of storage tanks located in the satellite building that will discharge to a DDW.

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3.12.2.2 Water Balance

From 2015 to 2012, the majority of the wastewater produced at the MEA satellite facility during production will be the production bleed. Starting in 2022, the wastewater flows will rise sharply as the bleed from the RO process and must be addressed.

Other liquid wastewater that will be generated will consist of process liquids (e.g., affected well development water, laundry water, and plant washdown water). These waste streams will account for an intermittent discharge with an maximum average of 1 to 2 gpm. The disposal water balance discussed below is of such a magnitude that these small quantities of wastewaters will be easily managed in the proposed disposal system. The well development water will be collected using a vacuum truck and delivered to the well workover fluid tank located in the satellite building (**Figure 1.1-8**). The other liquid wastes (i.e., laundry and plant washwater originating in restricted areas) described above will flow to plant sumps and transfer to a wastewater tank located within the satellite building. All of the above waste streams will be disposed of through the DDWs.

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The detailed MEA water balance for production and restoration for the life of the project is shown in **Appendix T**. The project required disposal water balance is depicted in **Table 3.12-4**, and the process flow diagram is shown as a flow chart in **Figure 3.12-1**. These water balances illustrate the anticipated water management and disposal capacity needed for production bleed and restoration activities. Two DDWs will be installed initially, and each is ecpected to have an injection capacity of 45 gpm. The 45 gpm minimum injection capacity is reasonable based upon DDWs drilled into the same formations at the existing plant.

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Two DDWs will accommodate all wastewater generated from startup in 2015 through the end of 2020. In 2021, groundwater restoration will result in increased wastewater volumes, which may require additional disposal capacity. Considering the capacity of the two DDWs, the need to install additional deep disposal well(s) and/or surge/evaporation ponds will be evaluated to supply long-term wastewater disposal. CBR has submitted an area permit application for multiple Class I non-hazardous waste injection wells at the MEA site.

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Operating procedures at the MEA site that will minimize the amount of water requiring disposal via DDW include: design wellfields to maximize the ability to continuously minimize the amount of production bleed through continuous and effective wellfield balancing; minimize the consumptive use of process water by injecting all of the ISR fluids except for the small production and restoration bleed streams that are necessary to maintain an inward hydraulic gradient in each wellfield configuration; and if necessary, two stages of RO may be used to treat restoration fluids and reduce the total required wastewater disposal capacity.

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As shown in **Appendix T**, only five MUs will be in production mode at any one given time. Total production flow over the life of the project will be variable, ranging from approximately 1,100 to 5,400 gpm. The production bleed (1.2 percent) and the RO bleed, over the life of operations, will vary from approximately 25 to 65 gpm and 80 to 250 gpm, respectively. Permeate flows will vary from 500 to 750

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gpm, with 750 gpm being the estimated average flow from 2022 to 2037. The amount of brine sent to DDW will range from approximately 167 to 250 gpm beginning in year 2022 and continuing until 2037.

Figure 3.12-2 depicts the water balance at MEA during the third quarter of 2024 when maximum production and restoration flows will occur (5,400 gpm and 1,800 gpm, respectively). As illustrated in **Figure 3.12-2**, process bleed during maximum production and operation will be approximately 65 gpm, with up to an additional 250 gpm RO bleed of disposal capacity needed to accommodate groundwater restoration. DDWs are expected to provide the majority of the disposal capacity needed at each expansion area. As has been demonstrated at the CPF, DDW injection rates may be greater than the assumed 45 gpm per well at the MEA site.

Until the capacity of the first two DDWs is known, the exact needs for additional water disposal beyond 2020 is not understood. Additional disposal options required for use during production and restoration activities will be dependent on both the volume of wastewater generated, degree of wastewater generation minimization through maximizing the efficiency of production and restoration activities including the RO process, and the actual injection capacity of DDWs (e.g., surge/evaporation ponds and/or land application).

For the years 2015 through 2020, two DDWs will be used. Each DDW can act as a backup for the other if maintenance is required. At the same time, plant operations can be curtailed as needed to ensure that an inward hydraulic gradient is maintained. A third option would be trucking water to the CPF evaporation ponds.

In the event of an extended total facility shutdown (e.g., power failures), the ability to maintain hydraulic containment of the wellfields has be assessed. This analysis demonstrated that hydraulic containment of the ISR wellfields could be provided using one or two wells (powered by portable generator) located near the downgradient edge of the MU wellfield, operating at a total pumping rate of 30 gpm. Groundwater extracted from the ISR wellfields would be either disposed of in an onsite DDW equipped with a portable generator, or trucked to the main CPF facility for disposal in the evaporation ponds.

In order to accomplish this analysis of being able to maintain hydraulic containment during an extended total facility shutdown, the following basic analyses were performed (Aqui-Ver 2013):

- The maximum velocity of groundwater under non-pumping conditions was calculated for the MEA ISR wellfields.
- A hypothetical pumping well was placed within an ISR wellfield and the zone of hydraulic containment (capture zone) was computed using an analytical groundwater flow model and particle tracking techniques. The well location and pumping rate were adjusted until an optimal capture zone was achieved.

Groundwater Velocity of the Basal Sandstone of the Chadron Formation

Under non-pumping conditions (e.g., facility shutdown, pre-development), the velocity of groundwater within the basal sandstone of the Chadron Formation (production aquifer) can be computed from Darcy's Law and a knowledge of aquifer properties and hydrologic data collected as part of the regional aquifer pumping test conducted at the MEA in May 2011 (Aqui-Ver 2011), as follows:

$$V = KI/ne$$ (Aqui-Ver 2011)

where V is the groundwater velocity, K is the hydraulic conductivity of the production aquifer, I is the baseline or pre-development hydraulic gradient, and ne is the aquifer effective porosity.

As a conservative measure, the maximum groundwater velocity was computed by using the maximum observed values for hydraulic conductivity (61.7 ft/day) and hydraulic gradient (0.00048) identified from baseline sampling and aquifer testing at the MEA. Using these aquifer properties and an estimated effective aquifer porosity of 0.2, the resulting maximum groundwater velocity of the production aquifer is approximately 0.15 ft/day (55 ft/year). It was concluded from this calculation that mining solutions from ISR operations would only migrate a very small distance over any reasonable period of time representing temporary facility shutdown.

ISR Wellfield Hydraulic Containment Analysis

Additional analyses were performed to demonstrate hydraulic containment can be maintained in the event of an extended facility shutdown. Because groundwater velocity is a maximum of 0.15 ft/day as previously described, hydraulic containment would essentially be provided without active remediation unless monitor wells were already on excursion status. Therefore, for purposes of this analysis, we have assumed a worst-case scenario in which downgradient monitor wells are on excursion status when the facility experiences a hypothetical temporary shutdown.

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To accomplish this task, an analytical groundwater flow model (ESI 1999) was used to simulate groundwater flow in the production aquifer at the MEA. Particle-tracking techniques were used to illustrate the zone of hydraulic containment (capture zone) produced by a hypothetical pumping well(s) placed within an ISR wellfield. MU 5 at the MEA was used for illustrative purposes in this analysis.

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The monitor well ring is assumed to be located 300 feet from the edge of the ISR wellfield pattern area (production zone), identical to the design used at the main Crow Butte ISR facility. Input parameters for the groundwater flow model were assigned in order to produce a conservatively small capture zone and provide a margin of safety, as follows:

Aquifer Transmissivity (T) – 2,469 ft^2/day (maximum observed from aquifer pumping test) (Aqui-Ver 2011)

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Regional Hydraulic Gradient (I) – 0.00048 (maximum observed from baseline monitoring) (Aqui-Ver 2011)

Effective Porosity – 0.2

Pumping Rate – 30 gpm

The zone of hydraulic containment was computed using reverse particle-tracking techniques after 30 days of pumping (zone will expand over time). **Figure 3.12-3** illustrates the zone of hydraulic containment produced by a single well placed near the downgradient edge of the MU 5 wellfield. The zone of hydraulic containment includes the entire ISR wellfield plus an adequate buffer zone. Although an adequate zone of containment is provided using a single well operating with a sufficiently large pump at 30 gpm, a similar zone of containment can be provided using two wells operating at 15 gpm each (30 gpm total) in the same general location and separated by approximately 300 feet (east-west) along the downgradient edge of the mine unit.

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The 30 gpm pumping rate is conservatively estimated based on maximum values of aquifer transmissivity and hydraulic gradient observed at the site. Under more realistic conditions (e.g. using average values for aquifer properties), the pumping rate needed to maintain hydraulic containment is significantly lower (10 gpm).

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These results are generally applicable to all MEA mine units. If multiple mine units are in operation at the time of the hypothetical shutdown, additional wells would be needed (e.g., one or two wells at a total rate of 30 gpm per mine unit) to maintain complete containment of multiple mine units.

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Historically, power outages at the CPF site last less than 24 hours. The longest time without power at the CPF was approximately 40 hours due to a winter storm. Potential adverse impacts associated with power outages are not anticipated.

CBR will ensure adequate DDW disposal capacity is available at each mine unit under normal operating conditions during production, production and restoration, and restoration phases described in this document. Such capacity demonstration will be phased, initially to address years 2015 through 2020 (with two DDWs), with additional demonstrations as needed in order to address future increases in production and restoration flows. Capacity demonstrations will be addressed in written procedures for NRC written verification prior to preoperational inspection (for years 2015 through 2020) and prior to construction of future mine unit expansions beginning in 2021.

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Cumulative impacts associated with the potential impacts on groundwater due to the concurrent operations of the CPF, MEA, NTEA, and TCEA projects are discussed in Section 4.14.

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3.12.2.3 Inspections

CBR will maintain an inspection program to routinely monitor the wastewater and other waste management systems, including containment berms, the DDWs, and associated structures and other assets used to manage wastes. Inspections will support the MEA operational procedures, including the SPCC Plan requirements. Monitoring will include daily, weekly, monthly, quarterly, and annual inspections. The inspection monitoring program will be a component of operating manuals of CBR's SHEQMS. The inspection procedures will be developed once final engineering design and construction drawings have been completed and approved by management.

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3.12.2.4 Potential Pollution Events Involving Liquid Waste

Although there are a number of potential sources of pollution present at the CPF, existing regulatory requirements from the NRC and NDEQ and provisions of the SHEQMS have established a framework that significantly reduces the possibility of a pollution incident. Extensive training of all personnel is standard policy at the existing CBR facility and will be implemented at the satellite facility. As discussed above, waste management facilities and systems will be inspected frequently. Detailed procedures are included in the SHEQMS, which will be adapted for use at the satellite facility.

Corrective action procedures needed to support existing procedures in the CBR's SHEQMS will be developed to address the most probable causes of potential releases/spills. The objective is to respond to such events as quickly as possible to minimize potential environmental damage or exposure to employees and the public. Some of the potential sources of liquid spills/releases that will be addressed include the following:

- Satellite processing facilities
- Wastewater tanks and associated piping
- DDWs and associated piping and equipment
- Trunklines to and from the wellfields to the satellite facility
- Wellhouse piping
- Wellfield piping and pumps
- Tanker trucks hauling process and waste liquids
- Trucks hauling loaded and eluted resin to and from the CPF

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3.12.2.5 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. 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 initial placement into service. Piping from the wellfields will generally be buried, minimizing the possibility of an accident. In addition, the flows through the wellfield piping and manifold pressure gauges in the wellhouses are monitored 24 hours per day, 7 days per week by control room operators using visual and audible alarms. Flow monitoring systems will alarm in the event of a significant piping failure, which will allow flow to stop, preventing any significant migration of process fluids. Wellfield buildings will also be equipped with wet alarms for early detection of leaks.

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Satellite Facility

The satellite facility will serve as a central hub for the mining operations in the MEA. Therefore, the satellite facility carries 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 satellite facility building will be designed so 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 with a capacity equal to that 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, either from a spill or from washdown water, will be drained through a sump and sent to the liquid waste disposal system.

Deep Well Pumphouse and Wellhead

The deep well pumphouse and wellhead will be designed so 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.

Transportation Vehicles

The release of pollutants to the environment could occur due to accidents involving transportation vehicles. This could involve vehicles transporting IX resin to and from the satellite facility or the CPF or transporting radioactive contaminated waste from the satellite facility to an approved disposal site.

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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 the SHEQMS Volume VIII, Emergency Manual, to ensure a rapid response.

The uranium-loaded resin will be transported from the satellite facility to the CPF processing building in a specially designed, low-profile, 4,000-gallon capacity tanker trailer. The primary access route is approximately 30 miles (48.3 km) long, of which approximately 11.6 miles (18.7 km) are on county or private roads. The Alternate A access route is approximately 14 miles (22.5 km) long, with all of the roads being unpaved county and private roads. In the event of an accident, each resin transport vehicle will be equipped with an emergency contingency package whereby the driver could initiate 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 would be minimal. Finally, each resin transfer vehicle will be equipped with a radio for communications with the CPF. This allows quick response and implementation of the emergency response plan for transportation accidents.

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Spills and Contingency Plans

Spills can take two forms within an ISR facility. These are surface spills (e.g., tankage leaks, piping ruptures) and subsurface releases (e.g., well casing failure) resulting in a release of waste solutions.

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Engineering and administrative controls are in place at the CPF 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 satellite processing building to the wellfield and back. With the current CBR monitoring system, these releases are generally small, quickly discovered, and promptly mitigated.

In general, piping from the satellite facility to and within the wellfield will be constructed of HDPE with butt-welded joints or equivalent. All pipelines will be pressure-tested before final operation. A break in a buried section of line would be unlikely because no additional stress is placed on the pipes. In addition, underground pipelines will be protected from vehicles driving over the lines, which is the major cause of failure. Typically, the only exposed pipes will be at the satellite facility, at the wellheads, and in the wellhouses in the wellfield. Trunkline flows and manifold pressures will be monitored for spill detection and process control.

3.12.3 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 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 satellite facility is expected to include spent resin, resin fines, empty reagent containers, miscellaneous pipe and fittings, waste oil, out-of-date reagents, well drilling wastes, and domestic trash. Solid wastes will be classified as contaminated or non-contaminated waste according to survey results. The solid waste will be segregated based on whether it is clean or carries the potential for contamination with 11(e).2 byproduct materials. These non-hazardous wastes will be stored in appropriate containers prior to disposal by an approved off-site waste disposal facility.

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All exploration and development holes drilled in the MEA will be abandoned in accordance with the requirements of State of Nebraska Title 135, Chapter 5.002 and the Mineral Exploration Permit as approved by NDEQ. The Hole Plugging Plan is outlined in Attachment 2 of the approved Application for Mineral Exploration Holes for Mineral Exploration Permit NE#0210824 (NDEQ 2009).

Drill cuttings will be captured within earthen drill pits. Upon completion of the hole, the pits will be filled in and the dirt mounded to allow for subsidence. Later, topsoil will be applied and the site and any surface disturbance will be leveled to conform with the surrounding area.

The largest volume of solid wastes requiring disposal at the MEA site will be produced during facility decommissioning. Soils would be included in decommissioning surveys, and any soils exceeding NRC release limits at 10 CFR Part 40, Appendix A, Criterion 6 would be removed and disposed of as 11e.(2) byproduct waste. Proposed decommissioning and reclamation activities are discussed in Section 5.

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3.12.3.1 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 that are not contaminated or that may be successfully decontaminated. Release of contaminated equipment and materials is discussed further in Section 5.

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CBR has recently estimated that the CPF 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 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.

3.12.3.2 11(e).2 Byproduct Material

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

11(e).2 byproduct material generated at ISR facilities consists of filters, PPE, spent resin, piping, and other materials. CBR has recently estimated that the CPF produces approximately 60 to 90 yd^3 of 11(e).2 byproduct material waste per year. This estimate is based on the historical number of shipments to the licensed disposal facilities. CBR estimates that the proposed satellite facility would produce approximately 60 yd^3 of 11(e).2 byproduct materials per year. These materials will be stored on site until a full shipment can be shipped to a licensed waste disposal site or licensed mill tailings facility.

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CBR currently has a contractual agreement with Dension Mines (USA) Corp. (DUSA) for the disposal of 11e.(2) byproduct materials at DUSA's White Mesa Mill site located near Blanding, Utah (CBR and DUSA 2010). 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. See additional discussions of this contractual agreement in Section 5.1.4.3.

Additional discussions of solid wastes are presented in Section 4.13.2.3.

If decontamination is possible, surveys for residual surface contamination will be made prior to releasing the material. Decontaminated materials carry activity levels lower than those specified in NRC guidance (NRC 1987). An area will be maintained inside the restricted area boundary for storage of contaminated materials prior to their disposal.

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3.12.3.3 Septic System Solid Waste

Domestic liquid wastes from the restroom, toilets, lavatories, and a sink in the lunchroom/break area will be disposed of in an approved septic system that meets the requirements of the State of Nebraska. The satellite building will not have a laboratory. Solid materials collected in septic systems must be disposed of by companies or individuals licensed by the State of Nebraska. NDEQ regulations for control of these systems are contained in Title 124 (NDEQ 2010c).

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3.12.3.4 Hazardous Waste

The potential exists for any industrial facility to generate hazardous waste as defined by the RCRA. In the State of Nebraska, hazardous waste is governed by the regulations contained in Title 128 (NDEQ 2010d). Based on waste determinations conducted by CBR as required in Title 128, CBR is a CESQG. To date, CBR only generates universal hazardous wastes such as fluorescent light tubes, 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 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 the SHEQMS Volume VI, Environmental Manual, to control and manage these types of wastes.

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Table 3.1-1 Major Land Use Definitions

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Table 3.1-2 Present Major Land Use Within a 2.25-Mile (3.6-Km) Radius of the Proposed Marsland Expansion Area License Boundary

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Table 3.1-3 Present Land Use Within the Proposed Marsland Expansion Area License Boundary

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Table 3.1-4 Agricultural Yields for Croplands in Dawes County 2010

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Table 3.1-5 Livestock Inventory for Dawes County 2007

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Table 3.1-6 Recreational Facilities Within 50 Miles (80 km) of the Proposed Marsland Expansion Area

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Table 3.1-7 Distance to Nearest Residence and Site Boundary from Center of MEA for each Compass Sector

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Table 3.1-8 Uranium Recovery Activities in Region of Proposed Marsland Expansion Area

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Table 3.3-1 General Stratigraphic Chart for Northwest Nebraska

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Table 3.3-2 Representative Stratigraphic Section – Marsland Expansion Area

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Table 3.3-3 USGS Abbreviated Modified Mercalli (MM) Intensity Scale

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Table 3.3-4 Historical Earthquakes in Northwestern Nebraska in Close Proximity to the Chadron and Cambridge Arches (1884 – 2009)

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Table 3.3-5 Earthquakes in Wyoming and South Dakota Within 125 miles of City of Crawford, NE (1992 – 2009)

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Table 3.3-6 Summary of Soil Resources Within the MEA

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Table 3.4-1 USGS Estimated Water Use in Dawes County 2005

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Table 3.4-2 Summary of Non-Abandoned Registered Water Wells for Dawes County, Ne on File as of April 08, 2013

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Table 3.4-3 Active, Inactive and Abandoned Water Supply Wells in the MEA and 2.25-Mile Area of Review

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Table 3.4-4 Minimal Horizontal Distance Separating a Municipal Water Well from Potential Sources of Contamination

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Table 3.4-5 Stream Classification of Niobrara River Subbasin N14

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Table 3.4-6 Summary of 2011 Marsland Pumping Test #8 Well Information

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Table 3.4-7 Summary of 2011 Marsland Pumping Test Results

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Table 3.4-8 Summary of Marsland Pumping Test Results Compared to Previous Testing

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Table 3.4-9 Baseline and Restoration Values for Current Crow Butte Production Area Mine Unit 1

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Table 3.4-10 Baseline and Restoration Values for Current Crow Butte Production Mine Unit 2

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Table 3.4-11 Baseline And Restoration Values For Current Crow Butte Production Mine Unit 3

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Table 3.4-12 Anticipated Changes in Water Quality During Mining

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Table 3.5-1 Monthly Climate Summary for Scottsbluff WSO Airport, NE (257665)

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Table 3.5-2 Marsland Expansion Area Vegetation and Land Cover Types

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Table 3.5-3 Federal and State Threatened, Endangered, and Candidate Species with the Potential to Occur Within the Vicinity of the Marsland Expansion Area

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Table 3.6-1 Meteorological Stations Included in Climate Analysis

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Table 3.6-2 Annual and Monthly Temperature Statistics for Scottsbluff Airport, NE

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Table 3.6-3 Scottsbluff Airport Monthly Wind Parameters Summary

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Table 3.6-4 Scottsbluff Airport 15-Year Wind Frequency Distribution

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Table 3.6-5 Marsland Expansion Area Maximum, Minimum and Average Monthly Temperatures

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Table 3.6-6 Marsland Meteorological Summary

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Table 3.6-7 Marsland Expansion Area Meteorological Station

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Table 3.6-8 Marsland Expansion Area Wind Summary

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Table 3.6-9 Marsland Annual Joint Frequency Distribution

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Table 3.6-10 Marsland Winter Joint Frequency Distribution

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Table 3.6-11 Marsland Spring Joint Frequency Distribution

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Table 3.6-12 Marsland Summer Joint Frequency Distribution

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Table 3.6-13 Marsland Fall Joint Frequency Distribution

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Table 3.6-14 Marsland Onsite Meteorological Station Description

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Table 3.6-15 Rapid City Mixing Heights

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Table 3.6-16 EPA National Ambient Air Standards (NAAQS)

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Table 3.6-17 Nebraska and South Dakota Ambient Air Monitoring Network in Region of Marsland Expansion Area

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Table 3.6-18 Comparison of Ambient Particulate Matter (PM_{10}) Monitoring Data for Regional Monitoring Sites

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Table 3.6-19 PM_{10} Annual Average Monitoring Data for South Dakota Monitoring Sites

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Table 3.6-20 $PM_{2.5}$ Annual Average Monitoring Data for Regional Monitoring Sites

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Table 3.6-21 Comparison of Ambient Particulate Matter ($PM_{2.5}$) Monitoring Data for Regional Monitoring Sites

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Table 3.6-22 Comparison of Sulfur Dioxide Values for Wind Cave and Badlands, SD Monitor Sites

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Table 3.6-23 Comparison of Nitrogen Dioxide 1-Hour 98th Percentile Concentrations for Wind Cave and Badlands, SD

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Table 3.6-24 Comparison of Nitrogen Dioxide Annual Average Values for Wind Cave and Badlands, SD Monitor Sites

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Table 3.6-25 Ozone Yearly 4th Highest 8-Hour Averages for Regional Monitoring Sites [a, b]

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Table 3.6-26 Prevention of Significant Deterioration (PSD) of Air Quality Allowable Increments

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Table 3.9-1 Scenic Quality Inventory and Evaluation for the Marsland Expansion Area

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Table 3.9-2 Determining BLM Visual Resource Inventory Classes

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Table 3.10-1 Historical and Current Population Change for Counties and Cities within 80 Km of Marsland Expansion Area 1970-2010

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Table 3.10-2 Population by Age and Sex for Counties within the 80-Km Radius of the Marsland Expansion Area 2010

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Table 3.10-3 Population Projections for Counties within an 80-Km Radius of the Current Crow Butte Project Area 2000-2020

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Table 3.10-4 2010 Population within an 80-Km Radius of the Marsland Expansion Area

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Table 3.10-5 Annual Average Labor Force and Employment Economic Sectors for Dawes and Box Butte Counties 1994 and 2009

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Table 3.10-6 Population and Demographics for Census Blocks Overlain or Adjacent to the MEA with Populations Recorded in 2010 Census

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Table 3.11-1 Crow Butte Resources Excursion Summary

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Table 3.12-1 Deep Disposal Well No. 1 Injection Radiological Data for Crow Butte Central Processing Facility (2008 - 2012)

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Table 3.12-2 Deep Disposal Well No. 2 Injection Radiological Data for Crow Butte Central Processing Facility (2012)

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Table 3.12-3 Deep Disposal Well Injection Non-radiological Data for Current Crow Butte Operations 2012

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Figure 3.1-1 Marsland Expansion Area Land Use

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Figure 3.1-2 Aerial Photo Depicting Location of Rural Residences and Other Land Features in the Area of Review

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Figure 3.1-3 Marsland Expansion Area Location of Gravel Pits and Oil/Gas Test Holes

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Figure 3.3-1 Bedrock Geology Map of the Three Crow Expansion Area

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Figure 3.3-2 Marsland Cross-Section Map Showing Artificial Penetrations

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Figure 3.3-3a Marsland Structural Cross Section A – A'

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Figure 3.3-3b Marsland Structural Cross Section B – B'

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Figure 3.3-3c Marsland Structural Cross Section C – C'

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Figure 3.3-3d Marsland Structural Cross Section D – D'

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Figure 3.3-3e Marsland Structural Cross Section E – E'

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Figure 3.3-3f Marsland Structural Cross Section F – F

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Figure 3.3-3g Marsland Structural Cross Section G – G

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Figure 3.3-3h Marsland Structural Cross Section H – H

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Figure 3.3-3i Marsland Structural Cross Section I – I

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Figure 3.3-3j Marsland Structural Cross Section J – J

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Figure 3.3-3k Marsland Structural Cross Section K – K

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Figure 3.3-31 Marsland Structural Cross Section L – L

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Figure 3.3-3m Marsland Structural Cross Section M – M

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Figure 3.3-3n Marsland Structural Cross Section N – N

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Figure 3.3-4 Marsland Expansion Area Type Log (M-1252)

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Figure 3.3-5 Marsland Isopach Map - Arikaree Formation

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Figure 3.3-6 Marsland Isopach Map - Brule Formation

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Figure 3.3-7 Marsland Isopach Map - Upper Chadron Formation

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Figure 3.3-8 Marsland Isopach Map - Middle Chadron Formation

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Figure 3.3-9 Marsland Isopach Map - Basal Sandstone of the Chadron Formation

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Figure 3.3-10 Marsland Structure Map - Top of Pierre Shale

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Figure 3.3-11 Location of Chadron Arch and Cambridge Arch in Nebraska

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Figure 3.3-12 Structural Features Map of the Crawford Basin

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Figure 3.3-13 Regional Structure Contour Map – Top of Pierre Shale

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Figure 3.3-14 Earthquake Hazard Ranking in the U.S.

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Figure 3.3-15 Seismic Hazard Map for Nebraska (2008)

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Figure 3.3-16 Seismicity of Nebraska 1990-2006

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Figure 3.3-17 Soils

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Figure 3.4-1 Nebraska's Major River Basins

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Figure 3.4-2 Niobrara River Basin (and Subbasins)

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Figure 3.4-3 Niobrara River Subbasin N14

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Figure 3.4-4 Marsland Expansion Area Surface Water Sampling Locations

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Figure 3.4-5 Mirage Flats Project, Nebraska

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Figure 3.4-6 Major Surface Features/Structures Within AOR as per Title 122, Chapter 11, Section 006.09

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Figure 3.4-7 Private Wells Located within 1 and 2 Kilometers of the MEA License Boundary

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Figure 3.4-8 Marsland Expansion Area Pumping Test Well Locations

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Figure 3.5-1 Wetland and Vegetation

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Figure 3.5-2 Wildlife Map

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Figure 3.6-1 Marsland Project Met Stations

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Figure 3.6-2 Scottsbluff AP Monthly Temperatures

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Figure 3.6-3 Scottsbluff AP Seasonal Diurnal Temperature Variations

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Figure 3.6-4 Regional Annual Average Minimum Temperatures

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Figure 3.6-5 Regional Annual Average Maximum Temperatures

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Figure 3.6-6 Monthly Relative Humidity Statistics for Scottsbluff AP

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Figure 3.6-7 Diurnal Variation in Relative Humidity for Scottsbluff by Season

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Figure 3.6-8 Scottsbluff AP Monthly Average Precipitation

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Figure 3.6-9 Regional Monthly Average Precipitation

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Figure 3.6-10 Scottsbluff AP Monthly Snowfall

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Figure 3.6-11 Regional Monthly Average Snowfall

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Figure 3.6-12 Regional Annual Average Precipitation

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Figure 3.6-13 Regional Annual Average Snowfall

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Figure 3.6-14 Scottsbluff AP 15-Year Wind Speeds

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Figure 3.6-15 Scottsbluff AP 15-Year Wind Rose

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Figure 3.6-16 Scottsbluff AP Diurnal Wind Speeds by Season

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Figure 3.6-17 Scottsbluff AP Cooling, Heating, and Growing Degree Days

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Figure 3.6-18 Scottsbluff AP Potential Evapotranspiration

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Figure 3.6-19 Marsland Expansion Area Monthly Temperatures

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Figure 3.6-20 Marsland Expansion Area Wind Rose

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Figure 3.6-21 Marsland Expansion Area Seasonal Wind Roses

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Figure 3.6-22 Marsland Expansion Area Diurnal Wind Speeds

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Figure 3.6-23 Marsland Expansion Area Wind Speed Distribution

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Figure 3.6-24 Project Area Monthly Average Wind Speeds

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Figure 3.6-25 Marsland Expansion Area Monthly Precipitation

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Figure 3.6-26 Marsland Expansion Area Potential Monthly Evapotranspiration

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Figure 3.6-27 Scottsbluff 15-Year Vs Baseline Year Wind Roses

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Figure 3.6-28 Scottsbluff 15-Year Vs Baseline Year Wind Directions

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Figure 3.6-29 Scottsbluff 15-Year Vs Baseline Year Wind Speeds

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Figure 3.6-30 Scottsbluff 15-Year vs Baseline Year Wind Speed Distributions

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Figure 3.6-31 Scottsbluff 15-Year Vs Baseline Year Wind Direction Distributions

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Figure 3.6-32 Location of Regional Ambient Air Monitoring Sites

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Figure 3.10-1 Significant Population Centers within an 80-Km (50 Mi) Radius of the Marsland Site

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4 ENVIRONMENTAL IMPACTS

The objective of the mining and environmental monitoring program is to conduct an economically viable and environmental responsible operation. The environmental monitoring programs used to ensure that the potential sources of land, water, and air pollution are controlled and monitored are presented in Section 6.

This section discusses and describes the degree of unavoidable environmental impacts, the short- and long-term impacts associated with operations, and the consequences of possible accidents at the CPF and the MEA.

4.1 Land Impacts

4.1.1 Land Surface Impacts Associated with Construction

CBR has developed plans for the development of the site based largely on the knowledge on the size of the ore body (depth, width, and length) and U_3O_8 content arrived at through exploration and delineation work at the MEA site.

It is estimated that a total of approximately 1,753 acres could be affected over the life of the MEA Project. Estimates of acreages have been provided in **Table 4.1-1** for the currently planned facilities as well as potential additional acreages that may be developed in the future (based on current knowledge of the ore body).

Approximately 591 acres will be required for the currently planned facilities, which consist of the satellite building and associated facilities (1.8 acres), the two DDWs (1.0 acre), access roads to the satellite facility and DDWs (1.7 acres), and 11 MUs (587.6 acres). The number of acres associated with roadways located within the MUs is included in the total MU acreage estimates. The number of acres of different types of habitat cover estimated to be impacted by the current planned construction activities are presented in **Table 4.1-1**.

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Based on the current knowledge of the MEA ore body, it has been estimated that 1,162 acres in addition to the 591 acres may be impacted over the life of the project. Estimates of the additional number of acres of different types of habitat cover that may be affected are shown in **Table 4.1-1**. As shown, the major type of habitat that would be affected is mixed-grass prairie, which makes up approximately 65 percent of the total 1,753 acres. The 1,753 acres will include cropland (128.4 acres) and livestock range (1,370.7 acres [1,142.7 acres mixed-grass prairie and 228 acres degraded rangeland]). The entirety of this approximately 1,753 acres may be dedicated to the project's needs over the life of the project. Using the assumptions above, construction activities over the life of the project could result in the loss livestock production of approximately $55,376.

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Currently planned site preparation and construction associated with the MEA satellite facility will include the following:

- Construction of a satellite process facility located approximately 11.0 miles (17.7 km) south-southeast of the CPF. This satellite facility will be housed in a building approximately 130 feet long by 100 feet wide and will contain IX and associated equipment capable of processing 6,000 gpm of production flow and 1,500 gpm of restoration flow
- Placement of a modular office building

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- Construction of chemical storage facilities and other support facilities
- Construction two DDWs for disposal of wastewater
- A deep well injection building and associated facilities
- Access roads, as required
- Construction of 11 wellfields

Site preparation and construction will include activities such as topsoil salvage, building erection, foundation installation, some contouring, trenching, and access road construction.

Environmental impacts of construction of the satellite facility are estimated in this section with mitigation measures discussed in Section 5. The impacts are also projected based on experience with the current operation and those that have been associated with this type of construction at the Crow Butte project over the past 17 years of commercial operation by CBR.

As stated above, currently planned construction of the satellite facility will require disturbance of an estimated 591 acres for the satellite facility and support facilities such as 11 MUs, DDWs, and road improvements. Of this total, approximately 2.3 acres will be associated with the satellite facility and DDWs, plus 1.7 additional acres of access roads. Surface disturbances will include construction of access roads, facility site grading, construction of DDWs, and contouring for control of surface runoff. All areas disturbed will be reclaimed during final decommissioning/reclamation/reclamation. The planned timeline for construction, production, restoration, and decommissioning was presented in Section 1.1.3.2.

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

Due to the relatively minor nature of disturbances created by ISR mining and the lack of evaporation ponds, no areas will be disturbed to the extent that subsoil and geologic materials are removed, causing significant topographic changes that need backfilling and recontouring. 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.

These surface impacts are unavoidable and will last for the duration of the project until final decommissioning. Mitigation measures for land surface impacts are discussed in Section 5.

4.1.2 Land Use Impacts of Construction and Operations

The principal land uses for the approximately 591 acres (**Table 4.1-1**) associated with the currently planned 11 MUs, processing facility, DDWs, and access roads consist primarily of cropland (71.7 acres) and livestock range (491.2 acres [347.6 acres of mixed grass prairie and 143.6 acres of degraded rangeland]). The entirety of this approximately 591-acre area will be

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dedicated to the project's needs over the 1-year construction period. As presented previously, livestock and livestock products carry a value of $40.40 per acre, while non-livestock lands carry a value of $13.61 per acre (NASS 2009). Based on this information, and assuming all available and suitable acreage within the MEA is currently employed to its greatest efficiency and effect, construction activities in the MEA would result in the lost livestock production of approximately $19,845 per year, and the lost production of crops valued at $976 per year. The exclusion of agricultural activities from this area during construction would not have a significant impact on local agricultural production due to the small size of land taken out of production; construction and operation would not have a significant impact on landowners due to the payment of royalties and leases, which will offset the losses from the land being removed from agricultural production.

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The principal land uses for the MEA and the 2.25-mile (3.6 km) AOR is grazing livestock and raising of crops. Rangeland accounts for 82.6 percent of the land use in the MEA and surrounding 2.25-mile (3.6 km) AOR as discussed in Section 3.1.2. The secondary land use within the MEA license boundary is cropland, which accounted for 8.9 percent of the land use in the MEA and the AOR. Land use was discussed in detail in Section 3.1.

For the proposed disturbance of 591 acres for the proposed MUs, satellite facilities, 11 MUs, and roadways, cropland accounts for 71.7 acres or 12.2 percent of the 591-acre total area. Rangeland accounts for 491.2 acres or 83.0 percent of the total area. Rangeland rehabilitation (6.9 acres), structural biotope (8.9 acres), forest land (5.6 acres), and drainage (7.3 acres) are the only other impacted land uses. **Table 4.1-1** provides the acres disturbed by the MEA satellite facility, MUs, and access routes, and **Figure 3.1-1** shows the land use for the MEA AOR.

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As a result of site preparation and construction, cattle production will be excluded from the areas under development. The total estimated area that will be impacted during the course of the currently planned project is the 491.2 acres (mixed-grass prairie and degraded rangeland) associated with the satellite facility, wellfields, and roads. As discussed in Section 3.1.2.1, livestock and livestock products had a value of $40.40 per acre, indicating that livestock production on impacted rangeland within the MEA has a potential value of approximately $19,845.

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As a result of site preparation and construction, crop production will be excluded from the areas under development. The total estimated cropland area that will be impacted during the course of the project is 71.7 acres associated with the satellite facility, wellfield, and roads. As presented previously, non-livestock lands carry a value of $13.61 per acre. Based on this information, the lost production of crops would be valued at $976 per year.

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Considering the relatively small size of the area impacted by operations, the exclusion of agricultural activities from this area over the course of operation will not significantly impact local or regional agricultural production. The limited impacts are considered temporary and reversible by returning the land to its former grazing use through post-mining surface reclamation.

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The current operations in the licensed area have shown that CBR can successfully restore the land surface following mining operations. Surface reclamation activities, including contouring and revegetation, have been performed routinely following initial MU construction. Additionally, CBR recently completed surface and subsurface reclamation of a significant portion of MU 1 following approval of groundwater restoration. These areas have been successfully recontoured, and revegetation has been completed in accordance with NDEQ requirements.

4.2 Transportation Impacts

4.2.1 Access Road Construction Impacts

Access roads will need to be constructed from the existing transportation corridors to the satellite facility. The main access roads will be designed to allow safe access from public roads by employees, contractors, and delivery vehicles. The 2010 average daily traffic counts for a segment of SH 2/71 near Marsland at the southern end of the MEA was 675 total vehicles, including 90 heavy commercial vehicles. Traffic levels on SH 2/71 increase to 695 total vehicles, including 90 heavy commercial vehicles in the vicinity of E. Belmont Road (NDOR 2010). Secondary and private roads connect with E. Belmont Road, River Road, Hollibaugh Road, and Squaw Mound Road to provide access to residences and agricultural lands within the MEA. The limited additional traffic related to the MEA operation will not significantly affect these routes.

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Access to the MEA site will be primarily via existing roads, with approximately 0.43 mile (0.69 km) of a new gravel road on site (Hollibaugh Road to the satellite building). The main access route to the MEA is via SH 2/71 west of Marsland, then east along Niobrara Street and River Road, and then north on either Squaw Mound Road or Hollibaugh Road (**Figure 1.4-1**). As noted in Section 3.2, Nebraska SH 2/71 and U.S. Highway 20 converge at Crawford. Nebraska SH 2/71 lies to the west of the MEA (**Figure 1.4-1**).

Road access impacts associated with air emissions and fauna and wildlife are discussed in Sections 4.6 and 4.5.4, respectively.

The junction of the BNSF and DM&E Railroads is located in the City of Crawford. No railways cross the MEA 2.25-mile (3.6 km) AOR. This rail line accommodates a significant amount of rail traffic, primarily from the coal mines in northeastern Wyoming.

The proposed project will have no impact on railroad operations in the area.

4.2.2 Transportation of Materials

Transportation of materials to and from the satellite facility is discussed in the following sections.

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4.2.2.1 Shipments of Construction Materials, Process Chemicals, and Fuel from Suppliers to the Site

Shipments of construction materials, process chemicals, and fuel from suppliers will be received at the satellite facility. These shipments will generate additional noise in the area as discussed in Section 3.7. Because the site access roads will be surfaced with gravel, the shipments will also generate additional dust. Air quality impacts and mitigation are discussed in Sections 4.6 and 5.5.

Based on the current production timeline and material balance, it is estimated that approximately 150 bulk chemical and fuel deliveries per year will be made to the satellite facility. This averages about one truck per working day for delivery of fuel and chemicals throughout the operational life of the project. Types of deliveries include CO_2, O_2, soda ash, propane, and motor vehicle fuel.

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Additionally, wellfield construction materials will be received periodically throughout the operational phase of the project. These shipments are expected to occur at a frequency of once per month.

4.2.2.2 Shipment of 11(e)2 Byproduct Material from the Site to a Licensed Disposal Facility

Low-level radioactive waste or unusable equipment contaminated with 11(e)2 byproduct material will be generated during operations and will be transported to a licensed disposal site. Because of the low volume of radioactive 11(e)2 byproduct material generated, these shipments will be infrequent (averaging two per year if using roll-off containers).

11(e)2 byproduct material shipments will be handled as Low Specific Activity (LSA) material. All shipments will comply with all applicable DOT and NRC regulations governing the transportation of this material.

4.2.2.3 Shipments of Uranium-laden Resin from the Marsland satellite facility to the CPF and Return Shipments of Barren, Eluted Resin from the CPF back to the Marsland satellite facility

Resin will be transported to and from the satellite facility in a 4,000-gallon capacity tanker truck. It is currently anticipated that one load of uranium-laden resin will be transported to the CPF for elution and one load of barren, eluted resin will be returned to the satellite facility daily. The transfer of resin between the two sites will occur on a portion of SH 2/71, country roads, and private roads. CBR has established a Primary Access Route and Alternative Routes A and B (**Figure 1.4-1**). The total miles for the Primary Access Route between the two sites will be 30 miles (48.3 km), with 11.6 miles (18.7 km) on unpaved county and private roads. The Alternative Route A is approximately 14 miles (22.5 km) long, with all of the roads being unpaved county and private roads. Alternative Route B is approximately 24.7 miles (39.7 km) long (approximately 14.8 miles [23.8 km] on SH 2/71 and approximately 9.9 miles [15.9 km] on unpaved county and private roads).

The Primary Access Route will be used unless weather conditions or some other unforeseen event (weather, roads closed, etc.) occurs that would cause the use of Alternative Route A or B. It is currently estimated that the Primary Access Route will be utilized approximately 99 percent of the time and Alternative Route A or B less than 1 percent of the time. Alternative Route B would be preferred over Alternative Route A since there are fewer unpaved roads and less potential for generation of roadway dust.

A discussion of the impacts of air particulate emissions due to vehicles traffic on the access routes is presented in Section 4.6.2

Resin or eluate shipments will be treated similar to 11(e)2 byproduct material shipments in regards to DOT and NRC regulations. Shipments will be handled as LSA material for both uranium-laden and barren eluted 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 NRC regulations will be the primary determining factor.

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4.2.2.4 Impacts to Public Roads

The additional traffic generated by construction and operation of the proposed MEA may result in degradation of public road surfaces. In particular, the additional traffic may adversely impact local gravel roads maintained by Dawes County. These impacts are expected to be minimal because the additional traffic is not significant in comparison with current traffic levels.

Mitigation measures for impacts to public roads are discussed in Section 5.2.

4.3 Geologic Impacts

4.3.1 Geologic Impacts

Geologic impacts are expected to be minimal, if any. No significant matrix compression or ground subsidence is expected, as the net withdrawal of fluid from the basal sandstone of the Chadron Formation will be on the order of 1 percent or less, and the anticipated drawdown over the life of the project is expected to be on the order of 10 percent of the available head or less. Further, once mining and restoration operations are completed and restoration approved, groundwater levels will return to near original conditions under a natural gradient. No faults are present within the project area that would be subject to potential reactivation due to fluid injection.

Impacts to paleontological resources due to operations are expected to be minimal.

4.3.1.1 Soil Impacts

Soils in the MEA are typically shallow to deep silt loams and loamy very fine sands. Consequently, wind and water erosion pose the most significant risks to soil health and productivity, especially where vegetation has been disturbed. A detailed discussion of the soils characteristics are presented in Section 3.3.1.6.

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Construction of the facilities at the MEA will affect soils. With proper implementation of BMPs, effects to soils are not expected to be significant within the MEA. Operational impacts to soils are expected to be minor, and would only occur if BMPs and mitigation measures are not properly constructed, maintained, and monitored. Improper surfacing of access roads could lead to rutting and erosion. The severity of soil impacts would depend on the number of acres disturbed and the type of disturbance. Potential impacts include soil loss, sedimentation, compaction, salinity, loss of soil productivity, and soil contamination. Effects to soils at the MEA would result from the clearing of vegetation, excavating, leveling, stockpiling, compacting, and redistributing soils during construction and reclamation. Disturbance related to the construction and operation of the MEA would continue until the area is revegetated.

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Wind erosion is possible at the MEA. Hazards for wind erosion are generally high to moderately high within the proposed MUs. These soils have one or more major constituents that are fine sand or sandy loam that can easily be picked up and spread by wind. Construction presents the greatest threat to soils with potential for wind erosion. Wind erosion will be controlled by removing vegetation only where necessary, avoiding clearing and grading on erosive areas, surfacing roads with locally obtained gravel, and timely reclamation. Many soils meet the criteria for high wind erosion hazard (NRCS 1977).

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Water erosion is also possible at the MEA, especially in areas disturbed by road and wellfield construction. Various soils within the MEA meet the criteria for severe water erosion hazard. Removal of vegetation for any activity exposes soils to increased erosion. Excavation could break down soil aggregates, increasing runoff and gully formation. Soil loss will be reduced substantially by avoiding highly erosive areas such as badlands and steep drainages. Locating roads in areas where cuts and fills would not be required, surfacing roads with gravel, installing drainage controls, and reseeding and installing water bars across reclaimed areas will also aid in reducing soil loss.

Assessments of the potential for flooding or erosion potential that could impact the proposed ISR mining processing facilities and MUs was performed for the MEA. The results of this study are discussed in Section 1.3.2.13. The complete reports, including tables and figures, are provided in **Appendices K-1 and K-2** (ARCADIS 2012, ARCADIS 2013). The studies addressed guidance in RG-1569 for an NRC licensee to assess the potential effects of erosion or surface water flooding on a proposed ISR facility. The ultimate objective of the MEA studies was to determine whether the potential for erosion or flooding may require implementation of special design features or mitigation measures. The results of these studies will be used for further analysis, mitigation measures, or modification of location of surface facilities, including well locations during the final engineering phase and prior to well installation and construction activities.

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Sedimentation in streams and rivers at the MEA could result from soil loss. Sedimentation could alter water quality and the fluvial characteristics of area drainages. Installation of appropriate erosion control measures as required by CBR's Construction Stormwater NPDES authorization (see Section 4.4.1) and avoidance of erosive soils will aid in reducing sedimentation.

Activity on the site has the potential to compact soils. Soils sensitive to compaction do exist on the site. Compaction of the soils could decrease infiltration and promote higher runoff. Construction and traffic will be minimized where possible, and soils will be loosened prior to reseeding during reclamation to control the effects of soil compaction.

Any soil on the site can be saline depending on site-specific soil conditions, such as permeability, clay content, quality of nearby surface waters, plant species, and drainage characteristics. Saline soils are extremely susceptible to soil loss caused by development. Soil erosion in areas with high salt content would contribute to salinity in the Niobrara River. Reclamation of saline soils can be difficult, and no method that works in all situations has yet been found.

Facility development would displace topsoil, which would adversely affect the structure and microbial activity of the soil. Loss of vegetation would expose soils and could result in a loss of organic matter in the soil. Excavation could cause mixing of soil layers and breakdown of the soil structure. Removal and stockpiling of soils for reclamation could result in mixing of soil profiles and loss of soil structure and productivity. Off-road travel could lead to unforeseen vegetation removal, soil compaction, and localized soil loss due to wind and water erosion. Therefore, off-site travel will be minimized to the extent possible.

A number of erosion and productivity problems resulting from the MEA may cause a long-term declining trend in soil resources. Long-term impacts to soil productivity and stability would occur as a result of large-scale surface grading and leveling until successful reclamation is accomplished. Reduction in soil fertility levels and reduced productivity would affect diversity of

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re-established vegetative communities. Moisture infiltration would be reduced, creating soil drought conditions. Vegetation would undergo physiological drought reactions.

Surface spillage of hazardous materials during construction or operations could occur at the MEA. If not remediated quickly, these materials have the potential to adversely impact soil resources. In order to minimize potential impacts from spills, a Spill Prevention, Control, and Countermeasure (SPCC) Plan will be implemented. The SPCC plan will include accidental discharge reporting procedures, spill response, and cleanup measures.

Soil Impact Mitigation Measures

BMPs have been included in the project description and will be followed to control erosion, minimize disturbance, and facilitate reclamation. The following mitigation measures will be valuable in reducing the effects to soil resources at the MEA. BMPs and mitigation measures relevant to soil resources are also discussed in the water quality and reclamation sections of this document. Fundamentally, efforts will be made to preserve existing vegetation where practical.

Sediment Control

- Divert surface runoff from undisturbed areas around the disturbed area.
- Retain sediment within the disturbed area.
- Do not direct surface drainage over the unprotected face of the fill.
- Operations and disturbance on slopes greater than 40 percent need special sediment controls and should be designed and implemented appropriately.
- Avoid continuous disturbance that provides continuous conduit for routing sediment to streams.
- Inspect and maintain all erosion control structures.
- Repair significant erosion features, clogged culverts, and other hydrological controls in a timely manner.
- If BMPs do not result in compliance with applicable standards, modify or improve such BMPs to meet the controlling standard of surface water quality.

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Topsoil

- Topsoil should be removed prior to any development activity to prevent loss or contamination.
- When necessary to substitute for or supplement available topsoil, use overburden that is equally conducive to plant growth as topsoil.
- To the extent possible, directly haul (live handle) topsoil from site of salvage to concurrent reclamation sites.
- Avoid excessive compaction of topsoil and overburden used as plant growth medium by limiting the number of vehicle passes, handling soil while saturated, and scarifying compacted soils.
- Time topsoil redistribution so seeding or other protective measures can be readily applied to prevent compaction and erosion.

Roads

- Restrict the length and grade of roadbeds.
- Surface roads with durable material (i.e., locally obtained native gravel).
- Create cut and fill slopes that are stable.
- Revegetate the entire road prism including cut and fill slopes.
- Create and maintain vegetative buffer strips, and construct sediment barriers (e.g., straw bales, wire-backed silt fences, check dams) during the useful life of roads.

Regraded Material

- Design regraded material to control erosion using activities that may include slope reduction, terracing, silt fences, chemical binders, seeding, mulching, and other activities.
- Divert all surface water above regraded material away from the area and into protected channels.
- Shape and compact regraded material to allow surface drainage and ensure long-term stability.
- Concurrently reclaim regarded material to minimize surface runoff.

Implementation of the above BMPs, SPCCs, and SWPPPs will minimize effects to soils associated with the construction of the satellite facility.

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4.4 Water Resources Impacts

4.4.1 Surface Water Impacts of Construction

When stormwater drains off a construction site, it can carry sediment and other pollutants that can potentially harm lakes, streams, and wetlands. The EPA estimates that 20 to 150 tons of soil per acre is lost every year to stormwater runoff from construction sites. For this reason, stormwater runoff may need to be controlled by the NDEQ NPDES regulations.

Construction activities at the CBR project to date have had a minimal impact on the local hydrological system. CBR conducts construction activities under NDEQ permitting regulations for control of construction stormwater discharges contained in Title 119 (NDEQ 2005). CBR is required by NDEQ General Construction Stormwater NPDES Permit NER 100000 to implement procedures that control runoff and the deposition of sediment in surface water features during construction activities. These procedures are contained in the SHEQMS Volume VI, Environmental Manual and require active engineering measures, such as berms, and administrative measures, such as work activity sequencing to control runoff and sedimentation of surface water features. CBR must annually submit a construction plan for the coming year and obtain authorization from the NDEQ under the general permit.

Administrative and engineering controls implemented by CBR during initial site preparation and construction of the satellite facility and related facilities are expected to ensure that surface water impacts are minimal.

4.4.2 Surface Water Impacts of Operations

4.4.2.1 Surface Water Impacts from Sedimentation

Protection of surface water from stormwater runoff during ongoing wellfield construction related to operations is regulated by the NDEQ as discussed in Section 4.4.1.

4.4.2.2 Potential Surface Water Impacts from Accidents

Surface water quality could potentially be impacted by accidents such as failure or an uncontrolled release of process liquids due to a wellfield accident. Section 4.4.1 discussed the measures to prevent and control wellfield spills. Wellfield areas are installed with dikes or berms as an additional measure to protect surface water. The berms prevent surface spills from entering all surface water bodies and drainages that connect to surface water bodies and eliminate public dose and contaminant pathways to surface water.

The satellite building will have secondary containment (curbing around the structure) to contain any accidental spills or releases of contaminated fluids. This will eliminate the potential for such discharges to the adjoining groundwater surface and potential contamination of the surrounding soils and the Brule Formation. In addition, there is a regular program of inspections and preventive maintenance. Furthermore, it is expected that surface water impacts from potential accidents at the satellite facility and related facilities will be minimal.

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4.4.3 Groundwater Impacts

Potential impacts to water resources from mining and restoration activities include the following:

4.4.3.1 Groundwater Consumption

Groundwater impacts and consumption related to the satellite facility operation will be fully assessed in an Industrial Groundwater Permit application required by NDNR (application to be submitted following NDEQ approval of the MEA Class III UIC permit). Information from the existing Groundwater Permit for the current license area indicates that the drawdown from mining operations in the basal sandstone of the Chadron Formation is minimal (e.g., on the order of 10 percent of the available head). Based on drawdown data from years of operation in the current license area, and on the formation characteristics from the MEA Pumping Test, the drawdown effect on the Chadron aquifer as a result of operations has been and is expected to remain minimal.

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Groundwater consumption from the operation is expected to be on the order of 0.5 to 2.0 percent of the total mining flow (6,000 gpm). Consumptive volume (1,500 gpm) will increase during aquifer restoration, especially during the groundwater sweep phase. However, it is expected that in peak years net consumption for the entire operation will be on the order of 300 to 320 gpm.

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A simple hydrologic drawdown-distance analysis, using the Theis (1935) equation for confined aquifers, was conducted by CBR to estimate the drawdown at the MEA (assumptions presented in **Appendix W**. The analysis used the water balance disposal estimate for the year 2024, which corresponds to the tenth year of operations. The year 2024 in the Marsland water balance is the year when the highest consumptive ground water is assumed. The analysis assumes that four mine units are in restoration with an estimated 250 gpm of consumptive water use, and five mine units are in production with a bleed stream of 65 gpm. The total consumptive water use estimated for that year is 315 gpm. The 315 gpm consumptive water use represents the worst case water for water use during the operation of the MEA.

The drawdown analysis of the MEA estimates that the drawdown during worst case year of operation is approximately thirty feet in the areas where active restoration is occurring. The estimated drawdown is about 6 to 7 percent of the total head available. The static water level at Marsland is about 465 ft. and the expected water level during the tenth year of operations is estimated to be 435 ft. The draw down in the basal sandstone of the Chadron Formation. at the monitor well ring. is approximately 15 ft and the worst case drawdown at the edge of the 2.25 mile review area will be about 2 ft. As such. this analysis of the MEA is in reasonable agreement with the actual operating data from the CBR Mine.

A review of the private wells within a 2.25-mile radius of the MEA found that all of the registered wells and nonregistered wells, where data was available, were not completed in the basal sandstone of the Chadron Formation (Section 3.4.1.2). All of the known well completions are completed in the overlying Brule and Arikaree formations. because the wells are much shallower (60' to 300') than the basal sandstone of the Chadron Formation (1000 ft +). and the water quality of the overlying formations is superior to the basal sandstone of the Chadron Formation. Further. the pumping test demonstrated the integrity of the confining layer that separates the aquifer in the basal sandstone of the Chadron Formation from the overlying aquifers.

4.4.3.2 Potential Declines in Groundwater Quality

Excursions represent a potential effect on the adjacent groundwater as a result of operations. During production. injection of the lixiviant into the wellfield results in a temporary degradation of water quality in the exempted aquifer compared to pre-mining conditions. Movement of this water out of the wellfield into the monitor well ring results in an excursion. Excursions of contaminated groundwater in a wellfield can result from an improper balance between injection and recovery rates, undetected high permeability strata or geologic faults, improperly abandoned exploration drill holes, discontinuity and unsuitability of the confining units which allow movement of the lixiviant out of the ore zone, or poor well integrity.

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To date, there have been several confirmed horizontal excursions in the basal sandstone of the Chadron Formation in the current license area. These excursions were quickly detected and recovered through overproduction in the immediate vicinity of the excursion. In the majority of the excursions, the reported vertical excursions were actually due to natural seasonal fluctuations in Brule groundwater quality and very stringent UCLs. In no case did the excursions threaten the water quality of an underground source of drinking water because the monitor wells are located well within the aquifer exemption area approved by the EPA and the NDEQ. **Table 3.11-1** summarizes the excursions reported for the current license area.

The subsurface interval composed of the Lower Dakota, Morrison, and Sundance Formations has been identified as the DDW Injection Zone at the MEA. The subsurface geologic characteristics beneath the MEA will prevent disposal fluids injected into the Injection Zone from impacting the overlying fresh water aquifers (i.e.. Brule and Chadron Formations). Between the lowermost Chadron Formation and the Injection Zone are more than 2.500 feet of sediments primarily consisting of low permeability shale. This separating aquitard protects against vertical migration

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of injected fluids to the overlying Brule and Chadron Formations. Shales above and below the Injection Zone will encase the disposal fluids within the receiving formations, and no structural elements with the potential to disrupt the natural vertical containment have been identified. The primary groundwater supply in and near the MEA is the Brule Formation, typically encountered at depths from approximately 30 to 200 feet below land surface, with the exception of locations where the overlying alluvium is not present. In general, the static water level for the Brule Formation wells in the MEA ranges from 50 to 150 feet below land surface, depending on local topography. The estimated concentrations of TDS within the Injection Zone are in excess of 10,000 milligrams per liter (mg/L). No harmful or reactive incompatibility between the formation brine and the waste constituents are expected.

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CBR has satisfactorily operated a Class I DDW at the nearby CBR CPF facility since 1994 without any adverse impacts. A second DDW well was approved and placed into operation in fourth quarter of 2011.

4.4.3.3 Potential Groundwater Impacts from Accidents

Groundwater quality could potentially be impacted during operations due to an accident such as an uncontrolled release of process liquids due to a wellfield accident. If there should be a wellfield accident, potential contamination of the shallow aquifer (Brule), as well as surrounding soil, could occur. Wellfield accidents could take the form of a slow leak or a catastrophic failure, a shallow excursion, an overflow due to excess production or restoration flow, or due to the addition of excessive rainwater or runoff.

The satellite building will have curbing around the structure to contain any accidental spills or releases of contaminated fluids. This will eliminate the potential for such discharges to the adjoining groundwater surface and potential contamination of the surrounding soils and the Brule Formation.

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The DDWs will receive wastewater from wastewater tanks located in the satellite processing facility via an underground PVC/HDPE pipeline. Flow rates from the tankage, tank levels, and flowrates are all controlled and monitored to ensure any potential leakage is rapidly detected. All flows and pressures will have limits and alarms programmed in to alert the operator as limits are approached and to control feed pumps. The details of these systems will be addressed in the Class I permit application that will be submitted to the NDEQ as part of the required permitting process. CBR has successfully operated a Class I DDW for approximately 19 years without any significant spills or releases.

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Another potential cause of groundwater impacts from accidents could be releases as a result of a spill of injection or production solutions from a wellfield building or associated piping. To control these types of releases, all piping is either PVC, HDPE with butt-welded joints, or equivalent. All piping is leak-tested prior to production flow and following repairs or maintenance.

4.5 Ecological Resource Impacts

4.5.1 Impact Significance Criteria

The following impact significance criteria were used to determine the significance of construction and operation of the proposed project on wildlife and vegetation resources within the project area. These criteria were developed based on professional judgment, involvement in other NEPA projects throughout the West, and state and federal regulations:

- Removal of vegetation such that, following reclamation, the disturbed area(s) would not have adequate cover (density) and species composition (diversity) to support pre-existing land uses, including wildlife habitat;
- Unauthorized discharge of dredged or fill materials into, or excavation of, waters of the U.S., including special aquatic sites, wetlands, and other areas subject to the Section 404 of the Clean Water Act, Executive Order 11988 - flood plains, and Executive Order 11990 - wetlands and riparian zones;
- Reclamation is not accomplished in compliance with Executive Order 13112 - Invasive Species;

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- Introduction and establishment of noxious or other undesirable invasive, non-native plant species to the degree that such establishment results in listed invasive, non-native species occupying any undisturbed rangeland outside of established disturbance areas or hampers successful revegetation of desirable species in disturbed areas;
- A substantial increase in direct mortality of wildlife caused by road kills, harassment, or other causes;
- Incidental take of a special status species to the extent that such impact would threaten the viability of the local population;
- Elimination or permanent reduction in size of an officially designated critical wildlife habitat, or otherwise rendering such habitat unsuitable;
- Any effect, direct or indirect, resulting in a long-term decline in recruitment and/or survival of a wildlife population; and
- Construction disturbance during the avian breeding season or impacts to reproductive success which could result in the incidental loss of fertile eggs or nestlings, or otherwise lead to nest abandonment, which would violate the regulations prescribed by the MBTA.

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4.5.2 Vegetation

As described in detail in Section 3, a total of 11 wellfields, a satellite facility, and access roads will be constructed in 2014 with an expected mine life of operation of approximately 7 years. As shown on **Figure 3.5-1**, wellfield development will occur primarily in areas dominated by mixed-grass prairie and degraded rangeland vegetation.

Vegetation removal and soil handling associated with the construction and installation of wellfields, pipelines, access roads, and satellite facilities would affect vegetation resources both directly and indirectly. Direct impacts would include the short-term loss of vegetation (modification of structure, species composition, and areal extent of cover types) due to soil disturbance and grading activities. Indirect impacts would include the short-term and long-term increased potential for non-native species invasion, establishment, and expansion; exposure of soils to accelerated erosion; shifts in species composition and/or changes in vegetative density; reduction of wildlife habitat; and changes in visual aesthetics.

The total number of acres currently identified as having the potential for disturbance within the 4,622.3-acre permit area over the long-term operation of the project will be approximately 1,753 acres (**Table 4.1-1**). Initially, the construction of the satellite building(s)/associated facilities, MU 1, and necessary roadways would result in short-term surface disturbances of approximately 78 acres (approximately 2 percent of the total permit boundary acreage). The production building and associated facilities would disturb an area of 1.8 acres (area containing the production facilities). **Table 4.1-1** provides a breakdown of the area of disturbance by the type of habitat cover acreage.

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Over the life of the project, it is currently estimated that 38 percent of total permit area acreage would be disturbed due to site development and operation. The likelihood of impact is greatest for the primary vegetation cover types of mixed-grass prairie (1,143 acres) and degraded rangeland (228 aces), which occupy approximately 78 percent of the total acreage with the potential for disturbance (1,753 acres). Mixed-grass prairie and degraded rangeland habitat cover (1,143 and 228 acres, respectively) account for 25 percent and 5 percent, respectively, of the total permit acreage of 4,622.3 acres. There are no plans to disturb the deciduous streambank forest habitat cover type within the permit boundary; other cover types would be subject to minor amounts of disturbance (**Table 4.1-1**).

The majority of new roads are located within proposed wellfields. A new access road will serve as the entrance roadway to the satellite production facility and offices. Estimated acreage disturbance was based on a 25-foot wide entrance road and 12-foot wide MU roads. Road locations and distances are illustrated on **Figure 1.4-1**.

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The proposed DDWs will be located to the northwest of the satellite facilities (**Figure 1.1-7**) located within mixed-grass prairie habitat consisting of an area of approximately 50 x 50 feet. Potential impacts from the DDWs are considered minimal, based on the operating history of the DDW located at the current CBR operating facilities.

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Construction activities, increased soil disturbance, and higher traffic volumes could stimulate the introduction and spread of invasive, non-native species within the MEA. Non-native species invasion and establishment as a result of previous and current disturbance has become an increasing concern in western states. These species often out-compete desirable species, including special status species, rendering an area less productive as a source of forage for livestock and wildlife. Additionally, sites dominated by invasive, non-native species often have a different visual character that may negatively contrast with surrounding undisturbed vegetation. Currently, the MEA has a relatively high level of noxious weeds and other unwanted invasive, non-native species in the areas adjacent to roads, but to a lesser degree in areas located farther from roads.

In general, the duration of effects on cultivated agricultural land and mixed-grass prairie vegetation are significantly different. Cropland areas can be readily returned to production through fertilizer treatments and compaction relief. However, disturbed native prairie tracts require reclamation treatments and natural succession to return to pre-disturbance conditions of diversity (both species and structural). Reestablishment of mixed-grass prairie to pre-disturbance conditions would be influenced by factors that are both climatic (growing season, temperature, and precipitation patterns) and edaphic (physical, chemical, and biological) conditions in the soil.

Previously planted agricultural fields would be recontoured to approximate pre-existing contours and ripped to depths of 12 to 18 inches to relieve compaction. Mixed-grass prairie tracts disturbed by surface activities would be completely reclaimed. Reclamation of mixed-grass prairie would generally include: (1) complete cleanup of the disturbed areas (wellfields and access roads); (2) restoring the disturbed areas to the approximate ground contour that existed before construction; (3) replacing topsoil, if removed, over all disturbed areas; (4) ripping disturbed areas to a depth of 12 to 18 inches; and (5) seeding recontoured areas with a locally adapted, certified weed-free seed mixture.

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4.5.3 Surface Waters and Wetlands

Dooley Spring, Willow Creek, and other ephemeral features are the only potentially available surface waters within the MEA. These features lack defined banks and have no streambed. Generally, these features are dry, and they would only be expected to carry water during exceptional precipitation events. Direct disturbance to these features would take place where they would be crossed by access roads. This would occur in several locations, including one location along the main access road to the satellite facility. Culverts will be installed below each road crossing to maintain natural flows. Therefore, there would not be any long-term direct impacts on the integrity of any of the drainages within the MEA.

The Niobrara River is a perennial stream located downstream of the MEA; this river could potentially be indirectly affected by changes in water quality or quantity. Water quantity would not be changed by the proposed project. Hydrologic analysis completed for this project indicates that the MEA generally carries a low potential for erosion (and therefore a low potential for sediment delivery to the Niobrara River). However, there are some small, localized areas within the MEA that carry a moderate to high erosion potential. If wells cannot be placed outside of areas within the wellfields deemed to carry moderate to high erosion risks, mitigation measures (e.g., berms) will be implemented to minimize the potential for flooding and erosion. The mitigation measures will be defined during final engineering and prior to any construction. As a result of these mitigation measures, sediment delivery to the Niobrara River will be negligible.

One wetland site was identified by HWA (2012) within the MEA. This wetland is located outside of the area proposed for disturbance. Therefore, no direct impacts to wetlands are anticipated. Additionally, the potential for sedimentation of wetlands within and near the MEA is anticipated to be minimal due to mitigation measures that would be implemented to reduce erosion risk.

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4.5.4 Wildlife and Fisheries

The effects on wildlife would be associated with construction and operation of project facilities, which include displacement of individuals of some wildlife species, loss of wildlife habitats, and an increase in the potential for collisions between wildlife and motor vehicles. Other potential effects include a rise in the potential for poaching, harassment, and disturbance of wildlife because of increased human presence primarily associated with increased vehicle traffic. The magnitude of impacts to wildlife resources would depend on a number of factors, including the time of year, type and duration of disturbance, and species of wildlife present.

4.5.5 Big Game Mammals

The principal wildlife impacts likely to be associated within the proposed project include: (1) a direct loss of elk, deer, and pronghorn habitat; (2) the displacement of these big game species; (3) an increase in the potential for collisions between wildlife and motor vehicles; and (4) an increase in the potential for poaching and harassment of wildlife.

Direct removal of habitat used by big game mammals would include 1,143 acres of mixed-grass prairie. Small amounts of drainage (31.2 acres), mixed conifer (194.6 acres), and range rehabilitation (7.1 acres) cover types would also be removed. Because mixed-grass prairie would be the primary vegetation type affected, the proposed project would be more likely to affect big game species that primarily inhabit grassland vegetation (e.g., pronghorn) than big game species that primarily inhabit shrubland, forested, or riparian areas (e.g., elk, deer). The amount of habitat disturbed would decline over time as construction areas not needed for the production phase were reclaimed to their pre-existing contours and vegetation type. Overall, direct loss of habitat would have a minor, short- to long-term impact on big game species using the MEA.

In addition to the direct removal of habitat due to the development of wells and associated satellite facilities, disturbances from drilling activities, and traffic would affect wildlife use of the habitat immediately adjacent to these areas. Big game habitat would effectively be reduced by an amount greater than the disturbance footprint acreage, because big game would avoid a wider area than just the infrastructure itself. Big game mammals may adjust their ranges or seasonal migration routes slightly to avoid the new source of disturbance on the landscape. This could result in reduced herd productivity if animals have to expend more energy to travel between seasonal ranges or if adjacent habitats are not of a similar or higher quality to the habitats lost or cannot absorb the additional individuals. If avoidance responses extend out to 0.5 mile (0.8 km) beyond the MEA, this would equate to 1.8 percent of the overlapping elk herd unit, 0.5 percent of the overlapping deer herd unit, and 0.5 percent of the overlapping pronghorn herd unit being affected by the proposed project.

However, big game mammals are adaptable and may adjust over time to non-threatening, predictable human activity. In addition, the magnitude of displacement would decrease over time as: (1) the animals have more time to adjust to the operational circumstances; and (2) the extent of the most intensive activities such as drilling and road building diminishes and the wellfield is put into production. By the time the wellfield is under full production, construction activities will have ceased, and traffic and human activities in general would be greatly reduced. As a result, this impact over the long term would be minimal, and it is unlikely that big game mammals would be permanently displaced under full field development. The level of big game mammal use of the project area is more likely to be determined by the quantity and quality of forage available. Forage would be restored once disturbed areas were reclaimed.

The potential for vehicle collisions with big game mammals would increase as a result of increased vehicular traffic associated with the presence of construction crews and would continue (although at a reduced rate) throughout all phases of the wellfield operations. To minimize the potential for wildlife collisions, drivers would be required to follow posted speed limits. Development of new roads would allow greater access to more areas and may lead to an increased potential for poaching of big game animals. Vehicle collision impacts and poaching of big game mammals are anticipated to occur infrequently, and no long-term adverse effects on populations are expected.

Based on the foregoing, long-term adverse effects are not expected on any local big game mammal populations.

4.5.6 Carnivores and Small Mammals

The direct disturbance of wildlife habitat in the MEA likely would reduce the availability and effectiveness of habitat for a variety of common small mammals and their predators. The initial phases of surface disturbance and noise would result in some direct mortality to small mammals and avoidance of the area by carnivore species that are more sensitive to human disturbance. In addition, a slight increase in mortality from increased vehicle use of roads in the area would be expected.

Carnivores and small mammals inhabiting the mixed-grass prairie and degraded rangeland vegetation types would be more affected by direct habitat loss than carnivores and small mammals inhabiting other vegetation types in the MEA. The temporary disturbances expected to occur during the construction period would tend to favor generalist wildlife species that are relatively tolerant of human activity, such as ground squirrels and striped skunks, and would have more impact on species that are relatively sensitive to human activity, such as mountain lions. Because of the high reproductive potential of small mammals, they would rapidly repopulate reclaimed areas as habitats become suitable. The initial phases of surface disturbance would result in some direct mortality and displacement of small mammals from construction sites. Quantifying these changes is not possible because population data are lacking. However, the impact is likely to be low, and the high reproductive potential of these small mammals would enable populations to quickly repopulate the area once reclamation efforts are initiated. No black-tailed prairie dog colonies are located within or near the proposed disturbance area, so there would not be any impacts on this species.

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Bats have a lower reproductive potential than other small mammals, so the removal of bat roost sites, maternity colonies, or hibernacula could have an adverse effect on local bat populations. However, the majority of habitat that would be affected by the proposed project is open, mixed-grass prairie, which is not generally suitable for bat roosting. There would be 194.6 acres of impact to any forested habitat (mixed conifer), and no deciduous streambank forest (the most likely bat roosting habitat in the MEA) would be affected.

4.5.7 Passerines and Upland Game Birds

Impacts to passerines would include short- and long-term habitat loss, primarily for birds using mixed-grass prairie habitat, and an effective loss of habitat extending beyond the disturbed areas if birds avoid the project facilities due to noise or activity. These effects are likely to attenuate with time as construction areas are reclaimed to the original habitat and as human activity decreases after the construction period ends. Generalist species that are more tolerant of human activity (e.g., mourning doves) are likely to be least affected by the proposed project, while specialist species that are more sensitive (e.g., grasshopper sparrows) may be affected more. Overall, given the reclamation practices that would be put into place, the minimal long-term surface footprint of the project, and the measures that would be taken to avoid impacting nesting birds, impacts on passerines are anticipated to be minor and not significant at the population level for any species.

The potential effects of the operation and maintenance of project facilities on upland game birds may include direct mortality of eggs or nestlings (if construction were to take place during the nesting season), habitat loss, and nest abandonment and reproductive failure caused by project-related disturbance and increased noise. Other potential effects on upland game birds involve increased public access and subsequent human disturbance that could result from new construction and production activities. These effects will attenuate with time as areas no longer needed for the project are reclaimed and human activity decreases after the construction phase.

No sharp-tailed grouse leks are known to occur within the project area. However, noise related to drilling and production activities may affect sharp-tailed grouse use of leks and/or reproductive success. Reduction of noise levels in areas near leks would minimize this potential impact. If leks are found, surface disturbance will be avoided within 0.25 mile (0.4 km) of leks. If disturbance activities within the 0.25-mile (0.4 km) lek buffer areas are avoided, no impacts are expected. Areas with large tracts of mixed-grass prairie would provide the best quality nesting habitat, 1,143 acres of which would be directly affected by the proposed project. Some of this area would be reclaimed once no longer needed for the production phase. To protect sharp-tailed grouse nesting habitats, construction activities will be limited within a 1-mile (1.6 km) radius of an active lek between March 1 and June 30. Significant impacts to leks and subsequent reproductive success are not expected if these guidelines are implemented.

4.5.8 Raptors

As noted in Section 3.5.7.3, seven raptor nests were observed within the MEA boundary during the 2011 field survey. The potential impacts to raptors within the MEA include: (1) direct loss of nesting habitat; (2) disturbance to nesting raptors from noise and activity and reduction in nest productivity; (3) temporary reductions in prey populations; and (4) mortality associated with roads.

The proposed project would result in the loss of 1,337 acres of potential raptor nesting habitat in the MEA over the life of the project, which includes mixed-grass prairie and mixed conifer vegetation types. Over time, some of this habitat would be restored through reclamation of areas no longer needed for production. Overall, long-term habitat losses would be minor. The development of proposed wellfield pads and satellite facilities would disturb an estimated 1,143 acres of mixed-grass prairie, a potential habitat for several species of small mammals that serve as prey items for raptors. This impact would affect approximately 8 percent of the total project area, although this is not likely to be a limiting factor of raptor use within this area. The small amount of short-term change in prey base populations created by the construction activities is minimal in comparison to the overall status of the rodent and lagomorph populations. While prey populations would likely sustain some impact during the initial phase of the project, prey numbers would be expected to soon rebound to pre-disturbance levels following reclamation or active agricultural uses. Once reclaimed or in active agricultural uses, these areas would likely promote an increased density and biomass of small mammals comparable to those of undisturbed areas. For these reasons, implementation of the project is not expected to produce any appreciable long-term negative changes to the raptor prey base within the MEA.

There will be no new public roads constructed. However, there will be increased traffic due to site operations on current county roads. As use of the project area increases, the potential for encounters between raptors and humans would increase and could result in increased disturbance to nests and foraging areas. Closure to public vehicle use for roads located near active raptor nests would offset this potential impact. Some raptor species feed on road-killed carrion on and along the roads, while others (owls) may attempt to capture small rodents and insects that are illuminated in headlights. These raptor behaviors put them in the path of oncoming vehicles, where they are in danger of being struck and killed. The potential for such collisions would be reduced by requiring drivers to follow all posted speed limits.

4.5.9 Reptiles and Amphibians

The primary impacts on reptiles and amphibians would include 1) direct mortality of individuals during the construction period; 2) ongoing mortality of individuals from increased vehicle traffic; 3) short- and long-term loss of terrestrial habitats; and 4) changes in water quality in aquatic habitats.

The proposed project has the potential to result in the direct mortality of individual reptiles and amphibians that use terrestrial habitats where construction will take place. Quantifying these changes is not possible because population data are lacking; however, once construction was completed and human activity greatly reduced, the potential for direct mortality would decrease significantly. Mortality could also result from increased vehicle traffic on project roads. This would be a long-term affect but is not likely to result in population-level changes to any amphibian or reptile species.

There would be 1,143 acres of habitat loss for amphibians and reptiles that use native grassland habitats, and 194.6 acres of habitat loss for amphibians and reptiles that use coniferous habitats. Reptiles and amphibians may also use degraded rangeland, drainages, and range rehabilitation habitats in the MEA, of which 228 acres, 31.2 acres, and 7.1 acres would be lost, respectively. Some of the construction areas would be reclaimed when no longer needed and could then be re-populated by reptiles and amphibians. Long-term loss of both terrestrial and aquatic habitats would be minimal overall. As described in Section 4.5.3, mitigation measures would be used to minimize impacts on surface waters that may be used by reptiles and amphibians, and there would be no direct loss of wetland habitats that could serve as amphibian breeding sites.

4.5.10 Fish and Macroinvertebrates

Suitable habitat for fish and macroinvertebrates exists within the Niobrara River and its tributaries. Fish and macroinvertebrates in the Niobrara River could be affected by reductions in water quality as a result of upstream activities. Construction activities could result in runoff carrying sediment into surface waters downstream of the MEA. As discussed in Section 4.5.3, the potential for this to occur is low, given the low erosion potential of most the MEA and the mitigation measures that would be implemented for the limited areas of moderate to high erosion potential.

4.5.11 Threatened and Endangered Species

Black-footed Ferret

Because there are no known black-footed ferret populations in Nebraska, impacts to this species are highly unlikely. Also, there is no suitable habitat for this species (black-tailed prairie dog colonies) within the proposed disturbance area.

Whooping Crane

No impacts to whooping cranes are anticipated to occur as a result of the proposed project because suitable migration stopover habitat is not present within the MEA.

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Gray Wolf

Gray wolves are highly unlikely to occur in the MEA; therefore, impacts on this species would be highly unlikely. If dispersing gray wolves were to pass through the vicinity, these individuals would likely avoid the area due to anthropogenic noise and activity.

Swift Fox

Because swift fox are known to occur within the region, and suitable mixed-grass prairie habitat occurs throughout the MEA, potential impacts to this species may result from project implementation. Construction activities within these mixed-grass prairie habitats could affect potential swift fox denning and foraging habitats. Destruction of swift fox dens could result in direct mortality of adults or pups. If swift fox are denning in the immediate vicinity of a planned project facility, construction activities may displace adults away from the den, at least during daytime periods of construction. Displacement could prevent the adults from securing adequate food for pups or prevent adults for adequately caring for their young. In addition, vehicular traffic associated with the construction and operation of project facilities could result in vehicle collisions resulting in direct mortality.

Because the potential for the mortality and/or displacement of swift fox from construction and operational activities exists within mixed-grass prairie, mitigation measures will be implemented to avoid and/or reduce such incidents. Prior to beginning construction activities in suitable swift fox habitat, CBR will have qualified biologists perform surveys for swift fox dens, and avoidance measures will be implemented to protect any dens that are located. Surveys will be conducted that are consistent with the NGPC standard protocol included in the CBR Mineral Exploration Permit Number NE0210824 as Attachment 1, issued by the NDEQ on August 19, 2009. The procedures set forth in Attachment 1 are specific to drilling of boreholes; therefore, these procedures have been expanded to include MEA project development activities (e.g., construction, operational activities [e.g., wellfield development, satellite facility facilities, and access roadways] and decommissioning). The modified survey protocol to be used for the swift fox in the MEA is presented in **Appendix O** of Volume II of this application.

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Based upon the analysis of the effects of project implementation and the current and potential status of this species in the MEA, it is concluded that the proposed project and planned mitigation measures will result in no adverse population-level effects on the swift fox.

Fish

Three state-listed fish species (the blacknose shiner, northern redbelly dace, and finescale dace) may occur downstream of the MEA and therefore may be affected by the proposed project. No direct effects to these species are anticipated because they do not occur within the MEA.

However, indirect effects may include changes in water quality of the Niobrara River associated with upstream activities. As discussed in Section 4.5.3, the potential for sediment delivery to the Niobrara River is low given the low erosion potential of most of the MEA and the mitigation measures that would be implemented for the limited areas of moderate to high erosion potential.

4.5.12 Cumulative Impacts

Significant cumulative impacts to ecological resources are not anticipated, as no substantive impairment of ecological stability or diminishment of biological diversity within the MEA is expected to occur as a result of the proposed project. The project would add to the effects of other past, present, and future activities occurring in the region, including the effects of other past, present, and future uranium mining operations. When combined with these other activities, the MEA would have minor cumulative effects on ecological resources. The most substantial of these effects would be the loss of 1,143 acres of mixed-grass prairie habitat. However, because the overall long-term surface footprint of the project would be minimal, and much of the area proposed for disturbance during the construction phase would be promptly reclaimed to the pre-existing contour and cover type, long-term loss of mixed-grass prairie habitat would have a minor impact on regional ecological resources. Similarly, disturbance to wildlife from noise and activity would initially have a minor cumulative impact on the region's wildlife. This impact would diminish over time as human presence decreases after the construction phase is completed.

4.6 Air Quality Impacts

4.6.1 Air Quality Impacts of Construction

The relatively dry air in the MEA region, combined with seasonal high temperatures and wind extremes, create the potential for airborne dust from wellfield construction activities and traffic on unpaved roads. Under these conditions, it is expected that air quality will be impacted in the immediate vicinity of the proposed project over the short term. However, based on historical experience, overall construction activities at the satellite facility are expected to cause minimal effects on local air quality.

Effects to air quality would be increased by the addition of fugitive dust generated from vehicular traffic on unpaved roads (in addition to existing fugitive dust caused by wind erosion) and diesel emissions from construction equipment. Application of water (as necessary) to unpaved roads would reduce the amount of fugitive dust. Diesel emissions from construction equipment are expected to be short-term only, ceasing once the operational phase begins. NRC estimated fugitive dust emissions during the construction phase of uranium ISR operations are to be less than 2 percent of the NAAQS for $PM_{2.5}$ and less than 1 percent for PM_{10} (NRC 2009).

There will be an increase in the total suspended particulates (TSP) in the region as a result of construction of the satellite facility. This increase will be greatest during the site preparation phase of the satellite facility. Revegetation will be performed where possible to mitigate the problems associated with the resuspension of dust and dirt from disturbed areas. All areas disturbed during construction will be revegetated with the exception of facility pad areas, roads, and parking/storage areas. Of these, the most significant source of TSP is dust emissions from unpaved roads.

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Specific regulatory issues associated with air quality impacts of operation are discussed in Section 4.6.3.

4.6.2 Air Quality Impacts of Operations

The primary new emission source of non-radiological fugitive dust will be from re-entrained dust from vehicle travel on paved and unpaved roads. Fugitive dust emissions would be generated by activities such as onsite traffic related to operations and maintenance, employee traffic to and from the site, resin transfers from the satellite facility to the main CPF, and traffic delivering supplies to the site and product from the site.

Particulate matter with a diameter of ten micrometers (PM_{10}) was estimated using equations from EPA's AP 42, Fifth Edition, Volume I, Chapter 13: Miscellaneous Sources, Sections 13.2.2.2 (EPA 2006) and 13.2.1.3 (EPA 2011).

For this analysis, PM_{10} from tailpipe emissions are estimated using On Road Emission Factors from California ARB EMFAC2002 Scenario Year 2004 (Model Year A11965 to 2004). These emissions are expected to be minor and should not affect the local ambient air quality. Tailpipe emissions would also include NO_x, CO, SO_2, and non-methane-ethane VOCs which are not estimated in this analysis.

The project will be located in a NAAQS attainment area for all criteria pollutants. The operations of the satellite facility are not expected to result in significant amounts of fugitive dust emissions, and would therefore not be considered a major source of emissions under state permitting regulations.

4.6.2.1 Particulate Emissions During Operations

The amount of dust, as PM_{10}, generated from traveling on unpaved roads during operations can be estimated from the following equations taken from AP 42, Fifth Edition, Volume I, Chapter 13: Miscellaneous Sources (13.2.2.2 equations 1a and 1b). While both equations 1a and 1b provide a PM emission factor for unpaved roads, the difference is based on whether the road is within an industrial site or accessible to the public.

$$E = k\,(s/12)^a\,(w/13)^b \qquad (1a)$$

$$E = \frac{k\,(s/12)^a\,(S/30)^b}{(M/0.5)^c} - C \qquad (1b)$$

where k, a, b, c and d are empirical constants given below and

E = size-specific emission factor (lb/VMT)

s = surface material silt content (%)

W = mean vehicle weight (tons)

M = surface material moisture content (%)

S = mean vehicle speed (mph)

C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear.

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The constants for Equations 1a and 1b are taken from Tables 13.2.2-2 and 13.2.2-4, where:

k = 1.5 lb/VMT(equation 1a) and k = 1.8 (equation 1b)

a = 0.9 (equation 1a) and a= 1 (equation 1b)

b = 0.45 (equation 1a)

c = 0.2 (equation 1b)

d = 0.5 (equation 1b)

C= 0.00047 (equation 1b)

Surface material silt content is estimated at 10 percent by using the stone quarrying and processing mean average from Table 13.2.2-1 (EPA 2006). Mean vehicle weight is estimated at an average of 5.5 tons per vehicle based on estimated weights of 2 tons for employee and contractor vehicles, 5 tons for delivery vehicles and 40 tons for resin transfer trucks. Resin transfer trucks make up approximately 3 percent of the vehicle traffic. Mean vehicle speeds are estimated at 30 miles per hour on paved roads. Surface moisture content is estimated at 13 percent based on Table 13.2.2-3 (EPA 2006).

Onsite Emissions

Onsite emissions are generated within the project boundaries. Fugitive dust emissions generated within the project boundaries are calculated by estimating vehicle miles traveled (VMTs) within the MEA and the CPF. The roads located within the MEA and CPF boundaries are unpaved. Equation 1a from 13.2.2.2 (EPA) is used to calculate an emission factor for vehicles traveling on unpaved surfaces at industrial sites. Calculations are for PM_{10}

The total travel on unpaved within the project boundaries for personnel, resin transfer, deliveries and incidental travel will be approximately 22,854 miles per year. This is based on the following assumptions:

- 12 employees and 7 contractors arriving at the MEA and traveling 1.22 miles round trip (RT) daily
- 10 employees traveling both within the CPF (1.34 miles RT daily) and the MEA (1.22 RT miles daily)
- 7 delivery trucks (50 per week) traveling within the MEA (1.22 RT miles daily)
- 2 resin trucks traveling both within the CPF (1.34 miles RT daily) and the MEA (1.22 RT miles daily)

Equations 1a and 1b emission factors can be extrapolated to annual average uncontrolled conditions (but including natural mitigation) under the simplifying assumption that annual average emissions are inversely proportional to the number of days with measurable (more than 0.254 mm [0.01 inch]) precipitation (EPA 2006) where:

E_{ext} = annual size-specific emission factor extrapolated for natural mitigation, lb/VMT

E = emission factor from Equation 1a or 1b

P = number of days in a year with at least 0.254 mm (0.01 in) of precipitation

Onsite Emission - Unpaved

With an emission factor of 1.27 lb per VMT there will be a total PM_{10} emission of approximately 14.5 tons per year, uncontrolled, as a result of increased traffic on unpaved roads onsite. Mitigation measures such as the application of water to unpaved roads will be implemented as necessary. Application of water as dust control would reduce the total PM_{10} emisisons. Assuming a 10% control efficiency with the application of water as dust control, total PM_{10} emissions would be approximately 13.05 tons per year, controlled.

For this analysis, PM_{10} from tailpipe emissions are estimate using On Road Emission Factors from California ARB EMFAC2002 Scenario Year 2004 (Model Year A11965 to 2004). Assuming 22,854 VMT per year onsite and assuming a worst case scenario that all vehicles are diesel-powered heavy duty trucks (using the All Model Year Diesel Powered Heavy Duty Trucks from California Climate Action Registry General Reporting Protocol, Version 3.1, January 2009, Table C.4), PM_{10} emissions are estimated at 11.86 pounds per year.

Off Site Emissions

Off site emissions are generated outside the project boundaries. Fugitive dust emissions generated outside the project boundaries are calculated by estimating VMTs from Crawford to the MEA and VMTs between the MEA and the CPF. The roads traveled outside the project boundaries are both paved and unpaved. Equation 1b from 13.2.2.2 (EPA 2006) is used to calculate an emission factor for vehicles traveling on publicly accessible roads, dominated by light duty vehicles on unpaved surfaces. Calculations are for PM_{10}. Equation 2 from 13.2.1.3 (EPA 2011) is used to calculate the quantity of particulate emissions from resuspension of loose material on the road surface due to vehicle travel on a dry paved road extrapolated to average uncontrolled conditions by application of a precipitation correction term. Calculations are for PM_{10}.

The total travel on paved and unpaved outside the project boundaries for personnel, resin transfer, deliveries and incidental travel will be approximately 713,780 miles per year. Unpaved VMTs (201,445) and paved VMTs (512,334) are based on the following assumptions:

- 12 employees and 7 contractors traveling from Crawford to the MEA (11.94 RT miles RT daily unpaved and 36.8 RT daily paved)
- 10 employees traveling between the MEA and the CPF (19.98 miles RT daily unpaved and 36.8 miiles RT daily paved)
- 7 delivery trucks (50 per week) traveling from Crawford to the MEA (11.94 RT miles daily unpaved and 36.8 miles RT daily paved)
- 2 resin trucks traveling between the MEA and the CPF (19.98 miles RT daily unpaved and 36.8 miles RT daily paved)

The number of VMT for resins trucks (assumed 5 tons) is reduced for offsite travel. Therefore, the mean vehicle weight is estimated at an average of 4.6 tons.

Offsite Emission - Unpaved

The emission factor is extrapolated to annual average uncontrolled conditions based on natural mitigation because of rainfall and other precipitation from equation (EPA 2006). Unpaved roads off site are graveled. Surface material silt content is estimated at 4.8% by using the sand and gravel processing mean average from Table 13.2.2-1 (EPA 2006).

With an emission factor of 0.29 lb per VMT for PM_{10} generated on public roads that are unpaved, there will be a total dust emission of approximately 29 tons per year, uncontrolled, as a result of increased traffic on unpaved roads off site. Mitigation measures such as the application of water to unpaved roads will be implemented as necessary. Application of water as dust control would reduce the total PM_{10} emissions. Assuming a 10% control efficiency with the application of water as dust control, total PM_{10} emissions would be approximately 26 tons per year, controlled.

Offiste Emission - Paved

The quantity of particulate emissions from resuspension of loose material on the road surface due to vehicle travel on a dry paved road may be estimated using the following empirical expression:

E_{ext} = [k (sL)0.91 x (W)1.02] (1 – P/4N) (equation 2 from 13.2.1.3)

where k, sL, W, and S are as defined in Equation 1 and

E_{ext} = annual or other long-term average emission factor in the same units as k

P = number of "wet" days with at least 0.254 mm (0.01 in) of precipitation during the averaging period

N = number of days in the averaging period (e.g., 365 for annual, 91 for seasonal, 30 for monthly).:

k = particle size multiplier for particle size range and units of interest

sL = road surface silt loading (grams per square meter) (g/m2), and

W = average weight (tons) of the vehicles traveling the road.

For PM_{10}, k is 0.0022 lb/VMT (Table 13.2.1-1) and the average weight of vehicles is estimated at 4.6 tons. Silt loading is estimated at 0.2 (Table 13.2.1.-2). The number of wet days is estimated at 85 on an annual basis (Figure 13.2.1-2). The number of days in the averaging period is 365.

With an emission factor of 0.0.0023 lb per VMT for PM_{10} generated on public roads that are paved, there will be a total dust emission of approximately 0.58 per year, uncontrolled, as a result of increased traffic on unpaved roads off site. Mitigation measures such as the application of water to unpaved roads would reduce annual emissions.

For this analysis, PM_{10} from tailpipe emissions are estimate using On Road Emission Factors from California ARB EMFAC2002 Scenario Year 2004 (Model Year A11965 to 2004). Assuming 713,780 VMT per year off site and assuming a worst case scenario that all vehicles are diesel-powered heavy duty trucks (using the All Model Year Diesel Powered Heavy Duty Trucks from California Climate Action Registry General Reporting Protocol, Version 3.1, January 2009, Table C.4), PM_{10} emissions are estimated at 373 pounds per year.

4.6.3 Criteria Pollutant Regulatory Compliance Issues

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The statements in this section apply to both construction and operations phases of the proposed satellite facility.

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The NAAQS for PM_{10} are 150 micrograms per cubic meter (µg/m^3; 24-hour average), and 50 µg/m^3 (annual average). The NAAQS standards for other pollutants are presented in **Table 3.6-16**. All counties within the 50-mile (80 km) radius of the project are in attainment of NAAQS. Concentrations of the criteria pollutants from the operations are not expected to exceed the regulated or "threshold" level for one or more of the NAAQS pollutants within the 50-mile (80 km) radius.

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In addition to the NAAQS, there are national standards for the PSD of air quality. The PSD program is administered by the States of Nebraska and South Dakota, with their programs designed to protect the air quality in area that are in attainment with the NAAQS and to prevent degradation of air quality in areas below the standard (designed as clean air areas). The PSD requirements establish allowable pollution "increments" that may be added to the air in each area while still protecting air quality. The increment is the maximum allowable deterioration of air quality. The maximum allowable increments applicable to Nebraska and South Dakota are shown in **Table 3.6-26.**

The allowable increments vary by location across the states. Those areas characterized as Class I (i.e., National Parks and Wilderness Areas) and allow less incremental pollution increase. Class III areas are planning areas set aside for industrial growth. Class II areas are essentially all other areas of the state not designated as Class I or Class III. There are no Class I National Park and Wilderness Areas in Nebraska. The State of South Dakota has two Class I Areas: Badlands and Wind Cave National Parks. The Wind Caves National Park is the closer of the two to the MEA, at a distance of approximately 60 miles (96.5 km). Therefore, due to the distances to the MEA project site, no impacts associated with PSD requirements at these sites would be expected based on the estimated amount of emissions from the MEA operations site.

4.7 Noise Impacts

4.7.1 Noise Impacts of Construction

The project area is surrounded by agricultural lands and rural residences. The existing ambient noise in the vicinity of the project area is dominated by intermittent noise from the BNSF rail line located approximately 1 mile (1.6 km) west of the MEA boundary at its closest point. Intermittent, low levels of traffic noise from Hollibaugh and River Roads and agricultural equipment also occur. These roads are used primarily to access local residences and agricultural lands. Nebraska SH 2/71 is located about 4.5 miles (7.2 km) west of the MEA boundary. Noise from BNSF trains on the rail line and traffic noise from the roads would be intermittently audible to receptors within and in close proximity to the MEA.

Increased vehicle travel and the operation of construction equipment at the satellite facility during the construction phase of the project would result in a slight increase in noise impacts to residents who live close to the MEA. Potential noise impacts from construction equipment are expected to occur primarily from operation of drilling rigs during wellfield development. Although noise levels associated with a typical water well drilling rig may reach or exceed 100 A-weighted decibels (dBA) within 6.6 feet (2 meters) of the rig compressor, noise levels decrease to less than 90 dBA within 20 feet (6 meters) (NRC 2009) and 55 dBA at 3,500 feet (1,067 meters) from the source (BLM 2005). Impacts to residences and other sensitive receptors 984 feet (300 meters) or more from the facility would be small (NRC 2009). One occupied residence, located within the

MEA, is approximately 656 feet (200 meters) from the proposed wellfield in MU 4. Construction noise impacts at this residence would likely be moderate. All other residences near the MEA boundary are more than 984 feet (300 meters) from the proposed wellfield.

Construction activities would typically occur over an 8-hour work day, 5 days per week. Noise from construction would not be generated during nighttime hours. Increased noise levels would be intermittent and temporary. The resulting increase in vehicle noise from construction and construction traffic (including movement of heavy equipment, which would be much less dense and slower than typical highway traffic) would be barely perceptible over the existing ambient noise that is intermittently dominated by the BNSF railroad. Noise from construction and construction traffic would be temporary and would briefly add to existing noise levels.

4.7.2 Noise Impacts of Operations

Noise sources during operation are expected to increase due to increased vehicle travel and increased numbers of employees traveling to and from the City of Crawford for work and from resin transfer to the CPF. Train usage would not increase as a result of operation. Processing equipment at the MEA would be minimal and is not expected to add to existing noise sources. Increases in noise levels due to operation are expected to be lower than those generated during construction. Therefore, it is expected that noise levels during operation would be barely perceptible over the existing ambient noise dominated by the BNSF railroad.

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4.8 Historic and Cultural Resources Impacts

ARCADIS (Graves et al. 2011) completed an intensive pedestrian block cultural resources inventory of approximately 4,500 acres for the MEA during the period from November 2010 to February 2011. The MEA was inventoried for the presence of historic properties (cultural resources that are listed or eligible for listing on the NRHP) and may be impacted by proposed mine development. This inventory recorded 15 newly discovered historic sites and five historic isolated finds and updated the documentation on two previously recorded historic farmstead sites. All of the newly recorded historic sites were recommended not eligible for the NRHP and do not qualify as historic properties. Isolated finds are by definition not eligible for the NRHP. Historic farmstead DWOO-242 is recommended not eligible for the NRHP, but appears to be currently or recently occupied. Site DWOO-243 may have the potential to yield information important in history and may be potentially eligible for the NRHP, but is not recommended eligible based on the currently available information. Avoidance of these two sites by project actions is recommended. If these recommendations are followed, the proposed project will have no adverse effect on historic properties, and no further cultural resource investigations are recommended.

4.9 Visual/Scenic Resources Impacts

4.9.1 Environmental Consequences

The visible surface structures proposed for the MEA include wellhead covers, wellhouses, electrical distribution lines, and one satellite processing facility. The project will use existing and new roads to access each wellhouse and the satellite facility.

Each wellhead cover would consist of a tan weatherproof structure placed over each well. Each structure would be approximately 3 feet high and 2 feet in diameter. Each wellhouse consists of a small shed. The facility building would be approximately 100 feet by 130 feet in size. A permanent disturbance area around each wellhouse would be sized to provide an adequate vehicle turnaround. There would be an estimated 10 to 12 wellhouses in the MEA.

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Electric distribution lines would connect wellhouses to existing electric distribution lines. The distribution poles would be approximately 20 feet high. The poles would be wooden so that their natural color harmonizes with the landscape.

Short-term Effects

Temporary and short-term effects during the construction period to the visual character of the landscape at each well pad would result from wellhouse construction, well drilling, and associated construction of ancillary facilities, such as access roads and electric distribution lines. Drilling and other construction activities would typically occur 8 to 12 hours per day during the regular work week.

Following completion of facility installation, temporary disturbance areas would be reclaimed to preconstruction conditions. Only permanent disturbances associated with operations and maintenance of the facilities will remain following post-construction restoration.

Long-term Effects

Long-term effects for the project would result from the addition of structures to the landscape, such as the satellite facility, wellhouses, wellhead covers, and associated access roads and electric distribution lines. Effects from long-term activities would occur over the production life of the project.

Project development would alter the physical setting and visual quality of portions of the landscape, which would affect the overall landscape to some degree, as viewed from sensitive viewing areas. The proposed facilities would introduce new elements into the landscape and would alter the existing form, line, color, and texture, which characterize the existing landscape. The project would primarily affect croplands.

In foreground-middleground views, the satellite facility, wellhouses, and associated access road clearings would be the most obvious features of development. Clearings and access roads would be visible as light tan exposed soils in geometrically shaped areas with straight, linear edges that provide some textural and color contrasts with the surrounding cropland. The satellite facility, wellhouses, and wellhead covers would be painted to harmonize with the surrounding soil and vegetation cover. These facilities would be visible from Squaw Mound Road and the residences within or in close proximity to the MEA, but would be subordinate to the rural landscape.

The electric distribution line poles would be an estimated 20 feet tall, and would be located throughout the project area to connect wellhouses with existing lines. The distribution lines are similar in appearance to those typical of the rural landscape, but would occur at a higher density than on adjacent lands. The lines would be obvious to viewers at the sensitive viewing areas, but would not change the rural character of the existing landscape.

Wellhead covers would be difficult to discern in the landscape from any sensitive viewing area. The form and textural contrast would be very weak because the relatively low profile (3 feet high) and small size of the facilities would disappear into the surrounding textures of soil and vegetation. Generally, color contrasts are most likely to be visible in foreground-middleground distance zone. However, the wellhead covers would be painted a tan color that would harmonize with the surrounding vegetation and soil colors. Therefore, contrast of line, form, texture, and color would be low. The facilities would not be noticeable to the casual observer. Wellhead covers would be visually subordinate to the landscape in foreground-middleground distance zone.

The objective of VRM Class III is to partially retain the existing character of the landscape. VRM classes are discussed in Section 3.9.2.1. The level of change to the characteristic landscape should be moderate. The existing rural/agricultural landscape would be retained, but would be modified with a noticeable but minor industrial component. Line and textural contrasts of the wellhouses, the satellite facility structures, and associated access roads and distribution lines would be visible from sensitive viewing areas; however, contrasts would be low to moderate. The VRM Class III objectives would be met by proposed long-term project facilities.

4.10 Social and Economic Impacts

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, positive 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 Cameco 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 local economy. Local, state, and 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.

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 City of Crawford or in Dawes County. As discussed in further detail below, CBR currently employs a workforce of approximately 68 employees and two contractors with 14 employees. The majority of these employees have been hired from the surrounding communities.

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In summary, monetary benefits have and continue to accrue to the community from the presence of the existing 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 potential economic impact of the MEA.

4.10.1 Tax Revenues

Table 4.10-1 summarizes the recent tax revenues from the Crow Butte project in U.S. dollars.

Future tax revenues depend on uranium prices, which cannot be forecast with accuracy; however, these taxes also somewhat depend on the number of pounds of uranium produced by CBR. Spot market values for U_3O_8 peaked at approximately $125 per pound in 2007 and have since fallen to approximately $50 per pound as of August 2011 (UxC 2011). It is likely that market values will not return to the 2007 high in the near future and that future tax revenues will more likely be representative of 2008 and 2009 levels.

Present taxes are based on a relatively consistent production rate of 800,000 pounds per year. The additional production from the MEA facility should be approximately 553,000 pounds per year. The incremental contribution to taxes would be on the order of $950,000 per year in combined taxes.

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Beneficiaries of CBR contributions to the General Fund, and therefore to Dawes County government subdivisions, include school districts, fire districts, county and municipal government agencies, and the White River Natural Resource District.

4.10.2 Temporary and Permanent Jobs

4.10.2.1 Current Staffing Levels

CBR currently employs approximately 68 employees and two contractors employing 14 people on a full-time basis. Short-term contractors and part-time employees are also employed for specific projects and/or during the summer months. This level of employment is significant to the local economies. Total employment in Dawes County in 2010 was 5,691 (BEA 2011). Based on these statistics, CBR currently provides approximately 1.5 percent of all employment in Dawes County. In 2009, the CBR total payroll was $4,155,000. Of the total Dawes County wage and salary payments of $106,652,000 in 2009, the CBR payroll represented about 4 percent.

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Total CBR payroll for the past 5 years was:

2006	$2,543,000
2007	$3,822,000
2008	$3,941,000
2009	$4,155,000
2010	$4,200,000

The average annual wage for all workers in Dawes County was $27,347 in 2009. By way of comparison, the average wage for CBR employees was approximately $58,821. Entry-level workers for CBR earn a minimum of $16.15 per hour or $33,600 per year, not including overtime, bonuses, or benefits.

4.10.2.2 Projected Short-Term and Long-Term Staffing Levels

The MEA will require 10 to 12 full-time employees, four to seven full-time contractor employees, and 10 to 15 part-time employees and short-term contractors for construction activities. The full- and part-time employees will be needed for the satellite facility and wellfield operator and

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maintenance positions. Contractor employees (e.g., drilling rig operators) may also increase by four to seven employees depending on the desired production rate. It is anticipated that the majority of the proposed MEA full-time and part-time workforce and contractors would be available from the current labor force in Dawes County. The annual unemployment rate in Dawes County in 2010 was 4.5 percent, equating to 216 individuals (BLS 2011). CBR expects that any new positions will be filled from this pool of available labor. These additional positions should increase payroll by approximately $40,000 per month, or $400,000 to $480,000 per year.

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 CBR staff (less than 5 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.

Because skills and services required for the proposed MEA project would be available in the existing local labor force, it is not anticipated that the proposed project would require the migration of additional workers into the nearby City of Crawford and City of Chadron, or Dawes County. In the event that proposed project requirements for specialized skills could not be met with the current workforce or local labor force, a small number of workers could be hired from outside of Dawes County. However, any such labor needs would represent a negligible change in the population of Dawes County. It is not anticipated that there would be any change in the local population from implementation of the proposed project.

Because no changes in employment or population are anticipated as a direct result of implementation of the Proposed Action, no impacts to housing availability, including public housing, are expected. There would be no short- or long-term employees that would require temporary housing; therefore, the proposed project would not affect the lodging capacities of nearby communities.

There would be no noticeable increase in the local population from the construction, operation, and maintenance of the proposed project; consequently, there would be no increase in the need for law enforcement and fire safety, medical facilities, public schools, grocery stores, or other community resources in Dawes County.

No increases in existing levels of domestic water usage in Dawes County are expected, nor are effects to existing domestic water facilities anticipated from an increase in population. In addition, the water requirements of the MEA construction and operations would not affect municipal water systems.

Electricity, water, propane and other fuel, sanitary water, and wastewater treatment required for construction and operations will be provided by the utilities that currently provide these services to existing CBR operations. The proposed project may increase the total quantities of electricity, water, propane, and other fuel consumed by CBR activities for a limited period of time during operations at MEA because the satellite facility would commence operations as those in the Crow Butte Permit Area are winding down. Because the scope of production at MEA would be similar to current operations in the Crow Butte Permit Area, it is anticipated that fuel and utility requirements would be similar. No substantial increases are likely for new operations at the satellite facility over existing operational uses.

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It is not anticipated that construction or operational activities would increase costs to other customers supplied by the affected utilities or increase the requirement for utility services beyond the capacities of the providers. There would be no substantial uses of electricity for construction activities. Fuel would continue to be provided by local suppliers. There would be no interruption of fuel deliveries to other customers from increased propane, diesel, and gasoline usage at MEA construction sites.

The Solid Waste Agency of Northwest Nebraska currently has the capacity for approximately 99 years of service, and would not be affected by the receipt of construction wastes or trash from the satellite facility. Other wastes are managed on site by CBR. Provision of waste services by local waste disposal providers would not be affected, as wastes are managed on site by CBR.

4.10.3 Impact on the Local Economy

It is anticipated than the monetary benefits and costs from the satellite facility would be similar to those associated with current CBR operations. In addition to providing a number of well-paid jobs in the local communities of the Cities of Crawford, Harrison, and Chadron, Nebraska, CBR actively supports the local economies through purchasing procedures that emphasize obtaining all possible supplies and services in the local area. **Table 4.10-1** summarizes the tax revenues from the CPF.

Total CBR payments made to Nebraska businesses for the past 5 years were:

2006	$4,396,000
2007	$5,167,000
2008	$7,685,000
2009	$8,185,000
2010	$4,330,900

The vast majority of these purchases were made in the City of Crawford and Dawes County. This level of business is expected to continue depending upon CBR project activities in any given year, although not in strict proportion to production. As production at the CPF mine site ceases due to depleted ore reserves, expansion areas will be brought on stream. These expansion areas will be sequenced (brought online) in a manner that will continue CPF production consistent with current production rates.

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While there are some savings due to some fixed costs, additional expenses are expected to be higher (e.g., wellfield development). Therefore, it can be estimated that the overall effect on local purchases will be proportional to the number of pounds of uranium produced. Local purchases that will be made annually for the MEA are estimated to be in excess of $1,000,000. Most of these purchases will continue to be made in the City of Crawford and Dawes County. In addition, mineral royalty payments accrue to local landowners. Production royalties of $532,000 were paid to landowners in 2010. Additional royalty payments would be made to MEA landowners. Most of the landowners are residents of Dawes County; therefore, beneficial impacts to county revenues and local businesses will be accrued through the spending and circulation of these dollars in the local economy.

4.10.4 Economic Impact Summary

As discussed in this section, CBR currently provides a positive economic impact to the local Dawes County economy. Development of the MEA would have a positive impact on the local economy as summarized in **Table 4.10-2**. The Proposed Action requires no in-migrating workforce from outside of the local area that currently provides the CBR labor force (primarily communities in Dawes County). Consequently, no increases in housing or community service demands would occur, and existing and planned facilities would not be adversely affected.

4.11 Environmental Justice

As discussed in Section 3.10.3, the combined population of the Census Block Groups within or adjacent to the MEA was 32. The entire population was white; one individual identified as Hispanic. The next nearest minority populations reside within the City of Crawford, located approximately 15 miles (24.1 km) north-northwest of the MEA, and the Village of Hemingford, located approximately 15 miles (24.1 km) south-southeast. Races in the City of Crawford consist of white non-Hispanic (95.6 percent), American Indian (0.9%), Hispanic (1.0 percent), person reporting two or more races (2.3 percent), and smaller percentages of races. Races in the Village of Hemingford consists of white non-Hispanic (96.1 percent), American Indian (1.2 percent), Hispanic (4.6 percent), persons reporting two or more races (2.1 percent), and smaller percentages of other races. The total percentage is greater than 100 percent because Hispanics could be counted in other races.

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As discussed in Section 3.10.3, no concentrations of minority populations were identified as residing in rural areas near the proposed MEA. There would be no disproportionate impact to minority population from the construction and implementation of the MEA.

Lower income levels are characteristic of predominantly rural populations and small communities that serve as a local center of agricultural activity. No adverse environmental impacts would occur to the population within the MEA from proposed project activities; therefore, there would be no disproportionate adverse impact to populations living below the poverty level in these Block Groups.

4.12 Public and Occupational Health Impacts

4.12.1 Non-radiological Impacts

As previously discussed in this section, 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. Non-radiological emissions include NO_x, CO, SO_2, VOC, and PM_{10} (operating equipment and fugitive dust due to traffic on unpaved areas).

In addition to gaseous and airborne effluents, three types of wastes would be generated at the proposed satellite facility: liquid, solid, and sanitary. 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 per the site's SPCC Plan.

Solid wastes generated would consist primarily of domestic waste. These wastes are classified as contaminated or non-contaminated waste according to radiological survey results. Non-contaminated solid waste is collected regularly on the site and disposed of in a sanitary landfill permitted by the NDEQ. CBR's estimate of annual quantities of non-contaminated generated solid waste for the MEA is presented in Section 4.13.2.3. No significant non-radiological impacts associated with management of relative small quantities of solid wastes would be expected.

The MEA is expected to only generate a small amount of hazardous waste and is expected to be classified as a CESQG. 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 the SHEQMS Program Volume VI, Environmental Manual. The SHEQMS document is reviewed annually and the sections updated as required. No hazardous waste materials will be disposed of on-site; all such wastes will be managed as per NAC Title 128 (hazardous waste regulations) and either recycled or disposed of at an approved hazardous waste handling and diposal facility.

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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 UIC Regulations. Septic tank solids will be periodically removed 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 MEA operations.

For any spill, the free liquids would be recovered and any contaminated soils would be removed and placed in an off-site disposal site approved for the type of waste generated.

In summary, the design and construction of the satellite facility will concentrate on minimizing the potential for releases of non-radiological waste materials. For example, CBR would use diking or flow cut-off and flow isolation procedures for radiological and non-radiological spill control. A quality assurance/quality control (QA/QC) system will be used, which would involve preoperational testing of equipment, periodic testing and regular inspection of equipment (e.g., pipelines, manifolds), and associated monitoring of line flows and pressures with automatic shutdowns in response to flow or pressure changes. Consequently, any spills should be small with little impact on the environment.

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4.12.2 Radiological Effects

An assessment of the radiological effects of the satellite facility must consider the types of emissions, the potential pathways present, and an evaluation of potential consequences of radiological emissions.

The satellite facility will have a production flow capacity of approximately 6,000 gpm and will use fixed-bed downflow IX columns to separate uranium from the pregnant production fluid. The facility will also have a capacity to treat 1,500 gpm of restoration solution. The restoration process will use fixed-bed downflow IX columns to remove the uranium and RO to remove the dissolved solids. Waste disposal at the satellite facility will be via two DDWs, which will receive fluids from wastewater tanks located in the satellite building. The satellite facility will not have any precipitation equipment. The loaded IX resin will be transferred from the columns to a resin trailer for transport to the CPF for regeneration and stripping. The reclaimed resin will be transported back to the satellite facility and reused in IX columns.

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The uranium-bearing regenerant at the CPF is treated in the uranium precipitation circuit. The precipitated uranium is vacuum dried.

The primary airborne radiological emission from the facility will be radon-222 gas (radon) and its decay products. Radon is present in the ore body and is formed from the decay of radium-226. Radon is dissolved in the lixiviant as it travels through the ore body to a production well, where the solution is brought to the surface. The concentration of radon in the production solution is calculated using methods found in RG 3.59, "Methods for Estimating Radioactive and Toxic Airborne Source Terms for Uranium Milling Operations" (March 1987). The details of this calculation are found in **Appendix N.**

MILDOS-AREA was used to model radiological impacts on human and environmental receptors (e.g., air and soil) using site-specific radon release estimates, meteorological and population data, and other parameters (Savignac 2011a). In addition, the vegetation pathway was assessed and is discussed in Section 6.2.1.5 (Savignac 2011b).

The following sections briefly discuss the assumptions and methods used to estimate the potential radiological impacts of the satellite facility coupled with the CPF. A detailed presentation of the source term and other MILDOS-AREA parameters is included in **Appendix M-1.** The anticipated effects are compared to the naturally occurring background levels. This background radiation, arising from cosmic and terrestrial sources, as well as naturally occurring radon gas, comprises the primary radiological impact to the environment in the region surrounding the proposed project.

4.12.2.1 Exposure Pathways

The proposed satellite facility is an ISR uranium recovery facility. The only source of planned radioactive emissions from the facility is radon gas and its decay products, which are dissolved in the leaching solution. Radon gas may be released as the solution is brought to the surface and processed in the satellite facility. Unplanned radon emissions from the site are possible as a result of accidents and engineered structure failure but are not addressed in the MILDOS-AREA modeling. A human exposure pathway diagram addressing planned and unplanned radiological emissions is presented on **Figure 4.12-1.**

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The satellite facility will have pressurized downflow IX columns capable of processing 6,000 gpm of production solution. The satellite facility will also have IX and RO equipment with a capacity of 1,500 gpm to process restoration solutions. Up-flow IX columns are not planned for the MEA.

Within the pressurized columns, the radon will remain in solution and will be returned to the formation. It will not be released to the atmosphere. There will be minor releases of radon during the air blowdown prior to resin transfer to the resin trailer. The air blowdown and the gas released from the vent during column filling will be vented into the exhaust manifold and discharged via the main radon exhaust stack. It is estimated that less than 10 percent of the radon contained in the process solutions will be vented to atmosphere.

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In the source term calculation, Cameco estimates that, in the absence of evaporation ponds, 25 percent of the contained radon found in the 6,000 gpm flow processed by pressurized downflow IX columns will be released to the environment

After the IX resin is loaded, it will be transferred to a resin trailer. The trailer will transfer the resin to the CPF for additional processing. The stripped and regenerated resin will be transferred to the trailer, returned to the satellite facility, and transferred into a process column. It is anticipated that two round trips will occur per day.

The injection wells will generally be closed and pressurized, but periodically vented. It is estimated that 25 percent of the radon produced in the production fluids will be released in the wellfield. A sensitivity analysis demonstrated that radiation doses using a 25 percent/75 percent distribution of radon released from the MU wellhouses and from the satellite facility did not appear to be significantly different from the doses calculated using a 10 percent/90 percent distribution, respectively (Savignac 2011a). See discussions in Section 4.12.2.6 and **Appendix M-1**.

Atmospheric emissions of radon will lend its presence to all quadrants of the area surrounding the MEA and the CPF. Radon itself impacts human health or the environment marginally, because it is an inert noble gas. Radon has a relatively short half-life (3.8 days), and its decay products are short-lived, alpha emitting, non-gaseous radionuclides. These decay products have the potential for radiological impacts to human health and the environment. **Figure 4.12-1** shows that all exposure pathways, with the possible exception of absorption, can be important depending on the environmental media impacted. All of the pathways related to air emissions of radon were evaluated using MILDOS-AREA (Savignac 2011a).

4.12.2.2 Exposures from Water Pathways

The solutions in the zone to be mined will be controlled and adequately monitored to ensure that migration does not occur. The overlying aquifers will also be monitored.

The satellite facility will not have evaporation ponds or surge tanks to store waste solutions, thereby eliminating the potential of releases and exposures via water pathways. Wastewater tanks used to manage project wastewater will be located in the satellite building. The satellite facility processing building will be located on a curbed concrete pad to prevent any liquids from entering the environment. The pad will be of sufficient size to contain the contents of the largest tank if it ruptures. Solutions used to wash down equipment will drain to a sump, pumped to the wastewater tanks, and pumped to the DDWs.

Chemical storage tanks located outside the satellite building will be located within spill containment dikes in order to control any spills or releases from the storage tanks.

The wastewater collected in the wastewater tanks within the satellite building will discharge to two DDWs, which will be the primary method of waste disposal at the satellite facility. The DDWs will be completed at a depth of approximately 4,000 to 5,000 ft, isolated from any underground source of drinking water by approximately 1,500 ft of Pierre Shale. The well will be constructed under a permit from the NDEQ and will meet all requirements of the UIC program.

Because no routine liquid discharges of process water are expected, there are no definable water-related pathways.

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4.12.2.3 Exposures from Air Pathways

The only source of radionuclide emissions is radon released into the atmosphere through a vent system or from the wellfield. As shown on **Figure 4.12-1**, atmospheric releases of radon can result in radiation exposure via three pathways, inhalation, ingestion, and external exposure.

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Radiation dose rates were determined using the NRC computer code MILDOS for the proposed MEA project (Savignac 2011a). The objective of this evaluation was to:

- Determine the radiation doses to members of the public within a 50-mile (80 km) radius of the MEA using the NRC computer code MILDOS.
- Determine the potential annual dose rate to workers on the site.
- Determine the sensitivity of the MILDOS estimates of radiation dose.

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This section summarizes the major findings of the MILDOS evaluation. For more detailed information on assumptions, inputs, outputs, and other elements of the model, the MILDOS report is provided in **Appendix M-1.**

For comparison, naturally occurring background radiation from cosmic and terrestrial sources, is approximately 365 mRem/yr.

4.12.2.4 MILDOS Output – Radiation Dose Rates

Table 4.12-1 presents the dose rates calculated for the major cities and towns within 50-mile (80 km) radius of the MEA; eight residences; two unoccupied structures; and for the north, south, east, and west property boundaries. Locations of these receptors are shown on **Figures 4.12-2** and **4.12-3.** The dose rates were calculated using the MEA on-site meteorological data and using an operating purge rate of 44 gpm (to account for the absence of surge/evaporation ponds) for the closed-pressurized uranium extraction circuit used at the MEA site.

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Because radon is released from both the mine fields header houses and from the satellite plant, the doses were proportioned 25 percent from the mine fields and 75 percent from the satellite. **Table 4.12-2** presents the total dose from the satellite facility, MEA MUs 1 through 5 and A through F under typical operating conditions from both sources of radon. Conclusions from those dose rates are as follows:

- All dose rates to the public at the property boundaries, the cities and towns within a 50-mile (80 km) radius from the MEA, and at the nearest residence were below the 100 mRem/yr limit specified in 10 CFR 20.
- The highest MEA boundary dose rate was 80 mRem/yr at the south property boundary.
- The highest residential dose rate was 21 mRem/yr at residence 2.
- The highest dose rate at cities and towns within a 50-mile (80 km) radius from the MEA was 0.9 mRem/yr at the Towns of Hemingford and Marsland.
- The 10 CFR 190 dose rate was 0 mRem/yr, which was below the 10 mRem/yr dose limit for emissions that exclude radon and its progeny.
- The population effective dose rate within 50-mile (80 km) radius from the MEA Project was 1.6 person-Rem/yr and 0 person-Rem/yr beyond the 50-mile (80 km) radius.

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For comparison, naturally occurring background radiation, from cosmic and terrestrial sources, is approximately 365 mRem/yr.

The radiation doses from the production wells and from the wells in restoration are identical. The doses from the new wells are all zero. See **Appendix M-1** for production well doses, restoration well doses, new well doses. The doses presented in these appendices have not been proportioned among the mine field emissions and the satellite stack emissions.

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4.12.2.5 MILDOS Output – Public and Occupational Radiation Dose Rates

Dose rates for the public apply to delivery personnel, regulatory inspectors, visitors, or other personnel that may spend 10 hours per month on site. Occupational dose rates apply to personnel that may spend an estimated 1,500 hours per year working on site, such as company employees or contractors. For example, a water sampling technician who works an estimated 5 days per week, 6 hours per day, 50 weeks per year near the fine fields or satellite plant would spend 1,500 hours on site each year.

Table 4.12.2 shows the MEA public and occupational dose rates. For typical operating conditions, the maximum dose rate to the public was 3 mRem/yr (with an average of 2 mRem/yr) and the maximum occupational dose rate to employees and contractors was 35 mRem/yr (with an average of 19 mRem/yr).

4.12.2.6 Radon Release Points

The radiation dose rates from typical operations used the following:

- 25 percent radon released from the MU wellhouses
- 75 percent radon released from the satellite plant vent stack

That distribution has been used historically in MILDOS assessments. For comparison, dose rates were calculated using:

- 10 percent radon released from the MU wellhouses
- 90 percent radon released from the satellite plant vent stack

The dose rates from both distributions are presented in **Table 4.12-3**. A comparison of the 25 percent/75 percent distribution of radon in column 2 with the 10 percent/90 percent distribution of radon release in column 3 shows that the averages and standard distributions are nearly identical. That similarity suggests that, within the range of values selected for the radon distribution between releases at the mine fields and releases at the satellite plant, the distribution is not important for assessing the doses to people around the MEA site.

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A MILDOS sensitivity analysis was conducted to identify how input parameters affect the calculated radiation dose. Input parameters and variables are discussed in **Appendix M-1.**

The sensitivity analysis demonstrated that:

- When assuming an unrealistic upper bound process purge rate of 222 gpm, neither the occupational dose rate nor the public dose rate exceeded 100 mRem/yr.

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- Radiation doses calculated using a 25 percent/75 percent distribution of radon released from the MU wellhouses and from the satellite plant did not appear to be significantly different from the doses calculated using a 10 percent/90percent distribution, respectively.
- Assuming an unrealistic upper bound purge rate, the maximum dose to the public on site 10 hours/month is 3 mRem/yr.
- Assuming an unrealistic upper bound purge rate, the maximum occupational dose rate to employees and contractors on site 1,500 hours/yr is 35 mRem/yr.
- A sensitivity analysis was performed to identify how input parameters affect the calculated radiation dose.

4.12.2.7 Exposure to Flora and Fauna

There are two primary potential pathways for radiological exposures to flora and fauna: radon emissions and accidental spills of radiological containing fluids (e.g., lixiviant).

- Radon Releases

Radon emissions at uranium ISR facilities such as the proposed satellite facility (i.e., no yellowcake dryer and associated facilities) are considered the primary air contaminant during operations. Radon emissions during normal operations are considered the most important pathway for exposure to flora and fauna due to deposition of radon-222 decay products on surface water, surface soils, and vegetation. The MILDOS-AREA model provides an estimate of surface deposition rate as a function of distance from the source for the radon-222 decay products and calculates surface concentrations.

The exposure to flora and fauna was evaluated in the Environmental Report submitted in September of 1987 (Ferret 1987), and the doses were found to be negligible. Based on this evaluation, the proposed MEA, TCEA, and NTEA projects are not expected to have a measurable impact on dose to flora and fauna.

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The potential exists for individual mobile fauna (e.g., small mammals and birds) to have contact with higher but short-term contact with concentrations of radon-222 than the public due to the potential proximity to releases. However, due to the typical mobility of such animals, it is likely that exposure to individuals would be intermittent, as opposed to a constant concentration for the entire year.

There are currently no regulatory dosimetric standards for the protection of flora and fauna, with radiological protection frameworks being traditionally focused on the protection of man. Historically, the International Commission on Radiological Protection (ICRP) has maintained a position towards human health versus non-human species that protection of humans from radiation exposure implicitly ensures an adequate protection of other living organisms and, therefore, the environment (Brechignac 2002 [ICRP 1977 and 1991]). However, the development of a system capable of ensuring adequate protection of the environment against the harmful effects of ionizing radiation is currently being debated (Brechignac 2002). The ICRP has issued a draft report for public comment primarily documenting methods that allow prediction of known concentrations of radionuclides within an organism's habitat (ICRP 2010). This work is still underway.

- Fluid Discharges

There are currently no planned discharges from the satellite facility, with wastewaters being discharged to two Class I DDWs. Therefore, any fluid discharges would be associated with spills (e.g., pipeline break or leak). Spills of this type would be expected to occur within the restricted wellfield areas and between the wellfields and satellite process facility. The satellite processing building, fuel tanks, and chemical tanks would be constructed on pads engineered to contain any spill from a pipe rupture, leaking vessel, or inadvertent spill. Therefore, it is unlikely that any spills in the processing area would reach soils and vegetation. CBR operating procedures provide for ongoing monitoring of operational activities and for a rapid corrective action response to any spill, which would result in cleanup of the spilled material and, if applicable, removal of any contaminated soil and vegetation.

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Long-term experience at CBR has shown that single-event spills typically do not cause significant contamination of soil and vegetation.

There is limited potential for wildlife or domestic animals to consume contaminated vegetation or seeds. Other than the potential for accidental spills discussed above, which would be immediately assessed and cleaned up, the satellite facility would not be expected to significantly impact food sources such as vegetation and seeds upon which local animals depend.

4.12.3 Effects of Accidents

Accidents involving human safety associated with the ISR uranium mining technology typically have far less severe consequences than accidents associated with underground and open pit mining methods. ISR mining provides a higher level of safety for personnel and neighboring communities compared to conventional mining methods or other energy-related industries. Accidents that may occur would 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 be 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 RG–0706 and specifically at uranium ISR facilities in RG/CR-6733 (NRC 1980, CNWRA 2001). These analyses demonstrate that, for most credible potential accidents, consequences are minor so long as effective emergency procedures are followed and properly trained personnel are employed. The CBR emergency management procedures contained in the CBR SHEQMS Volume VIII, Emergency Manual, have been developed to implement the recommendations contained in the NRC analyses. Training programs contained in the CBR SHEQMS Volume VII, Training Manual have been developed to ensure that CBR personnel have been adequately trained to respond to all potential emergencies. The CBR SHEQMS Volume II, Management Procedures requires periodic testing of emergency procedures and training by conducting regular drills.

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RG-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. RG-0706 also considered transportation accidents. Some of the analyses in RG-0706 are applicable to ISR facilities, such as transportation accidents; however, many of the analyses do not apply due to the significantly different mining and processing methods. ISR 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 lower than that of a mill site.

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

4.12.3.1 Chemical Risk

RG/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 CBR is regulated by the OSHA. CBR 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 satellite facility. The satellite facility will use O_2, CO_2, and $NaHCO_3$ for addition to the injection solution. Na_2S may be used as a reductant during groundwater restoration activities. All other operations requiring process chemicals described in RG/CR-6733 will be performed at the CPF.

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

O_2

O_2 presents a substantial fire and explosion hazard. The O_2 storage facility is typically designed and installed by the O_2 supplier and meets applicable industry standards. As currently practiced at the CPF, CBR will install wellfield O_2 distribution systems at the MEA. Combustibles, such as oil and grease, will burn in O_2 if ignited. CBR ensures that all O_2 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 (CGA 1996). Construction of O_2 systems in the wellfield is addressed by procedures contained in the SHEQMS Volume III, Operations Manual. Emergency response instructions for a spill or fire involving O_2 systems are contained in the SHEQMS Volume VIII, Emergency Manual.

CO_2

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The primary hazard associated with the use of CO_2 is concentration in confined spaces, presenting an asphyxiation hazard. Bulk CO_2 facilities are typically located outdoors and are subject to industry design standards. Floor-level ventilation and CO_2 monitoring at low points is currently performed at the CPF to protect workers from undetected leaks of CO_2. Operation of CO_2 systems is currently addressed by procedures contained in the SHEQMS Volume III, Operations Manual. Emergency response instructions for a leak involving CO_2 are contained in the SHEQMS Volume VIII, Emergency Manual.

$NaHCO_3$

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$NaHCO_3$ is primarily an inhalation hazard. CBR typically uses soda ash and CO_2 to prepare $NaHCO_3$ 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 $NaCO_3$ systems is

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currently addressed by procedures contained in the SHEQMS Volume III, Operations Manual. Emergency response instructions for a spill involving $NaHCO_3$ or soda ash are contained in the SHEQMS Volume VIII, Emergency Manual.

4.12.3.2 Radiological Risk

Tank Failure

A spill of the materials contained in the process tanks at the satellite facility would present a minimal radiological risk. Process fluids will be contained in vessels and piping circuits within the processing building. O_2, H_2O_2, CO_2, propane, and fuel will be stored outside in storage tanks. The tanks at the satellite facility will contain injection and production solutions and IX resin. Elution, precipitation, and drying will be performed at the CPF. The satellite facility will be designed to control and confine liquid spills from tanks should they occur. The facility 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 facility process circuit or to the waste disposal system. Bermed areas, tank containments, or double-walled tanks will perform a similar function for any 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 would be repaired or replaced as necessary.

Facility Pipe Failure

The rupture of a pipeline within the satellite processing area would be easily visible and could 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 the SHEQMS 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.

4.12.3.3 Groundwater Contamination Risk

Lixiviant Excursion

Excursions of lixiviant at ISR facilities have the potential to contaminate adjacent aquifers with radioactive and trace elements 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 monitor well ring. A vertical excursion is a movement of ISR 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 processing facility or is sent to the liquid waste disposal system. When process bleed is properly distributed among the many mining patterns within the MU, 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 from each other. These spacing requirements have proven to be effective for monitoring horizontal excursions at CBR and will be employed at the satellite facility or as otherwise provided in the final permit. Monitor wells are sampled biweekly for approved excursion indicators. CBR proposes to implement the current approved excursion monitoring program at the satellite facility. The program is discussed in detail in Section 6.2.2.1.

Section 3.11.1.2 provided a discussion of horizontal excursions reported at the current CBR operation. 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 RG/CR-6733, significant risk from a horizontal excursion would occur only if it persisted for a long period without being detected (NRC 2000).

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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 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 5.1.3.1. Procedures for these activities are contained in the SHEMQS 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 4 acres. Shallow monitor wells are sampled biweekly for approved excursion indicators. CBR proposes to implement the current approved excursion monitoring program at the satellite facility, subject to NRC/NDEQ approval. The program was discussed in detail in Chapter 5 of the Technical Report.

4.12.3.4 Wellfield Spill Risk

The rupture of an injection or recovery line in a wellfield, or a trunkline between a wellfield and the satellite facility, would result in a release of either barren or pregnant lixiviant solution, which would contaminate the ground in the area of the break. All piping from the satellite facility to and within the wellfield will be buried for frost protection. Pipelines are constructed of PVC, 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 MU 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 CPF, 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 detecting significant piping failures (e.g., failed fusion weld) in the current operation.

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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.

4.12.3.5 Transportation Accident Risk

Transportation of materials to and from the satellite facility 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 facility to the CPF and return shipments of barren, eluted resin from the CPF back to the satellite facility

The first two types of transportation risks do not present an increase over the risks associated with operation of the current CBR facility because production from the proposed satellite facility is planned to replace declining production at the current facility. The shipment of loaded IX resin from the satellite facility and the return of barren, eluted resin represent an additional transportation risk that was not considered for the current operation.

RG-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 RG/CR-6733 determined were conservative with respect to probability distributions used in a later NRC transportation risk assessment (CNWRA 2001). For Marsland, uranium-loaded and barren resin will be routinely transported by tank truck from the satellite facility to the CPF. For the Crown Point ISR site located in New Mexico, NRC determined that the probability of an accident involving such a truck was 0.009 in any year (NRC 1997).

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

Accidents Involving Shipments of Process Chemicals

Based on the current production timeline and material balance, it is estimated that approximately 150 bulk chemical deliveries per year will be made to the satellite facility. This averages about one truck per working day for delivery of chemicals throughout the operational life of the project. Types of deliveries include CO_2, O_2, bicarbonate, H_2O_2 and soda ash.

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Accidents Involving Radioactive Wastes

11(e)2 byproduct material or unusable contaminated equipment generated during operations will be transported to an approved licensed disposal site. Because of the low levels of radioactive concentrations involved, these infrequent shipments are considered to have minimal potential impact in the event of an accident.

Accidents Involving Resin Transfers

One of the potential additional risks associated with operation of a satellite facility is the transfer of the IX resin to and from the satellite facility.

Resin will be transported to and from the satellite facility in a 4,000-gallon capacity tanker trailer. It is currently anticipated that one load of uranium-laden resin will be transported to the CPF for elution and one load of barren eluted resin will be returned to the satellite facility daily.

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The transfer of resin between the satellite facility and the CPF will occur on SH 2/71 and county and private roads. CBR has established a primary access route and an alternate access route. The primary access route will entail approximately 18.0 miles (29.0 km) of travel on SH 2/71 and approximately 12 miles (19.3 km) on county and private roads (**Figure 1.4-1**). The Alternate A access route is approximately 14 miles (22.5 km) long, with all of the roads being unpaved county and private roads. The planned access routes are discussed in more detail in Section 4.2.21.

Resin or eluate shipments will be treated similar to yellowcake shipments in regards to DOT and NRC regulations. Shipments will be handled as LSA material for both uranium-laden and barren eluted resin. Pertinent procedures include:

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- 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 be documented on the bill of lading.
- Licensed and trained CBR drivers will transport the resin between the satellite facility and the CPF.

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

Currently, CBR 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 help determine the most practical and efficient way of dealing with the shipment of barren resin. Regardless, compliance with all applicable DOT and NRC 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. These procedures would be followed to minimize the impacts from such an accident:

- Each resin hauling truck will be equipped with a radio that can communicate with either the CPF or the satellite facility. 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 ensure a reasonably quick response time in the case that the driver is incapacitated in an accident.
- Each resin transport vehicle will be equipped with an emergency spill kit that 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.

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4.12.3.6 Natural Disaster Risk

RG/CR-6733 evaluates the potential risks to an ISR facility from natural disasters. Specifically, the risk from an earthquake, a tornado strike, fire, and flooding 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. RG/CR-6733 recommended that licensees follow industry best

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practices during design and construction of chemical facilities. CBR is committed to following these standards.

Tornado Risk

NUREG/CR 6733 evaluates tornado risks associated with ISR facilities for the release of radioactive materials or hazardous chemical due to the effects of a tornado. It was determined that, in the event of a tornado strike, chemical storage tanks could fail, resulting in the release of chemicals. This guidance document concluded the risk of a tornado strike on an ISR facility was very low and that no design or operational changes were necessary to mitigate the potential risks. However, it was important to locate chemical storage tanks far enough from each other to prevent contact of reactive chemicals in the event of an accident.

The Crow Butte operation is located in an area subject to tornados. The site is located in Dawes County, Nebraska in which five tornado touchdowns were reported during the period of 2000 and 2012 between the months of May and August (NOAA 2012). The five tornado events did not exceed a Fujita or Enhanced Fujita scale (F- or EF-scale, respectively) magnitude of F0 or EF0 and no injuries, deaths, property damage, or crop damage occurred. According to the Fujita Tornado Damage Scale, a typical F0 tornado event will exhibit wind estimates less than 73 mph and produce light damage to the surrounding area. Most tornado events were reported to have taken place in open country, rangeland, and wooded areas. One of the tornados reported in Chadron had a magnitude of EF0 and damaged a tree and a windmill. The tornado events had damage paths ranging from 0 to 0.4 mile in length and had path widths ranging from 20 to 30 yards. Although Dawes County can be considered relatively weak in tornado risk, surrounding counties such as Sheridan County have been known to have tornado events classified as F1. Within the same time period, Sheridan County experienced an F1 tornado that caused approximately $150,000 in property damage.

It has been concluded that tornado risk in Dawes County is relatively low compared to that of the surrounding region. Dawes County historical area-adjusted tornado activity is significantly below Nebraska state average, and is 1.6 times below the overall U.S. average (City-Data 2012). The tornado index, a measure of the probability of tornado events and calculated using historical tornado events data and USA.com algorithms, was 205.07 for the State of Nebraska as a whole and 64.92 for Dawes County (USA.com 2013). During the final design phase, CBR will assess the location(s) and construction of chemical storage tanks and containment features in order to reduce the risk of potential leaks caused by tornado damage which may result in harmful chemical reactions.

CBR emergency procedures currently contained in the SHEQMS Volume VIII, Emergency Manual, provide instructions for response and mitigation of natural disasters and spills or radioactive materials. CBR's Emergency Manual contains emergency provisions such as notification to personnel of severe weather; evacuation procedures, security plans, and threats associated with source material; medical emergencies; damage inspection/assessment and reporting; and cleanup and mitigation of chemical spills. CBR will have separate containment berms around storage tanks to reduce the risk of mixing of incompatible chemicals in the event of a spill. In addition, the site's SOPs, training, and personal protective equipment will be available to personnel for response and mitigation of hazardous chemical releases.

Deleted: The project area, along with most of the State 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 3.3.1.4. ¶
The CBR operation is located in an area subject to tornadoes. CBR emergency procedures currently contained in the SHEQMS Program Volume VIII, Emergency Manual provide instructions for response and mitigation of natural disasters and spills or radioactive materials¶
Historically, there have been no fires of any significance during the operations of the CBR commercial operations, and none would be expected to occur at the proposed MEA site. CBR's Emergency Manual maintains procedures for dealing with potential fires, whether associated with man-made events at the operations or associated with wildfires. Wildfires have been not been a problem in the area of the MEA and are not considered a major threat to the MEA site. ¶
The risk of flooding is considered low due to the lack of permanent streams or rivers flowing through the MEA project area and historical annual rainfalls and snowmelt. CBR personnel are unaware of any major historical flooding of the site. CBR conducted an erosion analysis of the MEA site and will use the results of that study in siting assets and providing mitigation measures to prevent potential damage associated with flooding.¶

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Seismic Risk

The project area, along with most of the State 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. Dawes County-area historical earthquake activity is significantly above Nebraska state average, but it is 85 percent below the overall U.S. average (City-Data 2012). Seismology was discussed in detail in Section 2.6. No historical earthquake events that had recorded magnitudes of 3.5 or above have been reported in or near Dawes County (USA.com 2013).

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NUREG/CR-6733 concluded that risk from earthquakes at ISR facilities was no greater than for a tornado strike, and that no design or operational changes were required to mitigate the risk. However, the NRC advised that it was important to locate chemical storage tanks far enough from each other to prevent contact of reactive chemicals in the event of an accident.

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As stated above for potential tornado strikes, CBR emergency procedures currently contained in the SHEQMS Volume VIII, Emergency Manual provide instructions for response and mitigation of natural disasters and spills or radioactive materials. CBR will have separate containment berms around storage tanks to reduce the risk of mixing of incompatible chemicals in the event of a spill. In addition, the site's SOPs, training, and personal protective equipment will be available to personnel for response and mitigation of hazardous chemical releases.

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Fires

Historically, there have been no fires of any significance during CBR commercial operations, and none would be expected to occur at the proposed MEA site. CBR's Emergency Manual maintains procedures for dealing with potential fires, whether associated with man-made events at the operations or associated with wildfires.

Wildfires have typically not been a problem in the area of the MEA and are not considered a major threat to the MEA site. On August 31, 2012, CBR was ordered by the Dawes County Sheriff's Office to evacuate the current Crow Butte operations site due to threatening wildfire to the east of the project (CBR 2012). CBR advised the NRC of this order, operations were temporarily shut down, and site personnel were evacuated. All project personnel were evacuated with the exception of a crew of five CBR personnel that remained on site for security purposes. On September 1, 2012, the evacuation order was lifted and operations were restarted on September 2, 2013. The wildfire never entered the licensed area and, as a result, there were no releases to the environment. During the evacuation, all source material on the site was kept under 24-hour surveillance. CBR's Emergency Manual procedures were followed during the evacuation, and there were no incidents.

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Flooding

Flooding is considered a low-risk issue due to the lack of permanent streams or rivers flowing through the MEA project and historical annual rainfalls and snowmelt. CBR personnel are unaware of any historical flooding of the site. CBR conducted an erosion analysis of the MEA site and will use the results of that study in siting assets and providing mitigation measures to prevent any potential damage associated with flooding. The potential for flooding or erosion that could impact the proposed in-situ Marsland mining processing facilities and mine units is discussed in Section 1.3.2.13.

4.13 Waste Management Impacts

This section describes the waste management impacts from the satellite facility. The effluents of concern at ISR operations include the release or potential release of radon-222, radionuclides in liquid process streams, and dried yellowcake. Yellowcake processing and drying operations are conducted at the CPF. Loaded IX resin from the satellite facility will be transported to the CPF for elution, precipitation, drying, and packaging.

The yellowcake drying facilities at the CPF are composed 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 CPF have been reviewed by NRC and approved in the current license. The current waste streams and management programs were described in Section 3.12.

4.13.1 Gaseous and Airborne Particulates

The primary radioactive airborne effluent at the satellite facility will be radon-222 gas. Radon-222 is found in the pregnant lixiviant that comes from the wellfield into the satellite facility for separation of uranium. 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 satellite building minimizes employee exposure. Small amounts of radon-222 may also be released during solution sampling and spills, filter changes, IX resin transfer, RO system operation during groundwater restoration, and maintenance activities. These are considered minimal and infrequent radon-222 releases. The impacts from release of radon-222 were discussed in Section 4.12.2.

Other emissions to the air are limited to exhaust and dust from limited vehicular traffic. These impacts were previously discussed in Section 4.12.2. There are no significant amounts of process chemicals that will be used at the satellite facility. There are no significant combustion-related emissions from the process facility, as commercial electrical power is available at the site.

4.13.2 Liquid Waste

4.13.2.1 Sources of Liquid Waste

As a result of ISR mining, there are several sources of liquid waste. The potential wastewater sources that exist at the satellite facility will be similar to those currently generated and managed at the CPF. These sources of wastewater 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 management of these waters is discussed in Section 3.12.2.1.

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Liquid Process Waste

For the years 2013 though 2021, operation of the satellite facility results in one primary source of liquid waste, a production bleed as previously discussed. This bleed will be routed to a DDW water supply tank located in the satellite building. Process bleed is estimated at 0.5 to 2.0 percent of the process flow of 6,000 gpm. The impact of this process bleed was discussed in Sections 3.12.2.1 and 4.4.3. Starting in 2022, the wastewater flows will rise sharply as the bleed from the RO process used during restoration must be addressed.

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Aquifer Restoration Waste

Restoration of the affected aquifer commences following mining operations at MEA, 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

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Only the groundwater sweep and groundwater treatment activities will generate wastewater. During groundwater sweep, water is 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. The impact of this restoration waste stream was discussed in Section 3.12.2.1.

4.13.2.2 Liquid Waste Disposal

As discussed in Section 3.1.7, from 2015 through 2021, the majority of the wastewater produced at the MEA satellite facility requiring disposal will be the production bleed (25 to 65 gpm over the life of project). Starting in 2022, the wastewater flows will rise sharply as the bleed from the RO process used during restoration must be addressed.

Other liquid production wastewater will consist of process liquids (e.g., affected well development water, laundry water, and plant washdown water). These waste streams will account for an intermittent discharge with an maximum average of 1 to 2 gpm. The disposal water balance discussed below is of such a magnitude that these small quantities of wastewaters will be easily managed in the proposed disposal system. The well development water will be collected using a dedicated vacuum truck and delivered to the well workover fluid tank located in the satellite building (**Figure 3.2-1**). The other liquid wastes (i.e., laundry and plant washwater originated in restricted areas) will flow to plant sumps and will be transferred to a wastewater tank located within the satellite building. All of the above waste streams and tankage will be disposed of through the DDWs. The satellite building will not have a laboratory, and a septic system will be used for discharges from toilets, lavatories, and a sink in the lunchroom/break area. The MEA water balance is discussed in Section 3.1.7, with discussions on the management of the production and restoration waste streams.

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Restoration for MU 1 will begin approximately in the sixth year of operation. Two major waste streams generated during restoration that will require disposal will be RO bleed and brine. The

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RO bleed will be disposed of over the life of the project (2021 through 2037) at an average rate of 80 to 250 gpm. The amount of brine to be disposed of will range from 167 to 250 gpm beginning in the year 2022 and continuing until 2037.

One primary method of disposal of liquid wastes proposed for the satellite facility is by DDW.

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CBR has operated the DDW at the CPF license area for more than 10 years with excellent results and no serious compliance issues. CBR expects that the liquid waste stream at the satellite facility will be chemically and radiologically similar to the waste disposed in the current DDW. A second DDW became operational at the CPF in late 2011.

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CBR plans to install two DDWs at the MEA 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 satellite facility will be disposed of in the planned DDWs. No adverse environmental impacts are expected from this type of disposal because the liquid waste is permanently isolated in an unusable geologic formation.

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4.13.2.3 Solid Waste

Solid waste generated at the satellite facility is expected to include spent resin, resin fines, empty reagent containers, miscellaneous pipe and fittings, and domestic trash. In additional, some waste materials will be generated during drilling activities, such as drill cuttings (see discussions in Section The solid waste will be segregated based on whether it is clean or carries the potential for contamination with 11(e).2 byproduct materials. As with the current CPF, CBR will follow written waste management procedures per the SHEQMS; by following these procedures, no environmental impacts associated with waste generation, handling, and disposal would be expected. All solid waste generation, handling, and disposal will be carried out in compliance with all applicable county, state, and federal regulations. Good housekeeping is a requirement of the SHEQMS, which includes keeping facilities, equipment, and process areas clean and free of industrial waste or other debris. Good housekeeping includes promptly cleaning any spillage or process residue on floor or other areas that could be spread and collecting solid wastes in designated containers or areas until proper disposal.

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Non-contaminated Solid Waste

Non-contaminated solid waste is waste that is not contaminated with 11(e).2 byproduct material or that 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 that are not contaminated or that may be successfully decontaminated. Release of contaminated equipment and materials is discussed in further detail in Section 5 of the MEA Technical Report.

CBR estimates that the proposed 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.

11(e).2 Byproduct Material

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

11(e).2 byproduct material generated at ISR facilities consists of filters, PPE, spent resin, piping, and other items. CBR estimates that the proposed satellite facility would produce approximately 60 yd^3 of 11(e).2 byproduct materials per year. These materials will be stored on site until a full shipment can be shipped to a licensed waste disposal site or licensed mill tailings facility.

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.

Hazardous Waste

The potential exists for any industrial facility to generate hazardous waste as defined by the RCRA. Based on waste determinations, CBR is a CESQG. To date, CBR only generates universal hazardous wastes such as spent waste oil and batteries. CBR estimates that the proposed 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 the SHEQMS Program Volume VI, Environmental Manual to control and manage these types of wastes.

4.14 Cumulative Effects

Since the 2007 submission of the NTEA application to amend the CBR Source Materials License, Cameco Resources has submitted two additional applications for expansion. The TCEA and the MEA license amendment applications were submitted in 2010 and 2012, respectively. Each application addresses the cumulative environmental effects relevant at the time of submission; however, evolving business decisions have altered the planned sequence of activities.

This section evaluates the potential cumulative effects resulting from the proposed MEA project when added to other past, present, or reasonably foreseeable future actions (RFFAs). With the exception of 136 acres of the TCEA license boundary that extends into Sioux County, the proposed expansion projects are all located in Dawes County, Nebraska and within the Nebraska-South Dakota-Wyoming Uranium Milling Region as defined in the NRC GEIS (NRC 2009). The GEIS analyzed cumulative effects from proposed ISR facility construction, operation, groundwater restoration, and decommissioning by identifying and considering other past, present, and RFFAs in the Nebraska-South Dakota-Wyoming Uranium Milling Region. This analysis uses the GEIS methodology for cumulative effect analysis and provides updated information regarding past, present, and RRFAs near the Crow Butte Operation. The geographic boundary or Resource Study Area (RSA) for each resource is addressed in the cumulative impact analysis discussions of this section.

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4.14.1 Introduction

As stated in each of the applications, CBR would use the additional mineral resource available at the expansion areas to replace the declining resource at the CPF site. The addition of the expansion areas would be sequenced (brought on line) in a manner that continues production consistent with current CPF levels.

As noted in the MEA application (CBR 2012; ML12160A513), CBR is focused on obtaining an NRC license amendment to the current NRC Radioactive Materials License SUA-1534 and NDEQ permits required for construction and operation of the proposed MEA project. If licenses and permits are granted, construction of the MEA would begin in 2014, with production starting in mid-2015 and extending until approximately 2033.

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Similarly, as noted in the TCEA application (CBR 2010; ML102220278), if licenses and permits are granted, construction of the TCEA would begin in 2015, with production starting in mid-2016 and extending until 2032. CBR plans to use the NTEA to complement the MEA and TCEA operations when their production begins to decline. To accomplish this, the NTEA would be constructed in 2023, with production starting in 2024 and extending until 2032.

This submission is intended to update the timeline, highlight relevant information, and assess the cumulative effects of the proposed approach. The following tables from each application summarize the predicted environmental effects of each expansion area:

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- Table 2-2: Comparison of Predicted Environmental Impacts, Environmental Report, North Trend Expansion Area, pages 2-12 and 2-13;
- Table 2.6-1: Comparison of Predicted Environmental Impacts, Environmental Report, Three Crow Expansion Area, pages 2-9, 2-10 and 2-11; and
- Table 2.6-1: Comparison of Predicted Environmental Impacts, Environmental Report, Marsland Expansion Area, pages 2-11 and 2-12.

Note that fugitive dust emission estimates have been revsed for NTEA, TCEA and MEA, so the values in the above tables will be different.

4.14.1.1 Other Past, Present and Reasonable Foreseeable Future Actions

Crow Butte's CPF is the only operating ISR facility in Nebraska. CBR has identified several additional resource areas in the region near the CPF that could conceivably be developed as expansion areas with satellite facilities. Development of these facilities depends on further expansion area investigations by CBR and the future of the uranium market. If conditions warrant, CBR may submit additional license amendment requests to permit development of these additional resources. However, CBR currently projects that development of these areas would be primarily intended to maintain production allowed under the current license as reserves in the current licensed area and at the expansion areas are depleted.

Other than the CBR expansion projects, there are no other uranium exploration projects underway or proposed within 50 miles (80 km) of the expansion areas. Based on a review of past, present, and RFFAs, CBR has not identified any projects that would occur within the timeframe and geographic context of the proposed expansion projects; therefore, they would not contribute overlapping effects. The past, present, and RFFAs evaluated included uranium recovery projects, coal and other mining projects, oil production and exploration activities, potential wind energy projects, and proposed infrastructure and transportation projects. Identified projects within the region would not have overlapping effects because they were located more than 50 miles (80 km) from the proposed expansion projects or would not be expected to occur within the same timeframes the proposed expansion projects.

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4.14.1.2 Methodology

This analysis of cumulative effects uses the same methodology and significance levels as those used in the GEIS (NRC 2009). The following terms describe the level of cumulative effect:

- Small: The environmental effects are not detectable or are so minor that they would neither destabilize nor noticeably alter any important attribute of the resource considered.
- Moderate: The environmental effects are sufficient to alter noticeably, but not destabilize, important attributes of the resource considered.
- Large: The environmental effects are clearly noticeable and are sufficient to destabilize important attributes of the resource considered.

CBR has taken the information in the NTEA, TCEA, and MEA applications, especially the tables in the ER Attachment, and compiled two tables. **Table 4.14-1** reiterates the individual effects described in each application and describes the effects of the combined CBR activities. **Table 4.14-2** presents the unavoidable combined environmental effects of the combined CBR activities, along with CBR's proposed mitigation measures.

The existing CPF would transition to the proposed expansion areas to allow continued production at current levels. Late in the project life (2025 to 2040), all three expansion areas and the existing CPF would be operational with varying levels of activity.

There are no other ISR or industrial facilities in the vicinity of the proposed expansion areas. Other than the CBR uranium recovery activities, no known planned uranium recovery operations were identified in Nebraska. There are no other operating or proposed uranium recovery facilities located within a 50-mile (80 km) radius of the proposed expansion projects. Therefore, the cumulative effects associated with implementation of the proposed expansion projects are primarily limited to the combined effects when all of the proposed CBR operations and facilities are operating simultaneously.

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Other operating and proposed uranium facilities exist within the Nebraska-South Dakota-Wyoming Uranium Milling Region; however, these facilities would not contribute overlapping effects because they are more than 50 miles from the proposed expansion projects. The operating uranium recovery facility closest to the proposed expansion projects is the Smith Ranch-Highland uranium ISR facility located near Douglas (Converse County) in eastern Wyoming (NRC 2009). The proposed uranium ISR facilities closest to the proposed expansion areas that have filed applications are Powertech Uranium's Dewey-Burdock facility in Fall River and Custer Counties of South Dakota and Uranium One's Moore Ranch project in Converse County, Wyoming. These facilities are located more than 65 miles from CBR in the neighboring States of Wyoming and South Dakota.

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4.14.1.3 Analysis of Effects

Cumulative effects are described by resource in the following subsections. The resource areas addressed in the cumulative effects analysis include land surface, land use, transportation, geology and soils, surface water, groundwater, ecological, air quality, noise, historic and cultural, socioeconomics, non-radiological health, radiological health, waste management, and mineral resource recovery.

Land Surface

No planned land development projects were identified in the surrounding region of the proposed project. Construction of the expansion projects would require temporary and relatively superficial surface disturbances for construction of satellite plants and appurtenant facilities. There are only a few areas to be disturbed such that subsoil and geologic materials are removed, causing significant topographic changes that would need backfilling and re-contouring. Late in the project life, the footprint of the satellite plants and appurtenant facilities within the three expansion areas would result in a combined long-term ground disturbance of approximately 58 acres.

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Effects to the land surface would be mitigated 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 re-establishment of drainage patterns would be accomplished by returning the earthen materials moved during construction to their approximate original locations. In combination with other past, present, and RFFAs, implementation of the proposed expansion projects would result in a small cumulative increase in land surface disturbances.

Land Use

No planned land development projects were identified near the proposed project. The original license area for the CPF site is approximately 2,861 acres, and the surface area affected over the estimated life of the project is approximately 2,000 acres. Late in the project, when all three expansion areas and the existing operation are operating simultaneously, the expansion areas will displace an additional combined total of approximately 2,543 acres (assuming only 11 MUs) from crop production or livestock grazing. Wheat and hay are the major crops grown on croplands within the area. In 2007, Dawes County had 44,100 acres of cropland used to grow alfalfa hay and 43,445 acres used for winter wheat (NASS 2009).

Dawes County is composed of approximately 202,946 acres of cropland and 616,467 acres of permanent pasture and rangeland (other than cropland and woodland pastured), for a total of 819,413 acres of agricultural land (NASS 2013). The land uses displaced by the CBR proposed projects represent approximately 0.003 percent of this total agricultural land in Dawes County. Landowner mineral royalties and leases will offset the loss of crops. Considering the relatively small size of the area affected, the exclusion of agricultural activities from the expansion areas over the life of the operation should not have a significant effect on local agricultural production.

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These effects would occur over the life of the project; however, once mining is completed, these effects would be reversible by returning the land to its former cropland or rangeland uses through post-mining surface reclamation. Mitigation measures for the loss of agricultural production over the course of the project are discussed in Section 5.1. When considered with all the other past, present, and RFFAs in the vicinity, implementation of the proposed expansion projects would result in a small cumulative effect on land uses.

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Transportation

Over the long term, the volume of traffic on public roads would increase proportional to regional population growth. No planned transportation projects were identified in Dawes or Sioux

Counties. The annual average 24-hour total and heavy vehicle count for U.S. Highway 20 at the eastern approach to the City of Crawford for 2010 was 1,190 and 145, respectively (NDOR 2010). The 2010 average daily traffic counts for a segment of Highway 2/71 near the Four Mile Road intersection was 755 vehicles, including 95 heavy commercial vehicles (NDOR 2010).

At the peak of activities, the heavy truck traffic and additional vehicle traffic associated with the CBR facilities would increase to 1,000 trips per year and 12 to 16 trips per day, respectively. Relative to the current traffic volume on U.S. Highway 20 and Nebraska Highway 2/71, the additional traffic related to operation of the expansion areas would represent an increase of less than 5 percent. The additional traffic related to the construction and operation of the expansion areas would not significantly affect these main routes. In the area around the City of Crawford, the increased traffic is not anticipated to be unnoticeable because U.S. Highway 20 and Nebraska Highway 2/71are both significant transport routes.

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The additional traffic also would accelerate the rates of county road degradation and increase maintenance costs. The costs associated with Dawes County road maintenance, however, would be offset by tax revenues and CBR's assistance with maintenance materials, such as gravel, road signs, and new culverts. Consequently, when considered with all the other past, present, and RFFAs in the vicinity, the expansion projects would result in a small increase in cumulative effects on transportation facilities.

Geology and Soil

The proposed expansion projects would have no effects on geology. Therefore, there would be no cumulative effects.

Soils in the area would continue to be disturbed from past, present, and RFFAs. With proper implementation of BMPs to prevent erosion and control sediment, however, cumulative effects to soils are not expected to be significant. Rather, the proposed expansion projects would result in minimal or no cumulative effects to soils.

Surface Water

Population projections (see Section 2.3) suggest that future water use near the expansion areas would likely be similar to current conditions. Development of irrigation within the license area is unlikely because water supplies, topography, and climate are limiting. Irrigation within the review area is anticipated to be consistent with past practices (e.g., limited irrigation in the immediate vicinity of the White River). It is anticipated that the City of Crawford's municipal water supply would continue to be provided by the groundwater and infiltration galleries related to the White River and associated tributaries. Past, present, and RFFAs in the area are expected to result in no effects or only minimal effects to surface water effects. This conclusion is based on the determination that BMPs, including SPCC plans and SWPPPs, will be implemented to prevent erosion and control sedimentation. Therefore, the proposed expansion projects would result in minimal or no cumulative effects to surface water quality.

Groundwater

Uranium mineralization is limited to the basal sandstone of the Chadron Formation, which is isolated from underlying and overlying sands. Because the basal sandstone of the Chadron Formation (production zone) is a deep confined aquifer, the mining operations are expected to

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affect water quality only in the area of mining influence within this formation. Restoration will be conducted in this formation following completion of mining, restoring the groundwater to acceptable water quality levels approved by the NDEQ and NRC.

There is no documented domestic or agricultural use of groundwater from the basal sandstone of the Chadron Formation in the vicinity of the proposed expansion areas; therefore, no effects to other users of groundwater are anticipated.

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CBR has evaluated the cumulative impact of the operations of the MEA, TCEA, NTEA, and CPF mining activities as per the proposed timeline of development. The results of this evaluation are discussed below.

Potential cumulative impacts to groundwater resources are expected to be minimal due to the site controls and distance from the MEA site to the CPF and proposed TCEA and NTEA. The operational control and instrumentation systems and excursion monitoring system to be used at the MEA site are designed to quickly detect potential excursions and any leaks, spills, or releases. Therefore, any area of impact would be considered to be small. These same conditions will also apply to operations at the proposed NTEA and TCEA, and already apply at the CPF site. Therefore, it would be extremely unlikely for any groundwater impacts reaching beyond the license boundary at the MEA site, as well as the CPF, NTEA, and TCEA could contribute to any cumulative impacts.

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The NRC has indicated a concern with potential cumulative impacts on groundwater from operating multiple ISR facilities in the Crawford basin. In an effort to address these concerns, an evaluation of the potential cumulative impacts associated with development of expansion areas was conducted, and includes an assessment of water levels and water quality in the basal sandstone of the Chadron Formation, as well as overlying and underlying aquifers. Additionally, the effect of DDW operation on the Morrison and Sundance Formations was assessed. Existing water level data collected prior to and during active mining at the CPF site and expansion areas, hydraulic testing results, water quality results, and DDW design calculations were consulted in conjunction with the anticipated mine development and production timelines to assess potential cumulative impacts.

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Water Level Impacts

As has been demonstrated at the CPF, water levels in the basal sandstone of the Chadron Formation have decreased approximately 60 feet due to production (bleed rate implementation) in order to maintain an inward hydraulic gradient. Water quality in the basal sandstone of the Chadron Formation is considered poor compared to the shallower Brule formation. Therefore, there are limited wells completed in the basal sandstone of the Chadron Formation to allow for monitoring of offsite water levels. According to a 1991 Industrial Groundwater Use Permit, water levels in Crawford are expected to decrease up to 20 feet from static levels as a result of mining operations at the CPF site (CBR 2007).

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Additionally, pumping tests have been conducted in the basal sandstone of the Chadron Formation at similar rates as anticipated production bleed rates. These tests have generally been less than 3 days in duration, and have resulted in estimated water level decreases greater than 1 foot at a distance up to 5,700 feet from the pumping well (Petrotek 2002). The cone of depression would continue to expand during long-duration pumping, as is the case during

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production and groundwater restoration activities. Therefore, the results of pumping tests as well as observed and projected water levels resulting from the CPF mining operations indicate that water levels in the basal sandstone of the Chadron Formation will decrease in a mining unit, with drawdown propagating up to several miles from the pumping center.

Observed water levels in the overlying Brule Formation resulting from CPF mining operations and during pumping tests indicate the basal sandstone of the Chadron Formation and Brule Formations are hydraulically disconnected. Therefore, sustained water level decreases in the basal sandstone of the Chadron Formation are expected to have an insignificant effect on Brule Formation water levels.

The disposal option for process bleed water and groundwater restoration that is likely to impact groundwater levels or water quality is injection into the Morrison and/or Sundance Formations using DDWs. Each expansion area is expected to operate up to two DDWs. Characterization of the injection zone of DDW #2 at the CPF site indicates that the formation thickness is approximately 67 feet. In order to calculate a radius of influence resulting from DDW injection over the course of 10 years, mobile porosity was assumed to be 10 percent. The radius of influence resulting from injecting 45 gpm into a single well over 10 years is approximately 1,200 feet. The calculated radius of influence assumes uniform flow across the full injection interval (thickness) and area, and that no impediments to injection such as injection pressure or aquifer boundaries exist. While DDW configurations and locations at each expansion area are not yet determined, this calculation provides some estimate of the area where DDWs will displace formation groundwater, which may result in increased pressures or redistribution of groundwater to adjacent areas.

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Potential cumulative impacts associated with groundwater drawdown are expected to be minimal due to site controls and distance from the MEA site to the CPF and proposed TCEA and NTEA. This position is supported by a drawdown analysis conducted by Cameco in July 2013 (**Appendix W**). A simple hydrologic drawdown-distance analysis, using the Theis (1935) equation for confined aquifers, was conducted to estimate the drawdown at the MEA. The analysis used the water balance disposal estimate for the year 2024, which corresponds to the tenth year of operations. The year 2024 in the Marsland water balance is the year when the highest consumptive ground water is assumed. The analysis assumes that four mine units are in restoration with an estimated 250 gpm of consumptive water use, and five mine units are in production with a bleed stream of 65 gpm. The total consumptive water use estimated for that year is 315 gpm. The 315 gpm consumptive water use represents the worst case water for water use during the operation of the MEA.

The drawdown for the Crow Butte Project referenced in Section 4.4.3.1 states that based on the operating data, the available head over the formation has been reduced 10 percent, or for every 100 ft of water column over the formation, the column has been reduced by 10 ft.

The drawdown analysis of the MEA estimates that the drawdown during worst case year of operation is approximately thirty feet in the areas where active restoration is occurring. The estimated drawdown is about 6 to 7 percent of the total head available. The static water level at Marsland is about 465 ft, and the expected water level during the tenth year of operations is estimated to be 435 ft. The draw down in the basal sandstone of the Chadron Formation, at the monitor well ring, is approximately 15 ft and the worst case drawdown at the edge of the 2.25

mile review area will be about 2 ft. As such, this analysis of the MEA is in reasonable agreement with the actual operating data from the CBR Mine.

Private wells within a 2.25 mile radius of the MEA and found that All of the registered wells and nonregistered wells within a 2.25-mile radius of the MEA were not completed in the basal sandstone of the Chadron Formation. All of the known well completions are completed in the overlying Brule and Arikaree formations, because the wells are much shallower (60' to 300') than the basal sandstone of the Chadron Formation (1000 ft +), and the water quality of the overlying formations is superior to the basal sandstone of the Chadron Formation. Further, the pumping test demonstrated the integrity of the confining layer that separates the aquifer in the basal sandstone of the Chadron Formation from the overlying aquifers.

~~Cumulative impacts to aquifer water levels resulting from operation of expansion area mines should consider the duration of overlap and formation where impacts are likely to occur. In the basal sandstone of the Chadron Formation, drawdown associated with production at NTEA (start date in 2021), MEA (start date in 2015), and TCEA (start date in 2016) will all overlap with the final years of groundwater restoration at the CPF site. Based on the water level decreases expected to occur onsite and propagate out from each mine, overlapping drawdown in the basal sandstone of the Chadron Formation is expected. In the years 2024 through 2038, it is possible that each expansion area mine may be drawing water from the basal sandstone of the Chadron Formation. During this period, the overlapping water level decrease is expected to be greatest in the center point between two mines, and will likely be on the order of tens of feet. As restoration activities at the TCEA and MEA conclude (anticipated to be completed in 2038 and 2039, respectively), the only withdraw of basal sandstone of the Chadron Formation water will be at the NTEA. Few monitoring wells exist in the basal sandstone of the Chadron Formation outside mining lease boundaries, making extrapolation of observed onsite water level drawdowns resulting from CPF activities challenging. Therefore, quantification of overlapping water level drawdown resulting from simultaneous operation of multiple mines is difficult. However, the operation of multiple mines is expected to cause potentiometric surfaces in the basal sandstone of the Chadron Formation to decrease tens of feet in locations where overlap occurs.~~

Potential cumulative impacts to the Morrison and Sundance Formations resulting from operation of DDWs at expansion area mines are unclear. While radius-of-influence calculations indicate the area where formation water will be displaced by injected water, it is unclear where the displaced water migrates. The ability of these confined aquifers to accept injected water is limited by the presence of overlying and underlying confining units, aquifer storage, and hydraulic connection within the injected formation and with adjacent aquifers. Little characterization of the Morrison or Sundance Formations is available in the area of interest that would enable a meaningful evaluation of overlapping influences among the four mines.

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Surface water levels have been shown to be unaffected by current mining operations, as no discharge to surface water is permitted, and the deep disposal aquifers appear to be hydraulically disconnected from surface water. No changes to the lack of surface water impacts are expected as a result of expanded mining operations.

Water Quality Impacts

Water quality in the basal sandstone of the Chadron Formation during mining is controlled by induced hydraulic gradients toward the mine unit that limit injectate excursions. Monitoring wells outside the production wellfield are sampled biweekly to ensure that extraction wells are adequately removing the injectate. Changes to extraction well pumping rates are made to remedy observed injectate excursions that are indicated by perimeter monitoring well water quality results. Therefore, water quality in the basal sandstone of the Chadron Formation is not expected to be significantly affected during mining.

Mining unit-specific groundwater restoration water quality goals are determined as endpoints for restoration activities. During groundwater restoration, water is returned to at or near background conditions using the best practice technology for treatment. If background concentrations for mining-related groundwater constituents cannot be achieved using best practice cleanup technologies, NDEQ groundwater standards become the restoration goal. The objective of groundwater restoration is to return water quality back to that which is consistent with pre-mining use. Future use of groundwater is not expected to be affected by mining activities.

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The combined water quality controls in place during mining and aquifer restoration goals should result in water quality in mine units that are not significantly different than background and do not influence future use. Therefore, cumulative influences on water quality of the basal sandstone of the Chadron Formation resulting from operation of multiple mines is not expected. Injected water quality in the Morrison and Sundance Formations is monitored daily or weekly, depending on the parameter, and reported to the NDEQ monthly. Therefore, water quality in the deep injection formations will not be adversely impacted beyond what is permitted due to operation of DDWs at multiple mines as long as injectate water quality does not deviate from permit limitations.

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Conclusions

Water levels in the basal sandstone of the Chadron Formation have been shown to decrease near an active mine unit, with potentiometric surface depressions expanding several miles after years of active mining. This provides hydraulic control of injected water in order to minimize excursions that cause water quality issues. However, these water level decreases are expected to radiate from all mines that simultaneously draw water from the basal sandstone of the Chadron Formation during either production or groundwater restoration, and will induce overlapping potentiometric surface cones of depression. It is unclear as to the magnitude of decreases that may result from pumping at multiple mining areas, but it is expected to be on the order of tens of feet. The majority of the regional water wells are completed in the Brule Formation, and not the basal sandstone of the Chadron Formation, as water from the Brule Formation is preferred due to higher water quality and the preference for shallower wells.

Wastewater injected into the Morrison and Sundance Formations using DDWs will likely have injected radii of influences of greater than 1,000 feet. These injections will displace formation groundwater, although it is unclear where that water will migrate. Little characterization of the Morrison and Sundance Formations has been completed, and only observations of injection pressures and flowrates can be used to infer the ability to dispose of water using this method. The Morrison Formation has demonstrated the capacity to accept large volumes of an injected waste stream over an extended period of time at the nearby CPF.

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The subsurface geologic characteristics beneath the proposed expansion areas will prevent disposal fluids injected into the DDW injection zone from impacting the overlying fresh water aquifers. Between the lowermost drinking water source aquifer and the DDW injection are more

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than 2,500 feet of sediments primarily consisting of low permeability shale. This separating aquitard protects against vertical migration of injected fluids to the drinking water source aquifers. Shales above and below the DDW injection zone will encase the disposal fluids within the receiving formations, and no structural elements with the potential to disrupt the natural vertical containment have been identified.

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Water quality in the basal sandstone of the Chadron Formation during production is maintained by providing hydraulic control of the injectate. Extraction well operations are adjusted to remedy observed injectate excursions. Formation water quality is restored to either background conditions or conditions that are consistent with pre-mining water quality under the direction of the NDEQ. As a result, no significant degradation of water quality is expected to result from operation of expansion area mines. Water quality of the Morrison and Sundance Formations is protected by permitted specifications on injectate water quality. Therefore, if permit limitations are not exceeded, there will be no adverse cumulative impact beyond permitted levels as a result of operation of multiple mines. The EPA and NDEQ will not authorize deep disposal via a Class I injection well unless the permitting process demonstrates that adequate operating procedures and controls will be in place and the well will be properly sited so that the confinement zones and proper well construction minimize the potential for migration of fluids outside of the approved injection zone. The conditions and conclusions addressed in this section apply to the current CPF operations and the proposed MEA, TCEA, and NTEA sites.

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Ecological

Mixed-grass prairie habitat in the area would continue to be disturbed from past, present, and RFFAs. The project would add to the effects of other past, present, and future activities occurring in the region, including the effects of other past, present, and future uranium mining operations. Significant cumulative effects to ecological resources are not anticipated because no substantive impairment of ecological stability or diminishment of biological diversity within the expansion areas is expected to occur as a result of the proposed project.

The most substantial of these effects would be the loss of mixed-grass prairie habitat. However, because the overall long-term surface footprint of the project would be minimal, and much of the area proposed for disturbance during the construction phase would be promptly reclaimed to the pre-existing contour and cover type, long-term loss of mixed-grass prairie habitat would have a minor effect on regional ecological resources. Similarly, disturbance to wildlife from noise, construction, and operational activities would initially have a minor cumulative effect on the region's wildlife. This effect would diminish over time as human presence decreases after the construction phase is completed. Implementation of the proposed expansion projects would result in a small incremental effect on ecological resources when considered with all the other past, present, and RFFAs in the vicinity.

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Air Quality

Agricultural activities and vehicles traveling on public roads would continue to generate dust and vehicle emissions. Implementation of the proposed project would result in fugitive dust and pollutant emissions from the combustion of fuel to power the engines of construction vehicles and equipment. Combustion of gasoline and diesel fuels by combustion engines (e.g., vehicles, generators, construction equipment) would generate local emissions of PM, NO_x, CO, VOCs, and SO_2 during the site preparation and construction period. While construction equipment specs,

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including size, number of vehicles, and the hours each piece of equipment would operate, are not quantified, the emissions for these operations would be small.

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When all three expansion areas and the existing Crow Butte Operation are operational, the maximum combined dust emissions would be approximately 90 ~~55.1~~ tons per year for uncontrolled emissions. A comparison of the fugitive emission dust estimates associated with unpaved and paved roads is as follows:

Site	Uncontrolled Emissions			Controlled Emissions	
	Onsite	Offsite		Onsite	Offsite
	Unpaved	Unpaved	Paved	Unpaved	Unpaved
NTEA	6.53	7.62	0.127	5.87	6.85
TCEA	12.5	18.98	0.126	11.25	17.08
MEA	14.5	28.93	0.58	13.05	26
Total	**33.53**	**55.53**	**0.833**	**30.17**	**49.93**

Mitigation measures, such as the application of water to unpaved roads would be implemented as necessary, along with speed limits on the mine property. In addition, gravel that exists on offsite public unpaved roads contributes to some control efficiency, due to reduction in silt content. The controlled emissions listed above are based on using a 10 percent control efficiency.

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As far as cumulative impacts, the MEA is located to the south of the Pine Ridge Escarpment, whereas the NTEA, TCEA, and CPF sites are located to the north of the escarpment in the Crawford Basin (**Figure 1.1-3**). The escarpment rises roughly 300 to 900 feet above the basal plain and bounds three sides of the Crawford Basin. The distances of the nearest license boundaries of the CPF, TCEA and NTEA sites to the nearest MEA license boundary are 6, 9.1 and 12.4 miles, respectively. Therefore, fugitive dust emissions from the MEA site are not expected to contribute to cumulative impacts in the Crawford Basin area, nor or the NTEA, TCEA, and CPF emissions expected to impact the MEA area.

Along with other past, present, and RFFAs, the combined emissions of the proposed expansion areas and the existing operation are not anticipated to jeopardize NAAQS attainment status in the region or impair visibility within any federally mandated PSD Class I area. Consequently, implementation of the proposed expansion projects would result in small cumulative effects on air quality when considered with other past, present, and RFFAs in the vicinity.

Noise

Agricultural activities, vehicular traffic, and heavy train traffic in the vicinity of the expansion areas contribute to regional noise effects. Under implementation of the proposed expansion projects, the sources of noise would be widely dispersed and barely perceptible over the background noise. Implementation of the proposed expansion projects would result in small cumulative effects on noise when considered with other past, present, and RFFAs in the vicinity because of the rural nature of the area.

Historic and Cultural

The cumulative effects area for cultural resources is defined as each of the expansion areas (NTEA, TCEA, and MEA) and a 1-mile radius around each of these expansion areas. No traditional cultural areas or historic properties have been identified in the general area that would

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merit consideration of a larger area of potential effects. Records searches have been completed for each of these cumulative effects areas, and complete intensive cultural resource inventories have been completed for each of the expansion areas. A variety of potentially important prehistoric and historic resources are present in the general area, including Fort Robinson State Historic Park north of the TCEA. There are historic properties within the Fort Robinson State Historic Park near the TCEA. However, sites within the park are protected and would not be adversely affected. One previously reported historic structure in the MEA is recommended potentially eligible for the NRHP and is therefore a historic property. This historic property would be avoided. The project would have no effect to historic properties. Therefore, the project would not contribute to cumulative adverse effects to historic properties in combination with past, present, and RFFAs.

Visual/Scenic

Other than public roads and the existing Crow Butte Operation, there are no contributions to cumulative visual resource effects from past, present, and RFFAs. The structures within the proposed expansion areas would be visible from public roads and residences near the expansion areas; however, contrasts would be low to moderate. The TCEA is located in scenic landscape of the Pine Ridge area of northwestern Nebraska and is visible from sensitive viewing areas. Sensitive viewing areas in the TCEA include Four Mile Road, the primary transportation route through the TCEA, and rural residences. Fort Robinson State Park (Park), which is located to the north of the TCEA, is also a sensitive viewing area because of the potential visibility of proposed facilities to Park visitors. The lines and textural contrasts of the well houses, the satellite plant, and appurtenance facilities would be obvious to viewers at the sensitive viewing areas, but would be subordinate to the rural landscape.

The visual/scenic effects of the proposed expansion projects would be minimal because the expansion areas are dispersed, and the rolling terrain restricts or prevents simultaneous line of expansion area viewing of multiple facilities. Wellhead covers would be visually subordinate to the landscape in the foreground-middleground distance zone. The buildings at the satellite plants would be painted to harmonize with the surrounding soil and vegetation cover. With implementation of mitigation measures, such as aligning roads with existing topographic contours and avoiding straights lines, visual effects would be minimized.

Over the long term, the VRM Class III objectives would be met by the proposed project facilities within the expansion areas. Hence, implementation of the proposed expansion projects would result in a small incremental effect visual/scenic resources.

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Socioeconomics

Total employment in Dawes County in 2010 was 5,691 (BEA 2011). CBR currently employs a workforce of approximately 68 employees and two contractors with 14 employees. CBR currently provides approximately 1.5 percent of all employment in Dawes County. CBR payroll represents about 4 percent of the total Dawes County wage and salary payments. The majority of CBR's employees have been hired from the surrounding communities.

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When all three expansion areas and the Crow Butte Operation are operational, the combined total number of employees would increase by fewer than 30 workers compared to current staff. During construction, CBR expects to supplement the existing workforce for the proposed

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expansion project with an additional 10 to 12 full-time employees, four to seven full-time contractor employees, and 10 to 15 part-time employees and short-term contractors. The full- and part-time employees would be needed for operations at each of the expansion areas and to fill 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. Because skills and services required for the proposed expansion projects would be available in the existing local labor force, the proposed project is not anticipated to require migration of additional workers into the nearby City of Crawford and City of Chadron, or Dawes County. It is anticipated that the workforce and contractors required for the proposed project would result in nominal effects on local services because the total CBR employment would continue to represent approximately 4 percent of the employment in Dawes County.

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Monetary benefits would continue to accrue to the community from the presence of the existing Crow Butte Operation. Continued operation of the project simultaneously with the expansion areas would provide significant tax revenues to Dawes County similar to current conditions. In addition, mineral royalty payments accrue to local landowners, most of whom are residents of Dawes County. Future tax revenues depend on uranium prices, which cannot be predicted with accuracy; however, these taxes also somewhat depend on the number of pounds of uranium produced by CBR.

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Beneficiaries of CBR contributions to the General Fund, and therefore to Dawes County government subdivisions, include school districts, fire districts, county and municipal government agencies, and the White River Natural Resource District. Against these monetary benefits are the monetary costs to the communities near the project, such as those for county road maintenance. The current mine operation has not resulted in any significant effect to the community infrastructure (including schools, roads, water and sewage facilities, law enforcement, medical facilities, and any other public facility) in the City of Crawford or in Dawes County.

No adverse environmental impacts would occur to the local population from proposed project activities. Hence, construction and implementation of the proposed expansion areas would have no disproportionate adverse impacts to minority populations or people living below the poverty level.

CBR currently provides a positive economic impact to the local Dawes County economy. Development of the proposed expansion projects would have a positive impact on the local economy. Transition from operations at the current permitted CBR facilities to the proposed expansion areas would allow the uninterrupted continuation of these contributions towards the funding of Dawes County government subdivisions. The proposed expansion projects would result in beneficial socioeconomic effects to county revenues and local businesses similar to current conditions. Implementation of the proposed expansion projects would result in a small incremental effect on socioeconomics when considered with all the other past, present, and RFFAs in the vicinity.

Nonradiological Health

Over the long term, regional population increases agricultural activities would continue to generate wastes with a proportional potential for releases of non-radiological waste materials. The proposed facilities would be designed and constructed to minimize the potential for release of non-radiological wastes. Because production rates would continue similar to current levels, the amounts of nonradiological waste materials generated would approximate current conditions, and the risk of health or environmental effects would be similar to existing conditions. With implementation of the SPCC Plans and other standard operational procedures, the proposed expansion projects would not affect non-radiological health; therefore, there would be no cumulative effects.

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Radiological Health

For residents in the vicinity of the current Crow Butte Operation and the proposed expansion areas, the cumulative TEDE for all simultaneous operations was presented in Table 4.12-1 of the TCEA application. Table 4.12-1 demonstrates that the annual dose limit of 100 mRem/year found at 10 CFR §20.1301 would be attained. The MEA is sufficiently distant that it would contribute only 0.3 mRem/year under typical operating conditions in the vicinity of the City of Crawford. The highest dose rate at cities and towns within 50 miles of the MEA was 0.5 mRem/yr at the Town of Marsland, which is located approximately 7.2 miles from the MEA satellite facility.

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On October 17, 2006, CBR submitted a license amendment request to the NRC requesting an increase in the licensed flow at the CPF. License Condition 10.5 of SUA-1534 limited current operation to an annual facility throughput of 5,000 gpm exclusive of restoration flow. CBR requested an amendment to this license condition to increase production and assist restoration efforts. The production increase was to be accomplished by expanding the existing facility and mining existing wellfields to lower levels of soluble uranium. CBR requested approval to increase the annual facility throughput to 9,000 gpm exclusive of restoration flow. The amendment request did not change the annual licensed production rate of 2,000,000 pounds of U_3O_8 per year. NRC issued the license amendment on November 30, 2007.

The only environmental effect of the increased flowrate at the current operation is a corresponding increase in the emission of radon-222 from the current operation. The amendment estimated a 22 percent increase in the maximum public dose, and that the maximum public dose would remain well below the limit found in 10 CFR § 20.1301. Implementation of the proposed expansion projects would result in a small incremental effect on radiological health when considered with all the other past, present, and RFFAs in the vicinity. Implementation of the proposed expansion projects would result in a small incremental effect on radiological health when considered with other past, present, and RFFAs.

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Waste Management

Over the long term, regional population increases would result in generation of additional waste loading on disposal facilities; however, the capacities of local and remote waste disposal facilities are anticipated to remain adequate for the life of the project. Under implementation of the proposed project, relatively small quantities of solid wastes and no significant health or environmental effects are anticipated. Because production rates would remain similar to current levels, the amount of wastes generated would approximate current conditions. When considered with other past, present, and RFFAs, implementation of the proposed expansion projects would result in small incremental effects associated with non-radiological health.

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Mineral Resource Recovery

The only mineral known to be present in recoverable amounts that is economical for the proposed expansion areas and the CPF is uranium.

Local or regional gas and oil exploration and production operations are not expected to generate cumulative impacts in associated with the development of the proposed expansion areas. Historically, there have been approximately 137 oil and gas exploration wells, with more than 100 drilled in the 1950s through the 1970s, completed in Dawes County (NOGCC 2013a). All of these wells were abandoned, most recorded as dry holes. A total of 15 plugged and abandoned oil and gas exploration wells are located within the AORs of the MEA, NTEA, and TCEA. These wells were drilled between 1952 and 1981.

According to the NOGCC, there has never been any oil and gas production in Dawes County (NOGCC 2013b). There are no current applications for permits to drill in Dawes County (NOGCC 2013c). Two wells are currently producing in Sioux County, but are located at a significant distance southwest of MEA in Section 8 Township 25 North, Range 55 West and Section 11 Township 25 North, Range 56 West (NOGCC 2013a). For the months January through October 2012 and November through December 2011, there were no drilling permits issued for Dawes, Sheridan, or Box Butte Counties (NOGCC 2013d). There were four drilling permits issued for Sioux County, primarily in the southern part of the county. NOGCC annual production records for 2005 through 2012 indicated production for Sioux County, but no oil and gas production for Dawes, Box Butte, and Sheridan Counties (NOGCC 2013c).

The only non-fuel mineral produced in Dawes County is sand and gravel. The state's coal resources are insignificant and not economical to mine (NEO 2013); therefore, coal is not produced anywhere in Nebraska. Consequently, economical viable coal beds are not expected to be encountered during drilling within the MEA. Based on the above findings, it is concluded that there will be no cumulative impacts on other mineral resources underlying the proposed expansion areas.

CBR obtained surface and mineral leases from the appropriate landowners necessary to construct and operate the proposed ISR facilities. Uranium mineralization is limited to the basal sandstone of the Chadron Formation. There are no other uranium recovery facilities in Nebraska. Mineral resource recovery would remain similar to current conditions; therefore, implementation of the proposed expansion projects would result in no cumulative effects on mineral resource recovery.

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Table 4.1-1 Acres Disturbed by MEA Satellite Facility, Mine Units, and Access Routes

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Table 4.4-1 Crow Butte Resources Excursion Summary

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Table 4.10-1 Tax Revenues from the Current Crow Butte Project

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Table 4.10-2 Current Economic Impact of Crow Butte Uranium Project and Projected Impact from MEA

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Table 4.12-1 Radiation Dose Rates to Receptors Within 80 Km Radius of the MEA Site

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Table 4.12-2 Public and Occupational Doses for Marsland Expansion Area

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Table 4.12-3 Radiation Doses Calculated from Different Percentage Releases from the MEA Mine Units and the Satellite Facility

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Table 4-14.1 Combined Effects of North Trend, Three Crow and Marsland Expansion Areas

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Table 4.14-2 Unavoidable Combined Environmental Effects of North Trend, Three Crow and Marsland Expansion Areas

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Figure 4.12-1 Marsland Human Exposure Pathways for Known and Potential Sources of Radiological Emissions

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Figure 4.12-2 MILDOS Receptors Residences and Designated MEA License Boundary Locations

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Figure 4.12-3 MILDOS Receptors Cities and Towns in Region around MEA

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5 MITIGATION MEASURES

5.1 Land Use Impact Mitigation Measures

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

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Decommissioning of the wellfield and process facilities will be scheduled after agency approval of groundwater restoration. Decommissioning will be accomplished in accordance with an approved decommissioning plan and the most current applicable NDEQ and NRC rules and regulations, permit and license stipulations, and amendments in effect at the time of decommissioning.

The following is a list of general decommissioning activities:

- Plug and abandon all wells as detailed in Section 5.1.3.1.
- Determine appropriate cleanup criteria for structures (Section 5.1.4) and soils (Section 5.1.5).
- Conduct 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.
- Remove from the site all contaminated equipment and materials to an approved licensed facility for disposal or reuse, or relocate to an operational portion of the mining operation as discussed in Section 5.1.4.
- Decontaminate items to be released for unrestricted use to levels consistent with NRC requirements.
- Survey excavated areas for contamination and remove contaminated materials to a licensed disposal facility.
- Perform final site soil radiation surveys.
- Backfill and re-contour all disturbed areas.
- Establish permanent revegetation on all disturbed areas.

The following sections generally describe the planned decommissioning activities and procedures for the CBR facilities. These activities and procedures will apply to the MEA facilities as well as the current facilities. CBR will, prior to final decommissioning of an area, submit to the NRC and NDEQ a detailed decommissioning plan for their review and approval at least 12 months before final decommissioning. As required by 10 CFR 40.36 (f), records important to MEA decommissioning will be maintained in the office of the on-site RSO. Such information shall meet the criteria of 10 CFR 40.42 (g) (4) and (5).

5.1.1 General Surface Reclamation Procedures

The primary surface disturbances associated with the MEA will be the satellite facilities (uranium recovery building, fuel and chemical storage, shop, office, rest rooms, and wellfield production

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areas, and DDWs). Surface disturbances also occur during well drilling, pipeline installation, and road construction. These more superficial disturbances, however, involve relatively small areas or have short-term impacts.

The 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 pre-mining condition. For the CBR area, the reclaimed lands should be capable of supporting livestock grazing and providing habitat for 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 to re-establish original slope and topography and present a natural appearance. Surface reclamation efforts will strive to limit soil erosion by wind, water, and sedimentation and to re-establish natural trough drainage patterns.

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The following sections provide reclamation procedures for the facility sites, wellfield production units, and access and haul roads. Reclamation timelines 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 7.2.9 and include all activities anticipated to complete groundwater restoration, decontamination, decommissioning, and surface reclamation of wellfield and satellite facilities installed. These cost estimates are updated annually to cover work projected for the following year of mining activity.

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5.1.1.1 Topsoil Handling and Replacement

In accordance with NDEQ requirements, topsoil is salvaged from building sites (including the satellite building[s]), DDWs, and any other areas where topsoil is removed for purpose of site development. 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 wellfield, which are determined during final wellfield construction.

As described in Section 3.3.1.6, topsoil thickness varies within the MEA. Topsoil is usually thickest in and along drainages where material has been deposited and deep soils have developed. Therefore, topsoil stripping depths may vary 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 employed 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 perimeters 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 the mud pit is no longer needed, all subsoil is replaced and topsoil is applied. Mud pits generally remain open for 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.

5.1.1.2 Contouring of Affected Areas

Due to the relatively minor nature of disturbances created by ISR mining, there are only a few areas where subsoil and geologic materials are removed, causing significant topographic changes that need backfilling and recontouring. Generally, solar evaporation pond construction results in redistribution of sufficient amounts of subsurface materials, which requires replacement and contour blending during reclamation. This is usually one of the major surface disturbances at a uranium in-situ facility. However, no evaporation ponds will be constructed for use at the MEA project site. Therefore, the existing contours at Marsland 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 temporary during the operating period. These changes will be mitigated 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 re-establishment 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 re-established by removing fill materials and culverts and reshaping to as close to pre-operational conditions as practical. Surface drainage of disturbed areas located on terrain with varying degrees of slope will be accomplished by final grading and contouring appropriate to each location to allow for controlled surface runoff and eliminate depressions where water could accumulate.

5.1.1.3 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 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.

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5.1.2 Process Facility Site Reclamation

Following removal of structures as discussed in Section 5.1.4, subsoil and stockpiled topsoil will be replaced on the disturbances from which they were removed during construction, as practicable. 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 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. Motorgraders 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 to establish adequate drainage, and the final prepared surface will be left in a roughened condition.

5.1.3 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. Surfaces will be prepared as needed to blend any disturbed areas into the contour of the surrounding landscape.

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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.
- Buried well field piping will be removed.
- 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 contaminated materials 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 an NRC-licensed disposal facility.

Wellfield decommissioning will be an independent ongoing operation throughout the mining sequence at the CPF and at the MEA. 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.

5.1.3.1 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 CBR well abandonment program is to seal and abandon all wells to protect the groundwater supply and to eliminate any potential physical hazard.

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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. That formation can be used to adjust the amount of bentonite chips needed to plug the well screens and to calculate the minimum weight (lbs/gallon) of abandonment mud used to fill the hole to the surface and keep formation and mining pressures from allowing water to rise in the borehole. A pre-packaged bentonite-filled tube is currently used for plugging 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 descend into the screens. The drill rig then trips the 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 an appropriate abandonment mud is mixed. If the weight of the abandonment mud needs to be increased, barite may be added to increase the weight. Likewise, an appropriate drilling additive may be added to improve the ability of the abandonment mud to carry the barite. In situations where it appears that the operating pressure and formation pressure are great enough to impede mixing of 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, abandonment fluids will be added.

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

- A mechanical plug may be placed above the screened interval.
- Thirty to 50 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 NDNR also requires filing a well abandonment notice for all registered wells.

5.1.3.2 Buried Trunklines, Pipes, and Equipment

Buried process-related piping, such as injection and production lines, will be removed from the MU 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.

5.1.4 Removal and Disposal of Structures, Waste Materials, and Equipment

5.1.4.1 Preliminary Radiological Surveys and Contamination Control

Prior to decommissioning the satellite building, 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 decommissioning activities. In general, the contamination control program used during mining operations 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 water. In areas where contamination is not readily removed by high-pressure water, a decontamination solution (e.g., dilute acid) may be used.

5.1.4.2 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, and other components, will be inventoried, listed, and designated for one of the following removal alternatives:

- Removal to a new location within the CBR site for further use or storage
- Removal to another licensed facility for either use or permanent disposal
- 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.

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/100 cm^2
- Average total of 5,000 dpm/100 cm^2 over an area no greater than 1 m^2

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- 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 (ANSI 1999). In addition, CBR has routinely collected these measurements but has never found them limiting.

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Decontamination of surfaces will comply with the CBR 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 LSA-I material, UN2912, pursuant to 49 CFR 173.427.

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, and other components with water or acid to reduce interior contamination as necessary for safe handling.
- Survey the exterior surfaces of process equipment for contamination. If the surfaces are found to be contaminated, the equipment will be washed down and decontaminated to permit safe handling.
- Disassemble the equipment only to the degree necessary for transportation. All openings, pipe fittings, vents, and other components will be plugged or covered prior to moving equipment from the satellite 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.

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 measuring 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.

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Appropriate decontamination procedures will be used to clean any contaminated areas, the equipment will be resurveyed, and documentation of the final survey will be 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 NRC guidelines. The criteria to be used for release to unrestricted use will be the appropriate NRC guidelines at that time. Release surveys will be based on the release methods discussed in Section 1.4.3.

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 confirm removal of all contamination to appropriate levels.

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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 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.

These areas will be decontaminated as necessary to meet the standards for unrestricted use.

5.1.4.3 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 has a contractual agreement with DUSA for the disposal of 11e.(2) byproduct materials at DUSA's White Mesa Mill site located near Blanding, Utah (CBR and DUSA 2010). The White Mesa Mill is licensed by the NRC to allow the disposal of byproduct material generated as a result of operations at a licensed uranium ISR facility by placement of the byproduct material in the White Mesa Mill's tailings impoundment. For this agreement, the maximum annual volume for disposal is 3,823 m^3 (5,000 yds) of byproduct, which is a common maximum volume for many other agreements with the White Mesa Mill. Unless terminated by either party, the contract shall be automatically renewed each year for a maximum of four additional periods (i.e., up to June 30, 2015 at the latest). At the end of this period, Cameco can seek renewal for a designated period of time. Should Cameco contract with a new disposal facility, Cameco will notify the NRC in accordance with License Condition 9 of SUA-1534.

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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 DOT Hazardous Materials Regulations (49 CFR Part 173) and the NRC transportation regulations (10 CFR 71).

Deleted: 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.. 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. A contract for disposal at a minimum of one facility will be maintained current as required in NRC License SUA-1534.¶

5.1.5 Methodologies for Conducting Post-Reclamation and Decommissioning Radiological Surveys

5.1.5.1 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 5.1-1** and described below.

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 RESRAD runs are shown as Appendix A of the Wellfield Decommissioning Plan for Crow Butte Uranium Project presented in **Appendix N.** 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 ALARA 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 more than 100 m^2. According to the RESRAD runs presented in **Appendix N**, 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 a maximum of 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.

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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 because it has not been demonstrated that these levels can be detected with readily available field instruments.

Section 2.5 of **Appendix N** demonstrates that spills of process solutions at the CPF 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 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.

5.1.5.2 Excavation Control Monitoring

CBR will use 17,900 counts per minute (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.

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Hand-held and global positioning system (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 until 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 radium-226 concentration in soil using data from the few spill-related contaminated areas that existed at the CPF area. CBR believes that 17,900 CPM is a conservative value because the contaminated areas were small in size. The measured gamma emission rate per unit radium-226 concentration from small areas is normally lower than that which would be measured using large areas, such as a 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.

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Section 6.3 of **Appendix N** discusses the development of the 17,900 CPM action level. It does, however, allow for a revision of the number should it later be determined not appropriate.

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5.1.5.3 Surface Soil Cleanup Verification and Sampling Plan

Cleanup of surface soils will be restricted to 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 will be analyzed at an off-site analytical 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 next 10 percent of grid blocks 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 equivalent to the Benchmark Dose.

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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 NRC-approved statistical test will be conducted to demonstrate that the survey method provides for a 95-percent confidence level that cleanup guidelines have been met, as per acceptance criteria 6.4.3 of NUREG-1569 (NRC 2003). An appropriate statistical test for analysis of the survey data as described in NUREG-1575 (Multi Agency Radiation Survey and Site Investigation Manual) will be employed (NRC 2000). If the mean of the sample concentrations is lower than the criterion but the data fail the statistical test, CBR will follow procedures similar to those recommended in NUREG-1575.

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5.1.5.4 Subsurface Soil Cleanup Verification and Sampling Plan

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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 analysis of radium-226 and natural uranium over surveying to verify cleanup of subsurface excavations. The protocols are summarized in site procedures.

5.1.5.5 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 analysis of radium-226 and uranium over surveying to verify cleanup of ditches and impoundments. Surveying is applicable in larger impoundments; however, the effects of geometry are not as pronounced, particularly in areas not influenced by adjacent walls.

5.1.5.6 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 (NRC 2004). 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, SOPs, sample receipt, handling, 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 defined by 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.

5.2 Transportation Impact Mitigation Measures

The additional traffic generated by construction and operation of the proposed MEA may result in the degradation of public road surfaces, particularly local gravel roads maintained by Dawes County. These impacts are expected to be minimal because the additional traffic is not significant in comparison with current traffic levels. CBR contributes to the maintenance of these local roads through tax payments to Dawes County. In addition, CBR has voluntarily assisted Dawes County by providing materials to maintain county roads at the current operation. In the past, these materials have included gravel, road signs, and new culverts. CBR will continue to support Dawes County to mitigate impacts from company operations, including the MEA operations.

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5.3 Soils Impact Mitigation Measures

BMPs have been included in the project description, and will be followed for site preparation to control erosion, minimize disturbance, and facilitate reclamation. The following mitigation measures will reduce the effects to soil resources at the MEA site. BMPs and mitigation measures relevant to soil resources are also discussed in the water quality and reclamation sections of this document.

5.3.1 Sediment Control

- Divert surface runoff from undisturbed area around the disturbed area.
- Retain sediment within the disturbed area.
- Do not direct surface drainage over the unprotected face of the fill.
- Employ appropriately designed and implemented special sediment controls for operations and disturbance on slopes greater than 40 percent.
- Avoid continuous disturbance that provides continuous conduit for routing sediment to streams.
- Inspect and maintain all erosion control structures.
- Repair significant erosion features, clogged culverts, and other hydrological controls in a timely manner.
- If BMPs do not result in compliance with applicable standards, modify or improve such BMPs to meet the controlling standard of surface water quality.

5.3.2 Topsoil

- Topsoil to be removed should be removed prior to any development activity to prevent loss or contamination.
- When necessary to substitute for or supplement available topsoil, use overburden that is equally conducive to plant growth as topsoil.
- To the extent possible, directly haul (live handle) topsoil from the site of salvage to concurrent reclamation sites.

- Avoid excessive compaction of topsoil and overburden used as plant growth medium by limiting the number of vehicle passes and handling soil while saturated and scarifying compacted soils.
- Time topsoil redistribution so seeding or other protective measures can be immediately applied to prevent compaction and erosion.

5.3.3 Roads

Construct and maintain roads to minimize soil erosion by:

- Restricting the length and grade of roadbeds.
- Surfacing roads with durable material.
- Creating stable cut and fill slopes.
- Revegetating the entire road prism including cut and fill slopes.
- Creating and maintaining vegetative buffer strips, and constructing sediment barriers (e.g., straw bales, wire-backed silt fences, check dams) during the useful life of roads.

5.3.4 Regraded Material

- Design regraded material to control erosion using activities that may include slope reduction, terracing, silt fences, chemical binders, seeding, mulching, and other techniques.
- Divert all surface water above regraded material away from the area and into protected channels.
- Shape and compact regraded material to allow surface drainage and ensure long-term stability.
- Concurrently reclaim regraded material to minimize surface runoff.

Implementation of the above BMPs, SPCCs, and SWPPPs will minimize effects to soils associated with the construction of the satellite facility.

5.4 Water Resources Impact Mitigation Measures

5.4.1 Groundwater Quality Impact Mitigation Measures

Impacts to groundwater quality in the mining zone are mitigated by groundwater restoration activities following completion of mining. The primary purpose of restoration is to ensure that affected water in the exempted aquifer cannot impact an adjacent underground source of drinking water. To accomplish this purpose, the goal of groundwater restoration is to return the affected groundwater in the mining zone to suitability for pre-mining uses. It should be noted that the methods used for groundwater restoration result in a consumptive use of the groundwater resources, particularly during the groundwater sweep phase. Water usage was discussed in Section 3.4.1.

The methods to achieve this objective for the affected groundwater 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.

5.4.1.1 Ore Body Genesis

Based on regional deposition, the MEA ore body is expected to be similar mineralogically and geochemically to that of the ore body at the CPF. The ore bodies in the two areas are within the same geologic unit (the basal sandstone of the Chadron Formation) and have the same mineralization source. The sites are separated by only a few miles, and the cause of mineral deposition in the two areas appears to be similar. Neither site is anticipated to be significantly affected by recharge or other processes.

The uranium deposit in the MEA is similar to that found in the CPF license area. It is a roll front deposit in fluvial sandstone similar to those in Wyoming 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 from either the feldspar or volcanic ash content of the basal sandstone of the Chadron Formation. The source of the uranium could also be volcanic ash of the Chadron Formation which overlays the basal sandstone of the Chadron Formation. 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 basal sandstone of the Chadron Formation. The basal sandstone of the Chadron Formation 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. More detailed discussions of the geochemical description of the mineralized zone are presented in Section 3.3.1.2.

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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 basal sandstone of the Chadron Formation 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.

Because the deposition of the uranium was controlled between clay beds within the basal sandstone of the Chadron Formation, the mining solutions will be 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.

5.4.1.2 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 (g/L) 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 MEA in-situ mining operations.

Ion Exchange

The principal IX 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 basal sandstone of the Chadron Formation and the ore, magnesium and potassium in solution have no impact. The limited solubility of $CaCO_3$, and to a lesser degree, calcium sulfate, may increase the potential for calcium precipitation.

Laboratory tests have indicated that the maximum calcium IX capacity of the ore in a sodium lixiviant with 3.0 g/L total carbonate strength is 1.21 milliequivalents (meq) of calcium per 100 grams of ore. This equates roughly to 0.5 pound of calcium or about 1.2 pounds of $CaCO_3$ per ton of ore that could potentially precipitate. Not all of this calcium, however, will be realized because laboratory testing is run in a manner that indicates 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 are controlled. The formation characteristics dictate an equilibrium calcium concentration in the lixiviant system and IX 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 IX is small.

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. There is some uncertainty 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.

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The amount of calcium produced depends on the IX that is taking place, while the precipitation of calcium is a function of the lixiviant chemistry and the degree of supersaturation observed in the system. As a first approximation, the proportion of calcium precipitation occurring aboveground 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 aboveground, as is the case for most ISR operations including those projected for the MEA, then more of the calcium will precipitate underground than aboveground. The calcium precipitation is a function of turbulence in the solution, changes in dissolved 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 approximately 0.15 percent 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 MEA wastewater system (i.e., wastewater tanks located in the satellite building) and periodically acid cleaned, if necessary, to remove precipitated $CaCO_3$ from the filter housing or filter media.

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

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Should precipitation of $CaCO_3$ 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 $CaCO_3$ or particulate $CaCO_3$ is collected and placed into the waste disposal system. Upon decommissioning, $CaCO_3$ from the facility equipment tank residues will be disposed of in either a licensed tailings pond or a commercial disposal site.

The other possible precipitating species 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 IX 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 basal sandstone of the Chadron Formation, iron precipitation has not been a problem in mining operations to date.

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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.

Oxidation

The oxidant consumers in the basal sandstone of the Chadron Formation are H_2S in the groundwater, uranium, vanadium, iron pyrite, and other trace and heavy metals. The impact of these oxidant consumers on the operation of the facility 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 oxidized along with the uranium will be solubilized by the lixiviant, recovered with the uranium, and could potentially contaminate the precipitated yellowcake product. H_2O_2 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 IX resins. In in-situ operations with chemistries similar to the MEA, these sulfur species are completely oxidized to sulfate, which poses no problems.

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Organics

Organic materials are generally not present in the MEA 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.

5.4.1.3 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 an MU average as determined by the baseline water quality sampling program. This sampling program is performed for each MU before mining operations commence. Should restoration efforts be unable to achieve baseline conditions after diligent application of the 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 ISR mining. These secondary restoration values are approved by the NDEQ in the individual Notice of Intent (NOI) for each MU 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 ISR licenses of the NRC and its Agreement States. The EPA regulations issued under UMTRCA authority provide the principal standards for uranium ISR operations and groundwater protection, while the UIC regulations are considered additional requirements for ISR 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 ISR 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, at the point of compliance (mining zone after restoration), the concentration of hazardous constituent must not exceed:

5B(5)—At the point of compliance, the concentration of a hazardous constituent must not exceed—

(a) The NRC-approved background concentration of that constituent in the groundwater

(b) The respective value given in the table in paragraph 5C if the constituent is listed in the table and if the background level of the constituent is below the value listed

or

(c) An alternate concentration limit established by the NRC

CBR will comply with these provisions in terms of groundwater restoration limits.

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Establishment of Baseline Water Quality

In addition to pre-operational baseline groundwater monitoring, baseline groundwater quality is determined before mining in each MU by assigning and evaluating groundwater quality in "baseline restoration wells". A minimum of one baseline restoration well for each 4 acres, but not fewer than six wells total for each MU, are sampled to establish the MU baseline water quality. A minimum of four samples are collected from each well. The samples are collected at least 14 days apart. The samples are analyzed for the parameters listed in **Table 5.4-1**.

Tables 3.4-9 through **3.4-11** contain the restoration tables for MUs 1 through 3 in the CPF 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 MU in the NOI.

Establishment of Restoration Goals

The baseline data are used to establish the restoration standards for each MU. As previously noted, the primary goal of restoration is to return the MU to PPMP water quality condition on an MU average. Because ISR operations alter the groundwater geochemistry, it is unlikely that restoration efforts will return the groundwater to the precise water quality that existed before operations.

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Restoration goals are established by NDEQ to ensure that, if baseline water quality is not achievable after diligent application of BPT, the groundwater is suitable for any use for which it was suitable before mining. NRC considers these NDEQ restoration goals as the secondary goals. The NDEQ restoration values are established for each MU and are approved with the NOI to operate submittals according to the following analyses:

- For parameters that have numerical groundwater standards established in Title 118, the restoration goal is based on the Title 118 Maximum Contaminant Level (MCL).
- If the baseline concentration exceeds the applicable MCL as noted above, the standard is set as the MU baseline average plus two standard deviations.
- If there is no MCL for an element (e.g., vanadium), the restoration value is based on a wellfield average of the PPMP sampling data. Normal statistical procedures will be used to obtain the average.
- The restoration values for the major cations (calcium, magnesium, potassium, and sodium) 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 MU average plus one standard deviation.

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The current NDEQ restoration standards are listed in **Table 5.4-1**.

It is anticipated that the Class III UIC Permit issued for the MEA 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 5.4-1** 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 MU is based on the current Title 118 standard at the time the NOI is approved by the NDEQ.

Proposals for Alternate Concentration Limits (ACLs) will include consideration of factors listed under Criterion 5B(6) of 10 CFR Part 40, Appendix A and approval by NRC pursuant to Criterion 5B(5)(c).

5.4.1.4 Groundwater Restoration Methods

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 1.1-1**, MUs 2 through 6 are currently undergoing restoration, with MU 2 undergoing stability monitoring following active restoration. MU 1 groundwater restoration has been approved by the NDEQ and the NRC. On February 12, 2003, the NRC issued the final approval of groundwater restoration in MU 1 at CBR. This approval was the culmination of 3 years of agency reviews including a license amendment to accept the NDEQ restoration standards as the approved secondary goals. MU 1 consisted of 40 patterns installed in 9.3 acres immediately adjacent to the CPF. Included within the boundaries of MU 1 were five wells originally mined beginning in 1986 as part of the R&D pilot plant operation. Commercial mining activities began in 1991 and were completed in 1994. MU 1 was successfully restored to the approved primary or secondary restoration standards for all parameters.

CBR's approved restoration plan consists of four steps:

a. Groundwater transfer
b. Groundwater sweep
c. Groundwater treatment
d. Wellfield recirculation

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A reductant may be added at any time 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 Na_2S are discussed in Section 1.3.2.7. Instructions and safety precautions on the use of sodium sulfide are included in SHEQMS Volume III Operating Manual (Restoration Reductant [Sodium Sulfide]).

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Although CBR's CSA Class III UIC Permit requires a minimum of 6 months for stability monitoring of an MU to demonstrate the success of restoration (stabilization), for this license, the specified ore zone monitoring wells will be sampled at a frequency of once each quarter. The quarterly monitoring will continue until the data from the most recent four consecutive quarters indicate no statistically significant increasing trend for all constituents of concern. At that point, stabilization will be deemed complete subject to approval.

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Throughout restoration and stabilization, excursion monitoring consistent with Section 6.2.2.1 will continue until NRC determines that groundwater stabilization has been demonstrated. Stability monitoring may continue beyond the 6-month period as necessary. Stability monitoring will conclude, instead, when stabilization samples show that restoration goals on an MU average for monitored constituents are met and there is no significant increasing trend for a minimum of four quarters. At the end of the stabilization period, when restoration parameters have been achieved and there are no significant increasing trends for any of the restoration parameters, a request would be made to the appropriate regulatory agencies that the wellfild be deemed restored.. A cone of depression (inward hydraulic gradient) is not maintained during stabilization.

During mining until the start of stabilization, an overall hydrologic bleed will be maintained within the perimeter monitor well ring 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 3.4-12** column "Typical Water Quality During Mining at CPF" 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 control of the mining fluid. Vertical migration of fluids is less of a concern than lateral migration due to the underlying and overlying aquitards. 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 initiated a bioremediation pilot study in MU 4 at the existing CPF on December 17, 2008. If CBR decides to employ this type of remediation in the future, a request for a license amendment will be submitted to the NRC.

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: three pore volumes through IX treatment, six pore volumes through the RO, and two pore volumes of recirculation (total of 11 pore volumes for restoration). 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.

Because the final layout of the MUs has not been defined, an assumed pore volume for the MUs will be calculated as per the following:

Pore Volume (PV) = area x thickness x porosity x flare factor x 7.48 gal/ft^3

The calculated pore volume will be based on the square footage of the potential wellfield area, average under-ream interval of approximately 25 feet, an assumed 29 percent open pore space value, and an assumed flare factor of 20 percent. As additional drilling is performed, these values may be refined for use in calculating surety. All of these values are based upon experience at the CPF.

Geology and hydrology at the CPF is very similar to that of Marsland. Because there are fewer stacked roll fronts at Marsland, Cameco expects an under-ream interval closer to 20 feet. The 29 percent assumed open pore space value remains valid at Marsland.

NUREG-1569 indicates that, for surety purposes, the licensee should include the flare factor in its calculation of the number of pore volumes necessary for groundwater restoration (NRC 2003). The flare factor is defined by the NRC *as a proportionality factor designed to estimate the amount of aquifer water outside of the pore volume that has been impacted by lixiviant flow during the extraction process*. The flare factor is usually expressed as a horizontal and vertical component to account for differences between the horizontal and vertical hydraulic conductivity of an aquifer material (NRC 2003). At the MEA, little vertical flare is expected by virtue of the consistent overlying clay breaks and the underlying Pierre Shale.

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The horizontal and vertical flares are typically expressed as a multiple of the calculated pore volume. However, R/CR-6870 states that there are zones with low permeabilities that have proven to be more of a concern than in a wellfield where the balance is maintained. As in the case of the current CBR operations, a wellfield at MEA will be balanced on an individual pattern basis. Within the uranium ISR industry, this is the most effective way to mine an in-situ wellfield and restore groundwater (Powertech 2009). During operations, CBR will balance the MEA individual wells daily, a method that will reduce the pore volumes for restoration and minimize excursions beyond the flare zone.

Acceptance Criteria 2 in Section 6.1.3 of RG-1569 (NRC 2003) states, "Specific flare factors approved in the past vary from 20 to 80 percent and are typically based on experience from research and development pilot demonstrations." CBR's technical basis for the proposed 20 percent flare factor is the limited vertical flare and operational experience and hydrological modeling at the CPF. Given the similar operating approach and similar geology and hydrology, the NRC 2011 determination of 20 percent as an acceptable flare at the CPF is also appropriate for calculating pore volume at the MEA (NRC 2012: ML110320362)

As an example for use in the license application surety calculation, the calculated pore volume for a 75-acre MEA wellfield will be approximately 177,193,095 gallons. A 75-acre wellfield is the maximum area allowed by the State of Nebraska. In fact, the wellfields at the CPF average 50 to 60 acres and similar, smaller wellfields are expected at the MEA. This is based on a calculated square footage (75 acres = 3,267,000 ft^2) of the example wellfield, an average under-ream interval of 25 feet, an estimated 29 percent open pore space value, and a 20 percent flare factor. As noted earlier, this example calculation overestimates both the area and the under-ream interval, so that surety calculations for wellfields will be based upon the actual area and under-ream interval.

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Groundwater Transfer

During groundwater transfer, water may be transferred between the MU commencing restoration and an MU commencing mining operations. The higher TDS water from the MU in restoration is recovered and injected into the MU commencing mining. The direct transfer of water will lower the TDS in the MU 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 MUs until they become similar in conductivity. The recovered water may be passed through IX 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 MU must be ready to commence mining. If an MU is not available to accept transferred water, groundwater sweep, or other activity will be employed 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 MU, which sweeps the affected portion of the aquifer. The cleaner baseline quality water has lower ion concentrations that 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 MU. The number of pore volumes transferred during groundwater sweep, if any, is dependent upon the presence of other active MUs along the MU boundary, the capacity of the wastewater disposal system, and the success of the groundwater transfer step in lowering TDS.

Groundwater Treatment

Following groundwater sweep, water will be pumped from production wells to treatment equipment and then re-injected into the wellfield. IX, RO, and/or Electro Dialysis Reversal treatment equipment is generally used during this stage, as shown on the generalized restoration flow sheet on **Figure 5.4-1**.

Water recovered from restoration that contains 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 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 RO unit. The use of an RO unit: 1) reduces the TDS 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 wide difference in ion concentration.

The RO unit contains membranes that pass about 60 to 75 percent of the water, leaving 60 to 90 percent of the dissolved salts in the water that will not pass the membranes. **Table 5.4-2** 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 DDW. 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 water may be added to the wellfield injection stream to control the amount of "bleed" in the restoration areas.

The reductant (either biological or chemical) added to the injection stream during the groundwater treatment stage will scavenge any O_2 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. H_2S, Na_2S, or a similar compound will be added as a reductant. CBR typically uses Na_2S due to the chemical safety issues associated with proper handling of H_2S. A comprehensive safety plan regarding reductant use is implemented.

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

Wellfield Recirculation

Wellfield recirculation may be initiated at the completion of the groundwater treatment stage. To homogenize the aquifer, solutions may be recirculated by pumping from the production wells and re-injecting the recovered solution into injection wells.

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

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Once the restoration activities are completed, CBR will sample the restoration wells and determine if the MU has achieved the restoration values, on an MU average basis. If so, CBR will notify the regulatory agencies that it is initiating the stabilization 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 BPT 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.

5.4.1.5 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 5.4-1**. A cone of depression (inward hydraulic gradient) is not maintained during stabilization.

Although CBR's CSA Class III UIC Permit requires one sample per month for a minimum of 6 months for stability monitoring of an MU to demonstrate the success of restoration (stabilization), for CPF's NRC license, the specified ore zone monitoring wells will be sampled at a frequency of once each quarter. The quarterly monitoring will continue until the data from the most recent four consecutive quarters indicate no statistically significant increasing trend for all constituents of concern at which point will be deemed complete, subject to approval.

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Throughout restoration and stabilization, excursion monitoring, consistent with Section 6.2.2.1, will continue until NRC determines that groundwater stabilization has been demonstrated.

The sampling frequency will be one sample every other month for four quarters, 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.

5.4.1.6 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 NRC.

This information will also be included in the final report on restoration. In the unlikely event that a well goes on excursion during restoration, the process described in Section 5.7.8.3 of RG-1569 will be followed. Excursion monitoring operational procedures will include corrective action and notification plans in the event of an excursion. The NRC will be notified within 24 hours by telephone and within 7 days in writing from the time an excursion is verified. A written report describing the excursion event, corrective actions taken, and the corrective action results will be submitted to the NRC within 60 days of the excursion confirmation. If any of the wells are still on excursion status when the report is submitted, the report will also contain a timeline for submittal of future reports describing the excursion event, corrective actions taken, and results obtained. In the event of a vertical excursion, the report will contain a projected completion date for the extent of the vertical excursion.

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Upon completion of restoration activities and before stabilization, all designated restoration wells in the MU will be sampled for the constituents listed in **Table 5.4-1**. If restoration activities have returned the wellfield average of restoration parameters to concentrations at or below those approved by the NRC and the NDEQ, CBR will proceed with the stabilization phase of restoration. Groundwater restoration standards for the current CBR operations are established by the NDEQ, with concurrence of the NRC and EPA. This process will be adhered to for the MEA project.

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 MU and do not exhibit significant increasing trends, CBR would request that the MU be declared restored. Following agency approval, wells will be reclaimed, plugged, and abandoned as described in Section 6.2.3. CBR will not remove production or monitoring wells until the stability monitoring is concluded and agency approval is granted. In this way, these wells could be used to correct any excursion.

5.4.2 Surface Water Quality Impact Mitigation Measures

Surface water impacts due to stormwater runoff events are a possibility during all phases of the construction, operation, and reclamation of the proposed MEA project. Impacts include increased sedimentation and changes to the water quality of stormwater and snowmelt runoff discharging to ephemeral drainages and eventually the Niobrara River. Due to the minimal amounts of flows in the ephemeral drainages located on the MEA project site, and mitigation measures to be taken to minimize increased sedimentation and contamination of stormwater runoff, the potential for impacted stormwater runoff reaching the Niobrara River is expected to be rare.

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Potential impacts associated with stormwater and snowmelt runoff are discussed in Sections 4.4.1 and 4.4.2, 4.3.1.1, and 5.3. Steps to be taken to minimize impacts to surface water include the following:

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- Construction site planning and management (sequencing of construction, inspect and maintain BMPs, and runoff and sediment control features);
- Erosion control (use of erosion and stormwater and snowmelt runoff control features such as mulching, riprap, seeding, sodding, soil retention, and temporary slope drain);
- Runoff Control (diversion channels, grading to have areas sloped to minimize erosion, grass-lined channels, and permanent slope diversions);

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- Sediment Control (silt fences, hay bales, mulching, fiber rolls, sediment basins, sediment traps, storm drain inlet protection, and vegetated buffers);
- Minimize the amount of disturbance to surface areas, drainage channels, and natural vegetation, which will help to minimize erosion and runoff impacts;
- To the extent possible, maintain natural contours, stabilize slopes, and minimize the amount of off-road travel with vehicles;
- Employ existing spill cleanup and remediation procedures to address any spills of materials that could adversely impact the quality of any stormwater and snowmelt runoff;
- Provide berms and/or curbing for storage of fuels, hazardous materials, and chemicals that minimize the potential for any releases of spilled materials;
- As required, prepare and implement a SWPPP that meets applicable regulatory requirements;
- Use assessment of flooding and erosion potential studies in locating and protecting surface facilities from potential flooding events;
- Train contractors and employees in the handling, storage, distribution, and use of hazardous materials.

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5.5 Air Quality Impact Mitigation Measures

Operational activities within the MEA will cause a minimal increase in fugitive dust emissions. These emissions will be minimized on the mine property by strict enforcement of site speed limits. As discussed in Section 4.6, vehicle speed has a linear effect on the production of suspended particulates. Speed limits at the current operation are 25 mph or less. Similar controls will be implemented at the MEA.

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Dust emissions from county roads are expected to be a minimal incremental increase over those produced by current traffic levels. Implementation of dust mitigation measures (such as the application of water) to unpaved county roads are costly, but will be used as necessary. In the past, CBR has donated road surfacing materials to Dawes County for use on roads near residences that were adversely impacted by fugitive dust from CBR and public traffic. CBR will work with the county in any potential, similar assistance needs.

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5.6 Visual and Scenic Resource Impact Mitigation Measures

Mitigation measures are meant to minimize adverse contrasts of project facilities with the existing landscape. The measures should be applied to all facilities, even those that meet VRM objectives. Mitigation would enable proposed project facilities to harmonize with the surrounding landscape to the extent feasible.

In addition to selecting paint colors that harmonize with the surrounding landscape, several other measures would minimize adverse effects of project facilities in the landscape.

- Using existing vegetation and topographic features to screen wells, facilities, and roads
- Painting facilities with non-reflective paint that harmonizes with the surrounding landscape
- Avoiding straight line-of-sight road construction

- Aligning roads with the contours of the topography rather than cutting straight across contours to wellhouses, although this method of aligning the roads may result in a greater area of disturbance
- Constructing clearings to appear as natural clearings by rounding corners and feathering the vegetation interface between the clearing and the surrounding grasses and shrubs (in those areas where the existing vegetation is dense, clearings should be irregular in shape)
- Removing construction debris immediately because it creates undesirable textural contrasts with the landscape.

In general, resource protection measures proposed for erosion control, road construction, rehabilitation and revegetation, and wildlife protection would mitigate effects to visual quality.

Table 5.1-1 Soil Cleanup Criteria and Goals

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Table 5.4-1 NDEQ Groundwater Restoration Standards

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Table 5.4-2 Typical Reverse Osmosis Membrane Technology

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Figure 5. 4-1 Restoration Process Flow Diagram

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6 ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

This section discusses the environmental sampling program that CBR has implemented to assess preoperational and operational radiological and non-radiological conditions in the vicinity of the MEA.

6.1 Preoperational/Preconstruction Environmental Monitoring Program

CBR is in the process of completing the remaining sampling task of the conducting a PPMP in support of the MEA application, following the criteria outlined in RG 4.14 (NRC 1980). PPMP was delayed in order to allow for the completion of 1 year of on-site meteorological data collection. The MET data were needed for the proper location of the air and other environmental sampling locations and for completion of the MILDOS calculations. At the time of this application, a considerable amount of the PPMP has been completed, with at least 1 year of data collected for the following:

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- Air particulate monitoring
- Radon gas
- Ore zone groundwater monitoring (CBR MWs in the basal sandstone of the Chadron Formation)
- Non-ore zone groundwater monitoring (CBR monitoring wells in the Brule Formation)
- Surface water (Niobrara River)
- Fish tissue samples in Niobrara River
- Sediment samples (ephemeral drainages and Niobrara River)

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Remaining PPMP tasks are identified in **Figure 6.1-1**. These consist of additional surface water sampling of ephemeral drainages (as available), sediment samples for the Niobrara River during the dry season, alternative soil sampling for vegetable food uptake calculations, forage sampling, and direct radiation sampling. Sediment samples of the Niobrara during the wet season were collected in March 2013 and the analytical data are pending. With the exception of remaining food sampling (livestock), sampling of the other tasks will be completed by the end of the third quarter 2013.

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This section discusses the environmental sampling program that has been implemented to assess PPMP radiological background conditions in the vicinity of the MEA. The results of the PPMP, in contrast to the operational monitoring program implemented during satellite operations, will be used to determine the effects on the environment, if any, of the satellite facility and associated operations. The operational monitoring program is discussed in Section 6.2.

Deleted: The planned completion schedule (including sample collection, analysis, data preparation/submittal, and NRC approval) is shown on **Figure 6.1-1**. As per this schedule, plans are for the majority of the remaining PPMP to be completed and approved by December 2012. An expanded monitoring program of additional private water supply wells within the MEA license boundary and within 2 km of the MEA license boundary will continue through the first quarter of 2013 (see discussions in Section 6.1.2.1. As monitoring for each environmental medium is completed, the resulting data will be submitted to the NRC for acceptance review.¶

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The results of the MEA preoperational radiological monitoring are organized by environmental medium to allow ready comparison of monitoring data collected during preoperational, operational, and post-operational monitoring periods. A discussion of the scope of the monitoring program precedes the presentation of the data.

6.1.1 Baseline Air Monitoring

6.1.1.1 Selection of Air Monitoring Stations

Figure 6.1-2 shows the locations of the air monitoring stations, two nearby occupiable structures, with one being located inside the permit boundary, and the satellite facility. **Figures 3.1-2 and 4.12-2** show the remainder of the residences within the vicinity of the MEA license boundary.

RG-4.14 provides the following siting criteria:

1. Minimum of three locations at or near the site boundary
2. Occupiable structure within 10 kilometers of the site that is most likely to be impacted by the remote location representing background, usually upwind from the project site and milling operation
3. Milling operation

In accordance with these criteria, **Figure 6.1-2** shows three sampling sites at the project boundary (Sites MAR-1, MAR-4, and MAR-3). One of these (Site MAR-1) also coincides with the nearest, and most likely to be impacted, occupiable structure. A fourth sampling site (Site MAR-5) is intended to represent background conditions. Because the on-site wind rose indicates northeasterly winds to be the least frequent, this background monitoring site is located southwest of the project boundary at a distance of approximately 4 miles. A summary of monitor locations and elevations for each of the monitors is shown in **Table 6.1-1**.

Site MAR-2 is directly south of the proposed mill and slightly outside the project boundary. Sites MAR-3 and MAR-4 on the southernmost boundary of the project combine with Site MAR-2 to represent prominent downwind locations. The on-site wind rose shows north-northwesterly, northwesterly, and northerly winds to be the most frequent, accounting for more than 25 percent of the time. Hence, these three monitoring sites are located south-southeast, southeast, and south of the proposed milling operation. The wind roses are shown in **Figures 3.6-20** and **3.6-21**.

The wind rose was developed from data generated at an MEA on-site MET station. The MET monitoring station monitored temperature, precipitation, evaporation, wind speed and direction, and the standard deviation of the wind direction. The local meteorological station was operated from August 28, 2010 through August 29, 2011. Joint frequency data were compiled from this information. Further information on meteorological conditions is provided in Section 3.6.

6.1.1.2 Air Particulate Monitoring Program

RG 4.14 recommends that a total of five particulate monitoring stations be established as discussed above in Section 6.1.1.1. The locations of the air particulate samplers are shown on **Figure 6.1.2**. There are no operations at the satellite facility that could cause a significant release of airborne particulate radionuclides (e.g., lack of yellowcake drying). Therefore, radiologically contaminated air particulates are expected to be minimal.

The air monitoring program will be conducted and data submitted to the NRC for an acceptance review per the timeline on **Figure 6.1-1**. The results of the air monitoring data at sampling sites MAR-1 through MAR-5 for the fourth quarter of 2011 through the fourth quarter 2012 are presented in **Table 6.1-2**. The results are summarized as follows:

Deleted: RG 4.14 recommends that preoperational air monitoring should be conducted for air particulates, radon gas, and direct radiation at three locations at or near the site boundary, one at or close to the nearest resident or occupiable structure(s) (if within 6.2 miles [10 km] of site) and one at a control or background location. A summary of NRC's preoperational monitoring program is shown in **Table 6.1-35.**¶
CBR based the sample locations for the air monitors on the anticipated satellite facility location, proposed license boundaries, and predominant wind rose for the MEA site, which was based upon the MEA wind roses shown on **Figure 3.6-20** and **3.6-21**. The predominant wind direction is north-northwesterly and northwesterly, with the highest wind speeds also coming from those directions. The local wind direction is predominantly from the south-southwest approximately 45 percent of the time. Winds can also be from the northeast. The boundary sample locations were determined based upon this data.¶

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- Lead-210 measurements were a consistent 2E-14 µCi/ml at all monitor sites (reporting limit of 2E-15 µCi/ml) for all quarters except for the second quarter of 2012, where the lead level was 1E-14 µCi/ml (reporting limit of 2E-15 µCi/ml).
- Radium-226 levels at all monitor sites for all quarters exhibited a level at or less than 1E-16 µCi/ml (reporting limit of 1E-16 µCi/ml), except for the third quarter of 2012 where the radium-226 µCi/ml level was 5E-10 µCi/ml.
- Thorium-230 levels at monitor sites M-1 through M-4 for all quarters were at or less than 1E-16 µCi/ml, while the thorium-230 level at M-3 was 2E-16 µCi/ml (reporting limit of 1E-16 µCi/ml).
- Uranium levels at all monitor sites for all quarters were measured at <1E-16 µCi/ml (reporting limit of 1E-16 µCi/ml), with the exception of the first quarter of 2012, where levels of 3E-16 µCi/ml (reporting limit of 1E-16 µCi/ml) were measured at MA-2, MA-3, and MA-4, with MA-5 exhibiting a level of 2E-16 µCi/ml (reporting limit of 1E-16 µCi/ml).

The airborne particulate samples are 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 is the F&J Portable DF-75L-BL-AC brushless powered air sampler, 60 liter/min, 24 voltage current direct (VCD). This is air particulate sampler runs on solar and battery power. The sampler has a filter holder and a set flowrate that is maintained automatically in case of dust loading. It does not require operator attention.

The sampler is placed in a protective enclosure (with an exhaust fan and temperature controller) that protects from the elements while allowing unimpeded sampling of the ambient air. The vendor provided CBR with an SOP for the F&J DF-75L-BL-AC that provides guidance in meeting NRC requirements (**Appendix I**).

Clean filters are installed in the filter holder at the beginning of each sampling period. The pump flowrate is adjusted as necessary. The filter replacement timeline is determined based on the dust loading at a particular location. In general, historical operations of samplers without automatic flowrate controllers at the CPF have shown that samplers can run for 1 to 2 weeks without a significant reduction in the flowrate due to dust loading.

The air sampler draws air and suspended particulate matter through a 47 mm collection filter at a known volumetric rate for a known period of time. The collected set of filters for each air sampling unit is sent for contract laboratory analysis at the end of each quarter using standard chain-of-custody procedures. The filters are composited according to location. The composite samples are analyzed for the concentrations of natural uranium, radium-226, lead-210, and thorium-230. Filter sample replacement and additional handling procedures are described in the air sampler SOP.

The flowrate on the F&J portable sampler is calibrated at 6-month intervals using accepted calibration methods to ensure the accuracy of the volume of air sampled. Records of sampler calibration are available on file at the CPF.

CBR will continue to operate all five samplers as part of the operational air particulate monitoring.

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6.1.1.3 Radon Gas Monitoring Program

RG 4.14 recommends collection of radon gas samples at each of the air particulate monitoring stations (five or more sample points). Continuous samples or at least 1 week per month (at about the same time of the month) will be performed. Samples are analyzed for radon gas. The proposed PPMP and operational monitoring programs are shown in **Tables 6.1-35 and 6.1-36.**

Monitoring is being 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. The semiannual interval was chosen to ensure that monitoring results meet the lower limit of detection (LLD) requirement of 0.2 pCi/L (2 x 10^{-10} mCi/ml) from RG 4.14 and to be consistent with the semiannual intervals approved by NRC for the current operational monitoring.

The PPMP and operational monitoring plan are designed to meet the criteria outlined in RG 4.14 (NRC 1980). Radon-222 monitoring for sampling sites MAR-1 through MAR-5 was conducted from the fourth quarter of 2011 through the fourth quarter of 2012 (**Table 6.1-3**). The gross count for the entire time period for all sampling points ranged from 43 to 362, with an average of 168. The gross count for sampling points MAR-1 through MAR-4 ranged from 43 to 362 (average of 163), compared to MAR-5 (background location) with a range of 70 to 255 (average of 191). The average radon concentration for the entire sampling period ranged from 0.07 to 1.6 x 109 µCi/ml (average of 0.5 µCi/ml). The average radon concentrations for sampling points MAR-1 through MAR-4 ranged from 0.07 to 1.6 µCi/ml (average of 0.5), as compared to MAR-5 (background location) with a range of 0.1 to 1.0 µCi/ml (average of 0.6 µCi/ml).

6.1.1.4 Quality of Air Measurements

The accuracy of monitoring data is critical to ensure that the preoperational air monitoring program precisely reflects air quality. RG 4.14 specifies the following LLDs for air measurements:

Radionuclide	Recommended LLD µCi/ml	Actual LLD µCi/ml
Natural Uranium	1 x 10^{-16}	1 x 10^{-16}
Thorium-230	1 x 10^{-16}	1 x 10^{-16}
Radium-226	1 x 10^{-16}	1 x 10^{-16}
Radon-222	2x 10^{-10}	0.2 x 10^{-9}
Lead-210	2 x 10^{-15}	2 x 10^{-15}

Note: µCi/ml – microCuries per milliliter

6.1.2 Baseline Groundwater Monitoring

This section discusses the results of the radiological and non-radiological analyses for private water supply wells with the MEA and CBR monitor wells installed within the MEA for purposes of assessing the MEA site. Groundwater quality in the vicinity near the MEA is generally poor (Engberg and Spalding 1978). Groundwater obtained from the basal sandstone of the Chadron Formation has a strong sulfur odor as a result of localized reducing conditions associated with the ore body.

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Water quality data for private water wells provided in this section are from March 25, 2011 to March 21, 2013. Groundwater samples for the CBR monitor wells were collected from March 4 to May 3, 2011 for the Brule Formation monitor wells and March 12 to August 20, 2012 for CBR basal sandstone of the Chadron Formation monitor wells.

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In the March 2013 sampling event for the private water supply wells, there were a total of 45 water supply wells sampled. An additional 24 water supply wells could not be sampled for a variety of reasons, including wells being inoperable, power off, wells off for the season, windmill not working, and not in use. These wells are privately owned and in the control of the owners.

A summary of all private well groundwater quality data (radiological and non-radiological analytes) collected to date in the vicinity of the MEA, is presented in **Table 6.1-4.** The data are presented for the three water-bearing zones at the MEA: the Arikaree Formation, Brule Formation, and basal sandstone of the Chadron Formation. Based on sampling to date, water quality results for all private water supply wells completed in the Arikaree and Brule Formations and MEA monitoring wells for the Brule Formation indicate that TDS ranged from 200 to 537 mg/L, while TDS for the basal sandstone of the Chadron Formation is generally higher than 1,000 mg/L (**Table 6.1-4**). Similarly, conductivity for the private wells and the Brule Formation monitor wells ranged from 241 to 763 micromhos per centimeter (µmhos/cm), while conductivity for the basal sandstone of the Chadron Formation is generally higher than 1,000 µmhos/cm. Major cations and anions for the private wells and monitor wells in the Brule Formation ranged from 2.75 to 6.87 meq/L, whereas cations and anions ranged from 13.85 to 25 meq/L for monitor wells completed in the basal sandstone of the Chadron Formation. This would be expected when compared to the concentrations of TDS.

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Deleted: <#>Dissolved uranium concentrations in the Brule Formation for private wells and monitoring wells ranged from 0.0048 to 0.0373 mg/L and from 0.002 to 0.0095 mg/L, respectively. Uranium concentrations at monitoring well locations completed in the basal sandstone of the Chadron Formation ranged from 0.0003 to 0.084 mg/L. Dissolved radium-226 concentrations in the Brule Formation ranged up to 0.9 pCi/L for private wells and up to 2.6 pCi/L for monitoring wells. Dissolved radium-226 concentrations in monitoring wells completed in the basal sandstone of the Chadron Formation ranged up to 240 pCi/L. Background and restoration values are discussed in Section 6. ¶

6.1.2.1 Private Water Supply Wells

Preoperational baseline groundwater sampling and analyses of private wells are being carried out in two phases:

Phase 1

A select number of private water supply wells located within the MEA license boundary and less than 0.5 mile (0.8 km) from the license boundary were sampled in 2011 and analyzed for radiological and non-radiological parameters. The locations of these wells were based on placement around the license boundary and future MUs, with emphasis on downgradient locations. Within the license boundary, wells 705, 747, and 788 were monitored for three sampling events 2 weeks apart in 2011. Well 727 (within the license boundary) and wells 703, 723, 725, 741, 745, and 759 (less than 0.5 mile [0.8 km] outside of the license boundary) were sampled and analyzed for four quarters in 2011. The locations of these wells are shown on **Figures 3.4-6** and **3.4-7**.

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Phase 2

Consistent with requirements of RG 4.14, a more comprehensive monitoring program for additional private wells located within 1.24 miles (2 km) of the MEA license boundary was implemented in the second quarter of 2012. An additional 47 private wells were added to the sampling program, resulting in a total of 57 monitor wells being sampled.

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Private Wells Sampled in 2011	Private Wells Sampled in 2012
703, 705, 723, 725, 727, 741, 745, 747, 759, 788,	700, 702, 703, 704, 705, 706, 707, 714, 715, 716, 719, 720, 721, 722, 723, 725, 727, 728, 730, 731, 732, 733, 734, 735, 736, 737, 739, 740, 741, 742, 743, 744, 745, 746, 747, 748, 750, 752, 753, 754, 755, 759, 760, 777, 788, 794, 795, 799, 802, 809, 810, 811, 815, 821, 836, 841, 845
Private Wells Sampled in 2013	
700, 702, 703, 704, 705, 706, 707, 714, 719, 720, 721, 722, 725, 727, 728, 734, 737, 739, 742, 743, 744, 745, 746, 747, 748, 750, 752, 753, 754 755, 760, 777, 788, 794, 795, 799, 802, 809, 810, 811, 815, 821, 836, 841, 845	

Whenever operational, all of the active private wells located within 1.24 miles (2 km) of the license boundary, where landowner access can be obtained, will be monitored quarterly (**Figures 3.4-6 and 3.4-7**).

Deleted: Current plans are to initiate this additional private well sampling in the second quarter of 2012 (**Figure 6.1-1**). There could be delays in initiating sampling of some wells due to access negotiations, resulting in the sampling of some wells beginning in the third quarter of 2012, with completion in the second quarter of 2013.

There were a total of 136 active and inactive private water supply wells within the license boundary and associated AOR identified during the water user survey. The number of wells and their general locations within the MEA project AOR can be broken down as follows:

- Located within License Boundary: 13 active and two inactive
- Located within 0.6-mile (1 km) radius of the License Boundary: 30 active and two inactive
- Located between 0.6-mile (1 km) and 1.2-mile (2 km) radius of the License Boundary: 24 active and two inactive
- Located between 1.2-mile (2 km) radius and to AOR radius of the License Boundary: 54 active, eight inactive, and one unknown

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The remainder of this section discusses the results of the radiological and non-radiological analyses for private water supply wells within the MEA. Other information on the selected wells, including formation, depth, and usage, is provided in **Appendix A**. Available well registration and well completion records are provided in **Appendices E-1** and **E-2**.

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The radiological and non-radiological analytical results for the individual private wells are shown in **Tables 6.1-5** and **6.1-6,** respectively, and are summarized in **Table 6.1-4**.

The radiological analytical results for the Arikaree and Brule Formations were at levels that would be expected for background concentrations of the area.

Suspended uranium concentrations for the private wells completed in the Arikaree and Brule Formations were at a range of <0.0003 mg/L to 0.001 mg/L (average of 0.00021 mg/L), and dissolved uranium levels were 0.0028 to 0.0373 mg/L (average of 0.00745 pCi/L). Suspended uranium activity for the private wells ranged from <2.0E-10 to 0.4 μCi/L (average of 0.000151

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µCi/mL), and dissolved uranium ranged from 3.8E-10 to 18.1 µCi/ml (average of 1.335 µCi/mL). In comparison, the suspended uranium concentrations for the basal sandstone of the Chadron Formation monitor wells ranged from <0.0003 to 0.084 mg/L (average of 0.00354 mg/L) and dissolved uranium levels ranged from <0.0003 to 0.084 mg/L (average of 0.00942 mg/L).

Suspended radium-226 values for the private wells ranged from <0.06 to 0.2 pCi/L (average of 0.07 pCi/L) and dissolved radium-226 ranged from <0.1 to 9.5 pCi/L (average of 0.21 pCi/L). In comparison, suspended radium-226 values for the basal sandstone of the Chadron Formation monitor wells ranged from <0.1 to 45 pCi/L (average of 1.88 pCi/L) and dissolved radium-226 levels ranged from <0.1 to 390 pCi/L (average of 31.19 pCi/L).

The majority of the values for suspended and dissolved lead-210, polonium-210, and thorium-230 were below the reporting limit.

The concentration of dissolved uranium in the private wells completed in the Arikaree and Brule Formations within the NTEA, TCEA, and MEA compared as follows based on available data:

NTEA <0.0003 to 0.05 mg/L
TCEA 0.004 to 0.04 mg/L
MEA 0.0028 to 0.0373 mg/L

Dissolved uranium values for the TCEA tended to be somewhat higher than those for the NTEA and MEA.

Concentrations of dissolved radium-226 from private wells in the NTEA, TCEA, and MEA compared as follows:

NTEA <0.2 to 1.3 x 10^{-9} pCi/L
TCEA 0.006 to 1.5 pCi/L
MEA <0.1 to 9.5 pCi/L

The non-radiological analytical results were at levels consistent with what would be expected for background concentrations of the area (**Tables 6.1-4** and **6.1-6**). Concentrations of the parameters for the private wells versus CBR monitor wells completed in the Brule Formation are comparable, with some parameters for the private wells having somewhat lower average values than for the CBR monitor wells (e.g., dissolved sodium, sulfate, chloride, and conductivity; **Table 6.1-4**). The average values for sodium and sulfate for the private wells versus CBR Brule monitor wells was 20 versus 77 mg/L and 10 versus 33 mg/L, respectively. The average values for sodium and sulfate for the Brule monitor wells versus CBR basal sandstone of the Chadron Formation monitor wells was 77 versus 408 mg/L and 33 versus 173 mg/L, respectively.

Overall, similar trends in the NTEA and TCEA were seen for the same MEA water-bearing units.

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6.1.2.2 CBR Groundwater Monitor Wells

6.1.2.2.1 Water Level Measurements

Brule Formation

Water levels were measured for the Brule Formation at six monitoring wells on February 22, 2011 and nine monitoring wells on August 12, 2011 (**Table 6.1-7**). The static water level for wells screened in the Brule Formation in the vicinity of the MEA typically ranges from 50 to 150 feet bgs. Groundwater elevations measured during the two events ranged from approximately 4,051 to 4,274 feet amsl. A potentiometric surface map and groundwater flow directions for the February 22, 2011 event are depicted on **Figure 6.1-3**. Groundwater in the Brule Formation flows predominantly to the southeast across the entire MEA toward the Niobrara River drainage at a lateral hydraulic gradient of 0.011 ft/ft (Aqui-Ver 2011). Regional water level information for the Brule Formation is currently only available from the vicinity of the CPF.

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6.1.2.2.2 Basal Sandstone in the Chadron Formation

Water levels were also measured on February 22 and August 12, 2011 for the basal sandstone of the Chadron Formation at 12 monitoring wells (CPW-2010-1, Monitor-1, Monitor-2, Monitor-3, Monitor-4A, Monitor-5, Monitor-6, Monitor-7, Monitor-8, Monitor-9, Monitor-10, and Monitor-11; **Table 6.1-7**). The static water level for wells screened in the basal sandstone of the Chadron Formation in the vicinity of the MEA typically ranges from approximately 380 to 660 feet bgs. Groundwater elevations measured during the two measurement events ranged from approximately 3,703 to 3,717 feet amsl. A potentiometric surface map and groundwater flow directions for the February 22, 2011 event are depicted on **Figure 6.1-4**. Groundwater in the basal sandstone of the Chadron Formation flows predominantly to the northwest toward the White River drainage at a lateral hydraulic gradient of 0.0004 ft/ft (Aqui-Ver 2011). A minor variation in flow direction during the February 2011 event indicated localized westward flow in the vicinity of Monitor-10. Regional water level information for the basal sandstone of the Chadron Formation is currently only available from the vicinity of the CPF.

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Strong, vertically downward gradients exist at all locations within the MEA, indicating minimal, if any, risk for potential impacts to the Brule Formation from the underlying basal sandstone of the Chadron Formation under natural conditions. Observed head differences between the two water-bearing zones at six well pairs (BOW-2010-1 and Monitor-3, BOW-2010-2 and Monitor-4A, BOW-2010-3 and Monitor-8, BOW-2010-4 and Monitor-10, BOW-2010-5 and Monitor-11, and BOW-2010-6 and Monitor-1) ranged from approximately 330 to 500 feet during the February 2011 measurement event.

Available groundwater data for both the Brule Formation and basal sandstone of the Chadron Formation at the MEA do not indicate any documented flowrate variations or recharge issues that would impact groundwater quality as a result of ISR mining operations in the basal sandstone of the Chadron Formation. There are no surface water ponds within the MEA license boundary and only limited, intermittent flow in ephemeral drainages. The Brule Formation, while considered an overlying aquifer, is not an extensive or exceptionally productive system. The available monitoring data do not indicate any seasonality or pumping effects by domestic wells within this zone.

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6.1.2.3 Groundwater Quality Data for Brule and Chadron Formations

Tables 6.1-8, 6.1-9, 6.1-10 and 6.1-11 report the detailed results (radiological and non-radiological analytes) of three bi-weekly sampling events in March and April 2011 and four seasonal sampling events were conducted in November 2011 and February, June, and August 2012 for monitoring wells screened in the Brule Formation and basal sandstone of the Chadron Formation within the MEA. The analytical results in the above-referenced tables were included in the range of concentrations reported in **Table 6.1-4** (discussed above).

Three bi-weekly sampling events were conducted at ten Brule Formation monitoring wells (BOW-2010-1, BOW-2010-2, BOW-2010-3, BOW-2010-4A, BOW-2010-5, BOW-2010-6, BOW-2010-7, BOW-2010-8, Walters-1, and Walters-2). Three bi-weekly sampling events were conducted in March and April 2011 at ten monitoring wells completed in the basal sandstone of the Chadron Formation (Monitor-1, Monitor-2, Monitor-4A, Monitor-5, Monitor-6, Monitor-7, Monitor-8, Monitor-9, Monitor-10, and Monitor-11). Groundwater analytical laboratory reports are provided in **Appendix J**.

Four seasonal sampling events were conducted in both the Brule and basal sandstone of the Chadron Formations in November 2011 and February, June, and August 2012.

The groundwater sampling results for radionuclides of the Brule and basal sandstone of the Chadron Formations are presented in **Tables 6.1-8** and **6.1-10**, respectively. Groundwater analytical laboratory reports are provided in **Appendix J**.

Dissolved concentrations of selected radionuclides appear to be largely absent from the Brule Formation, with the exceptions of uranium and radium-226. For the CBR Brule monitor wells, suspended uranium concentrations ranged from <0.0003 to 0.0017 mg/L (average of 0.00024 mg/L) and dissolved uranium concentrations ranged from 0.002 to 0.0095 mg/L (average of 0.0056 mg/L). For the basal sandstone of the Chadron Formation monitor wells, suspended uranium concentrations ranged from <0.0003 to 0.0843 mg/L (average of 0.00354 mg/L), and dissolved uranium levels ranged from <0.0003 to 0.084 mg/L (average of 0.00942 mg/L).

Suspended uranium activity for the Brule monitor wells ranged from <2.0E-10 to 1.2E-09 µCi/mL (average of 1.59E-10 µCi/mL), and dissolved uranium activity ranged from 1.3E-09 to 6.4E-09 µCi/mL (average of 3.8E-09 µCi/mL). For the basal sandstone of the Chadron Formation monitor wells, suspended uranium activity levels ranged from <2.0E-10 to 6.2 µCi/mL (average of 0.151 µCi/mL) and dissolved uranium levels ranged from <2.0E-10 to 30.9 µCi/mL (average of 0.75E-10 µCi/mL).

For the Brule monitor wells, suspended radium-226 values ranged from <0.1 to 0.6 pCi/L (average of 0.535 pCi/L) and dissolved radium-226 ranged from <0.1 to 2.6 pCi/L (average 0.379 pCi/L). For the basal sandstone of the Chadron Formation monitor wells, suspended radium-226 values ranged from <0.1 to 45 pCi/L (average of 1.88 pCi/L) and dissolved radium-226 values ranged from <0.1 to 390 pCi/L (average of 31.19 pCi/L).

The concentrations of dissolved thorium-230 for the Brule Formation were below the RLs of 0.2 and 0.1 pCi/L at all locations, whereas dissolved thorium-230 for the basal sandstone of the Chadron Formation ranged up to 1.7 pCi/L; however, 70 of 77 samples yielded results <0.2

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pCi/L. As expected, suspended radionuclides were significantly higher in the wells of the basal sandstone of the Chadron Formation than in those of the Brule Formation.

Tables 6.1-9 and 6.1-11 presents the sampling results for non-radiological analytes of the Brule Formation and basal sandstone of the Chadron Formation, respectively. TDS concentrations for the Brule Formation ranged from 200 to 537 mg/L (average of 320 mg/L), whereas TDS for the basal sandstone of the Chadron Formation ranged from 778 to 1,490 mg/L (average of 1,086 mg/L). Alkalinity for the Brule Formation ranged from 125 to 217 mg/L, while alkalinity in the basal sandstone of the Chadron Formation was consistently detected above 245 mg/L at all sampling locations. Conductivity for the Brule Formation was detected at up to 763 µmhos/cm, while conductivity for the basal sandstone of the Chadron Formation was detected at above 1,340 µmhos/cm at all sampling locations. Major ion concentrations for the Brule Formation ranged from 423 to 775 mg/L, while concentrations for the basal sandstone of the Chadron Formation ranged from 1,319 to 2,227 mg/L. Similar trends in relative concentrations for the MEA were observed in water quality sampling at the TCEA and NTEA for these two water-bearing zones. Groundwater analytical laboratory reports are provided in **Appendix J**.

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In general, concentrations of TDS, specific conductance, and major ions in the basal sandstone of the Chadron Formation appear to be an order of magnitude larger than observed in the Brule Formation at the MEA. In addition, dissolved concentrations of selected radionuclides appear to be largely absent from the Brule Formation, with the exception of radium-226, which was detected at very low concentrations on the order of four magnitudes lower than dissolved concentrations measured in the basal sandstone of the Chadron Formation. To date, water quality sampling indicates that the Brule Formation and the basal sandstone of the Chadron Formation have unique geochemical signatures within the MEA.

6.1.2.4 Quality of Groundwater Measurements

The accuracy of monitoring data is critical to ensure that the water monitoring program precisely reflects water quality.

In addition to recommending the use of approved analytical methods for water quality measurements (contained in 40 CFR 136), the NRC also specifies analytical quality requirements in RG 4.14.

The private laboratory employed by CBR, Energy Laboratories, Inc. (ELI), reported the lower limits of detection for the surface and groundwater analyses as Minimum Detectable Concentrations/Lower Limits of Detection (MDC/LLD) values. ELI stated in a letter dated April 23, 2012 (ELI 2012, **Appendix Q**) that the reported MDC/LLD values for the MEA samples were in compliance with RG 4.14, Section 5 "LLD".

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Radionuclide	MDC/LLD for Water	
	µCi/ml	pCi/L
Natural Uranium	2×10^{-10}	0.2
Thorium-230	2×10^{-10}	0.2
Radium-226	2×10^{-10}	0.2
Polonium-210	1×10^{-9}	1.0
Lead-210	1×10^{-9}	1.0

Source: ELI 2012 (Appendix Q)
Note: For analytes reported in two significant figures, MDC/LLD values rounded off to only one significant figure (e.g., 1.3 pCi/L = 1 pCi/L).

ELI met the criteria of the guidance suggested by the NRC when reasonably achievable by available conventional laboratory methodology. If for some reason the MDC/LLD was not met on the original analysis, the samples were recounted or re-analyzed until RG 4.14 MDC/LLDs were achieved. See **Appendix Q** for additional discussions by ELI of MDC/LLD reporting.

MDC levels for surface and groundwater radiological analytes are presented in the respective data tables of this document as well as in the individual Analytical Summary Reports of **Appendix J**.

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6.1.3 Baseline Surface Water Monitoring

Surface water sampling in RG 4.14 calls for sampling of surface water passing through the project site or off-site surface waters that may be subject to drainage from potentially contaminated areas or that could be affected by a "tailings impoundment failure". Grab samples are to be collected monthly with samples analyzed for suspended and dissolved natural uranium, radium-226, and thorium-230.

RG 4.14 also requires surface water sampling from each large on-site body of water or off-site impoundments subject to direct surface drainage from potentially contaminated areas that could be affected by a tailings impoundment failure. Grab samples are to be collected quarterly, with samples analyzed for suspended and dissolved natural uranium, radium-226, and thorium-230. Semiannually, samples should be analyzed for suspended and dissolved lead-210 and polonium-210.

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Lack of water flow in ephemeral drainages in the MEA has prevented collection of surface water samples. Water samples were collected from the Niobrara River, which flows east to west to the south of the MEA license boundary (**Figure 3.4-4**). The results of this sampling program are discussed below. Historical water flow and water quality data were obtained from NDNR, NDEQ, and USGS databases (see discussions below). Water level measurements of the Box Butte Reservoir were obtained from the USBR (see discussions below).

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6.1.3.1 NDNR Niobrara River Ambient Stream Monitoring Program

- Flow Measurements for Niobrara River

The NDNR maintains stream gaging stations on the Niobrara River and reports data on its web page (NDNR 2011). Flow data reported in this section are for the section of the Niobrara River close to the proposed MEA (**Figure 3.4-4**). The description of the stream gaging stations and

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their locations is presented in **Table 6.1-12**. A summary of the stream gaging measurements from 1999 through September 2010 for the designated stream gaging stations are shown in **Table 6.1-13**. The sampling location at Agate is an exception, with data being available from 2006 through September 2010. Monthly flow measurements for stream gaging stations in the upper reaches of the Niobrara River for each of the designated years are presented in **Table 6.1-14**. A graph of the flow in cfs for the four Niobrara River stream gaging stations from 1991/1995 through 2007 is shown on **Figure 6.1-5**. In the Niobrara River west of Valentine, NE, which includes the area of the river in the vicinity of MEA, groundwater is the primary source of flow into the Niobrara River (Alexander et al. 2010). In this area of the river, the discharge of the river is steady and persistent, with overbank flooding being uncommon, except during winter ice jams (Shaffer 1975). Peak discharge extremes and minimum discharge flows for the years 1999 through 2010 are presented in **Table 6.1-13**.

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- Water Quality

The NDNR has not collected water quality on the Niobrara River in the area of the Marsland project since sampling was shared with the USGS prior to 1998 (Hayden pers. comm. 2011).

6.1.3.2 NDEQ Niobrara River Ambient Stream Monitoring Program

Water quality data for two of the NDEQ Niobrara River sampling stations were obtained from the NDEQ (NDEQ 2011b). Water quality data presented in this report is from the years 2003 through 2009, and consisted of major ions, physical properties, and metals, but no radiological analyses. Water samples were collected at a sampling station above the Niobrara River (NDEQ sample station SNI4NIOBR402/USGS 06454500) and a sampling point below Box Butte Reservoir (NDEQ sample station SNI4NIOBRA20/USGS 06455500) (**Figure 6.1-6**).

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- NDEQ Water Quality Sampling for Niobrara River Above Box Butte Reservoir (SNI4NIOBR402)

Monthly water quality data from the sample location above Box Butte Reservoir (SNI4NIOBR402) are shown in **Tables 6.1-15** through **6.1-21**, and are summarized in **Table 6.1-22**. Water quality samples were analyzed for eight major ions. The dominant cation at the sampling location above Box Butte Reservoir (SNI4IOBR402) was calcium (range of 42.82 to 58.20 mg/L), followed by sodium (range of 22.3 to 40.6 mg/L), magnesium (range of 7.91 to 11.5 mg/L), and chloride (range of 3.0 to 14.0 mg/L) (**Table 6.1-22**).

Nutrients such as nitrogen and phosphorus compounds occur naturally in surface water, but elevated concentrations may occur due to agricultural runoff and wastewater discharges and septic systems. There are at least two cattle feeding operations close to the stretch of the Niobrara River near the MEA project site (NDEQ 2005). Maximum values for nitrite plus nitrate, total ammonia nitrogen, and total kjeldahl nitrogen were all lower than 2 mg/L for the above-referenced NDEQ samples. Five of 87 total phosphorus samples yielded concentrations higher than (maximum of 1.0 mg/L) the EPA recommendation of 0.1 mg/L for avoiding algal blooms.

The average of the dissolved O_2 readings was 8.32 mg/L, and ranged from 3.34 to 11.94 mg/L. There were only two low readings of 3.34 and 4.0 mg/L, with 87 of the total samples being above 5.4 mg/L. Lower readings appeared to occur during little to no flows or high flows.

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The NDEQ water quality standards state that, in order for water to support aquatic life, the pH S.U. should be maintained between 6.5 and 9.0, unless the pH values are outside this range due to natural conditions. One of 91 of the pH readings for the Niobrara River was outside the acceptable range of 6.5 to 9 S.U. The average of the pH values was 8.02 S.U. and ranged from 7.0 to a maximum value of 9.92 S.U. recorded on May 21, 2007.

Average temperature readings were 11.08 °C, ranging from -0.25 to 22.0 °C. Seasonal fluctuations indicate that water temperature is primarily dependent upon the ambient air temperatures.

Turbidity measurements indicated an average of 24.1 nephelometric turbidity units (NTU), with a range of 0.9 to 122. The majority of the turbidity measurements were less than 30 NTU (68 of 90 readings [76 percent]). The majority of the turbidity measurements above 30 NTU were during periods of either high flow or no flow/low flow conditions. There were only five readings above 50 NTU.

Total suspended solids (TSS) measurements ranged from <5 to 170 mg/L, with an average of 21.7 mg/L. The maximum value of 170 mg/L was the only value to exceed 100 mg/L, and the cause of the exceptionally high value is unknown based on available information. Daily readings for the months before and after this high reading were 30.5 and 38 mg/L, respectively. TSS values of 83 of the total number of 98 samples (85 percent) analyzed were less than 30 mg/L. Specific conductance values ranged from 100 to 539 µmhos/cm, with an average of 388 µmhos/cm. All 91 readings were 328 µmhos/cm and above except for the one reading of 100 µmhos/cm. The daily values for the months before and after the daily monthly reading of 100 µmhos/cm were 410 and 374 µmhos/cm. The cause of this exceptionally low value is unknown based on available information.

The above-mentioned NDEQ water quality data support the classification of the Niobrara River in the vicinity of the MEA project site. The NDEQ Water Quality Body ID N14-4000 is located to the south of the MEA (**Figure 3.4-3**). This segment is rated as Supported Beneficial Use for aquatic life, agricultural water supply, and aesthetics. However, this segment is classified as Impaired for recreational use due to the measured presence of E. coli (NDEQ 2010, 2005). As a result, the water body category for this segment of the Niobrara River has been established as Category 5 (waterbodies where one or more beneficial uses are determined to be impaired by one or more pollutants and all of the Total Maximum Daily Loads [TMDLs] have not been developed; NDEQ 2010). A TMDL is the maximum quantity of a pollutant a water body can receive and still meet its appropriate water quality criteria or goal (NDEQ 2010).

- NDEQ Water Quality Sampling for Niobrara River Below Box Butte Reservoir (SNI4NIOBRA20)

NDEQ water quality data were only available for 2008 for the Niobrara River below Box Butte Reservoir (SNI4NIOBRA20) (**Table 6.1-23**). The ranges for data available for the year 2008 are shown in **Table 6.1-24**.

- Box Butte Reservoir

Box Butte Reservoir is rated as Supported Beneficial Use for recreation, agricultural water supply, and aesthetics, but Impaired Beneficial Use for aquatic life (NDEQ 2010). The impairment classification is due to a fish consumption advisory for northern pike because of elevated mercury levels identified in tissues. As a result, the water body category for this lake has been established as Category 5 (waterbodies where one or more beneficial uses are determined to be impaired by one or more pollutants and all of the TMDLs have not been developed; NDEQ 2010). The agencies assessment of Box Butte Reservoir in 2012 determined this water body is also impaired for pH (NDEQ 2012).

6.1.3.3 U.S. Bureau of Reclamation

The USBR monitors the contents of the Box Butte Reservoir daily (USBR 2011b). Measurements (acre-feet) for the reservoir from 2003 through 2010 are shown in **Table 6.1-25.** The average value for the content of the reservoir was 8,985 acre-feet between 2003 and 2010. The minimum and maximum values were 2,352 and 21, 500 acre-feet, respectively (see summary values in **Table 6.1-26**). Since the 1950s, groundwater depletions of base flow and numerous farm conservation practices have greatly reduced inflow into the reservoir (USBR 2008).

Box Butte Reservoir is used as a source of irrigation water; consequently, the reservoir storage content (acre-feet) can vary considerably annually due to the use of the water for irrigation purposes downstream of the reservoir dam. Historically, the reservoir has experienced the highest reservoir elevations during the months of May and June, while September and October exhibit the lowest reservoir elevations following irrigation releases (USBR 2008).

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The reservoir has been impacted by drought conditions over the past decade, but has rebounded in 2010 and 2011, primarily due to heavy rainfall during 2011. On July 4, 2011, the reservoir held 21,500 acre-feet of water, which compares to 12,085 acre-feet of water on May 30, 2009 and 9,200 acre-feet of water on May 30, 2008 (USBR 2011b).

Under an agreement among the Mirage Flats Irrigation District, the NGPC, and the USBR, a minimum pool elevation is maintained at 3,978 acre-feet to support and maintain a viable fishery resource in the reservoir (USBR 2011a).

6.1.3.4 Crow Butte Sampling of the Niobrara River

CBR established two water quality sampling locations on the Niobrara River, with one sampling point (N-1) established upstream (west) of the MEA license boundary and one point (N-2) located downstream (east) of the license boundary (**Figure 3.4-4).** The downstream sampling point is located to assess potential impacts from either of the two ephemeral drainages that drain the MEA.

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CBR has collected samples for baseline water quality analysis for radiological and non-radiological parameters from January 2011 through March 2012; the objective was to collect 1 year of monthly data for the radiological parameters and quarterly data for non-radiological parameters. Samples for radiological analyses have been collected monthly; however, a sample for suspended radiological parameters for sampling point N-2 was not analyzed during the first quarter of 2011 due to an error on the part of the commercial lab employed by CBR. Samples for non-radiological parameters were collected quarterly for N-1 and N-2, although for the second and third quarters of 2011, samples were collected on May 16 and June 24.

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The individual analytical results, with reporting limits, for the radiological parameters (dissolved and suspended) are presented in **Tables 6.1-27 and 6.1-28**. A summary of these analytical results is shown in **Table 6.1-29.** The results of the analyses indicated that background levels are low, with the majority of the results at or below the RL (**Table 6.1-29**). The levels for dissolved uranium (as a metal) and uranium activity were all above the RL. The concentrations at N-1 and N-2 appear to be similar. The minimum and maximum radiological analytical results for N-1 and N-2 are summarized below.

Radiological Analyte Results for N-1 and N-2 Sample Points on Niobrara River				
	Dissolved Radiological Analyte		Suspended Radiological Analyte	
Analyte	Minimum	Maximum	Minimum	Maximum
Lead-210, pCi/L	< 0.6	50	< 0.5	< 9.0
Polonium-210, pCi/L	< 0.4	4.6	< 0.2	0.4
Radium-226, pCi/L	< 0.1	1.7	< 0.06	0.14
Thorium-230, pCi/L	< 0.1	< 0.8	< 0.04	0.2
Uranium Activity, μCi/ml	≤2.0E-10	4.9E+00	< 2.0E-10	4.5E-09
Uranium, mg/L	4.0E-04	1.0E-02	< 3.0E-04	6.6E-03

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The analytical results, with RLs, for the non-radiological parameters, are presented in **6.1-30**). A total of six quarterly samples have been collected. The analytical results for the major ions and physical parameters are summarized in **Table 2.9-31**, showing the minimum and maximum values. The results for N-1 and N-2 are similar, with the majority of the results for the dissolved metals at or below the RL.

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6.1.3.5 Quality of Surface Water Measurements

The accuracy of monitoring data is critical to ensure that the water monitoring program precisely reflects water quality.

In addition to recommending the use of approved analytical methods for water quality measurements (contained in 40 CFR 136), the NRC also specifies analytical quality requirements in RG 4.14. See discussions in Section 6.1.2.4 for details regarding the reporting of lower limits of detection for surface water analyses.

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6.1.4 Baseline Vegetation, Food, and Fish Monitoring

Reference is made in this section to "milling" or "mill site" as it applies to RG 4.14. The terms "milling" or "mill site" typically refer to a primary recovery method or facility used to extract uranium from mined operations (e.g., conventional milling). ISR facilities perform uranium "milling" under an expanded NRC definition of by-product material that includes discrete surface wastes resulting from uranium solution extraction processes. Therefore, references to "milling" or "mill site" in this section can be extrapolated to uranium ISR operations.

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6.1.4.1 Vegetation

RG 4.14 recommends sampling of grazing areas near the site in different sectors that will have the highest predicted air particulate concentrations during the milling operations.

Vegetation will be sampled as described in **Table 6.1-35 and Figure 6.1-1** following guidance in RG 4.14. Using the recently acquired meteorological data and completed MILDOS calculations, vegetation samples will be collected in grazing areas located downwind of the Marsland satellite facility in sectors having the highest predicted air particulate concentrations during operations. A minimum of three samples will be collected three times during the grazing season and analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210.

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6.1.4.2 Food

- Crops

RG 4.14 recommends that crops raised within ~1.86 miles (3 km) of the mill site be sampled at the time of harvest. The NRC has indicated that other food sources should be explored for sampling, such as private gardens in the area (e.g., sampling a variety of available garden plants). Grab samples should be analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210.

The PPMP will provide for a survey of a ~1.86-mile (3 km) area around the center point of the satellite facility to assess the availability of crops for sampling. This would determine the types of crops grown in the area.

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A survey within the ~1.86-mile (3 km) radius of the satellite facility will also be made for the presence of private gardens, with the priority on locating such gardens downwind from the MEA in the predominant wind direction. CBR will seek approval from the garden owner to be able to collect samples from at least three garden items being grown. Sampling of available gardens would involve sampling of leafy tissues, fruits, and other plant parts.

Vegetation samples will be collected in accordance with the SHEQMS Volume VI Environmental Manual (CBR 2010).

- Livestock

RG 4.14 recommends that livestock raised within ~1.86 miles (3 km) of the mill site be sampled at the time of slaughter. Grab samples should be analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. Livestock should include a variety of animals present in the area, including cattle, sheep, pigs, fowl, and others.

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CBR will survey the area for the presence of livestock, and when found, will seek approval from the owner(s) to collect tissue samples at the time of slaughter. Samples for crops and livestock will be obtained at the time of harvest or slaughter. Samples would be analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210.

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Sampling of livestock would involve sampling and analysis of tissues such as bone, muscle, liver, and kidney for each species (e.g., cattle and bison). Sampling targets would be identified, and a sampling program acceptable to both parties will be developed.¶

6.1.4.3 Fish

RG 4.14 requires that fish be collected, if available, from lakes and streams in the project site area that may be subject to seepage or direct surface runoff from potentially contaminated areas or that could be affected by a tailings impoundment failure. Fish should be collected, sampled, and analyzed semiannually for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. There are no streams or water impoundments located within the MEA license boundary.

There are only two ephemeral streams that are dry during the majority of the time due to the arid nature of the region. Therefore, fish sampling within the MEA license boundary is not feasible.

The nearest permanent stream is the Niobrara River located just to the south of MEA license boundary which flows into Box Butte Reservoir. Given the large sample size required to attain LLDs (14 pounds) and the limited fish population present in the stream, the fish sampling focused on northern pike in the inlet of Box Butte Reservoir. Box Butte Reservoir is overpopulated with northern pike and allows a larger bag limit than elsewhere in Nebraska. As the most prevalent species, a popular gamefish, and known human food source, sampling the meat of the northern pike is the only feasible approach to assessing potential dietary contribution to humans.

Tissue samples were collected from northern pike on August 22, 2011 and May 25, 2012 and analyzed for lead-210, polonium-210, radium-226, thorium-230, uranium, and uranium activity (**Table 6.1-32**). The analytical results were considered low. The sampling results are reported on a wet weight basis (as received). Sampling results for lead-210 were classified as "U" or undetected at minimum detectable concentration (<1.0E-06 and 7.9E-07 microCuries per kilogram [µCi/kg], respectively). One analytical result for polonium-210 was at the reporting limit of 5.0E-07 µCi/kg, with the other value not detected at the RL of 2.8E-07 µCi/kg. For radium-226, the sampling results were at or below the RLs of 2.0E-07 and 2.2E-07 µCi/kg. The thorium-230 concentration was 1.0E-5 µCi/kg versus the RL of 8.0E-06 µCi/kg for one sampling event, and was not detected at the RL of 6.7E-08 µCi/kg for the other sampling event. The uranium and uranium activity values were below the RLs of <0.0003 mg/kg and <2E-07 µCi/kg, respectively, for one sampling event, while for the other sampling event, levels of 0.00099 µCi/kg and 6.7E-07 µCi/kg were reported, respectively.

As of May 2010, the Nebraska Department of Human and Health Services (NDHHS) with the NDEQ, the NGPC, and the Nebraska Department of Agriculture (NDA), have issued fish consumption advisories for warning to limit the consumption of northern pike in Box Butte Reservoir due to elevated mercury concentrations (NDEQ 2011a). This advisory remains in effect in 2013.

Due to the lack of background data from the study area with which to compare the current findings, radionuclide data interpretation is impracticable at this time, other than that the concentrations are considered low. The radiological results will serve as background information for future sampling events and the development of long-term trends.

6.1.4.4 Quality of Vegetation, Food, and Fish (wet) Measurements

The accuracy of monitoring data is critical to ensure that the vegetation, food, and fish monitoring program precisely reflects radionuclide concentrations in RG 4.14.

The private laboratory employed by CBR (ELI) reported the lower limits of detection for fish tissue sample analyses as MDC/LLD values. ELI stated in a letter dated April 23, 2012 (ELI 2012, **Appendix Q**) that the reported MDC/LLD values for the MEA samples were in compliance with RG 4.14, Section 5 "LLD". The LLD levels specified in RG 4.14 will be met for future food, fish, and vegetation sample analyses.

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Radionuclide	MDC/LLD for Fish Tissue (wet)	
	µCg/kg	pCi/g
Natural Uranium	2×10^{-7}	0.2
Thorium-230	2×10^{-7}	0.2
Radium-226	5×10^{-8}	0.05
Polonium-210	1×10^{-6}	1.0
Lead-210	1×10^{-6}	1.0

Source: ELI 2012 (Appendix Q)

Note: For analytes reported in two significant figures, MDC/LLD values rounded off to only one significant figure (e.g., 1.3 pCi/g = 1 pCi/g).

ELI met the criteria of the guidance suggested by the NRC when reasonably achievable by available conventional laboratory methodology. If for some reason the MDC/LLD was not met on the original analysis, the samples were recounted or re-analyzed until RG 4.14 MDC/LLDs were achieved. See **Appendix Q** for additional discussions by ELI of MDC/LLD reporting.

MDC levels for surface and groundwater radiological analytes are presented in the respective data tables of this document.

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MDC levels for fish tissue radiological analytes are presented in **Table 6.1-32.**

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6.1.5 Baseline Soil Monitoring

RG 4.14 recommends that soil samples be collected as follows:

- Up to 40 surface soil samples would be collected at 300-meter intervals to a distance of 1,500 meters in each of eight directions from the center of the milling area. Surface soil samples would be collected to a depth of 5 cm using consistent sampling methods. Sampling would be conducted once prior to construction and repeated for locations disturbed by excavation, leveling, or contouring. All samples would be analyzed for radium-226, and 10 percent of the samples analyzed for natural uranium, thorium-230, and lead-210.
- Five or more surface soil samples (to a depth of 5 cm) would be collected at the same locations used for air particulate samples. Samples would be collected once prior to construction. Samples would be analyzed for natural uranium, radium-226, thorium-230, and lead-210.
- Five subsurface samples collected at the center point location and at distances of 750 meters in each of four directions. Subsurface soil samples would be collected to a depth of 1 meter and divided into three equal sections for analysis. Samples would be collected once prior to construction and repeated for locations disturbed by construction. All samples would be analyzed for radium-226, and one set of the samples would be analyzed for natural uranium, thorium-230, and lead-210.

Soil samples will be collected at 300-meter intervals to a distance of 1,500 meters in each of eight directions from the center_point of the satellite facility. In addition, transects will be made through the center area of each proposed mine unit to collect samples at 300-meter intervals. Sampling distances for some sampling points on transects from the center_point of the satellite

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facility and through the mine units may be modified to obtain a more representative sampling of the project area (e.g., proposed wellfield layouts).

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Surface soil samples to a depth of 5 cm will be collected at 300-meter intervals to a distance of 1,500 meters (where feasible) along established transects. Any areas disturbed by excavation, leveling, or contouring would be resampled. All surface samples (5 cm) will be analyzed for radium-226, and 10 percent of the samples for natural uranium, thorium-230, and lead-210. Surface soil samples at each air monitoring station will be analyzed for natural uranium, radium-226, thorium-230, and lead-210. All surface soil sampling will occur once prior to construction and repeated for any locations disturbed by excavation, leveling, or contouring. Subsurface samples will be analyzed once prior to construction and repeated for any locations disturbed by construction.

In this application, Cameco requests a soil sampling program different from that specified in NUREG-1569, Standard Review Plan for In situ Leach Uranium Extraction License Applications. Specifically, Cameco proposes taking soil samples at both a 5 cm and 15 cm depth as recommended by NUREG-1569, Acceptance Criteria 2.9.3 (2) for background decommissioning, with the exception of samples taken at the air monitoring stations. In a public meeting (ML 12255A258), NRC stated that, in light of the EPA's technical basis for its radium-226 soil cleanup standard (refer to EPA 520/4-82-013-2, Final Environmental Impact Statement for remedial Action Standards for Inactive Uranium Processing Sites [40 CFR 192], Volume II, October 1982, pages D-51, 52), where EPA found no difference in health protection between averaging contamination throughout the top 5 cm of soil versus the top 15 cm of soil, it is not necessary to sample to 15 cm at the air monitoring stations. That rationale is applicable here.

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For background samples (excluding the air monitoring stations), subsurface samples will be collected at the satellite facility center reference location and at a distance of 750 meters (alternate distances in some cases as explained above) in each of four directions. Additional subsurface samples will be collected along the additional transects discussed above. Any areas disturbed by construction will be resampled. Subsurface soil profile samples would be collected to a depth of 1 meter. Samples would be divided into three equal sections for analysis. All subsurface samples would be analyzed for radium-226 and one set of samples for natural uranium, thorium-230, and lead-210.

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Soil samples will be collected in accordance with the SHEQMS Volume VI Environmental Manual (CBR 2010).

6.1.5.1 Quality of Soil Measurements

The accuracy of monitoring data is critical to ensure that the soil monitoring program precisely reflects radionuclide concentrations. RG 4.14 specifies the following LLDs:

Radionuclide	Recommended LLD µCi/g
Natural Uranium	2×10^{-7}
Radium-226	2×10^{-7}
Thorium-230	2×10^{-7}
Lead-210 (dry)	2×10^{-7}

The LLD levels specified by RG 4.14 will be met for future soil sample analyses.

6.1.6 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.

RG 4.14 recommends that sediment samples be collected from sediments of surface water passing through the project site or off-site surface waters that may be subject to drainage from potentially contaminated areas. The PPMP and operational monitoring plan will be designed to meet the criteria outlined in RG 4.14 (NRC 1980). Samples are to be collected once following spring runoff and in late summer following a period of extended low flow.

Niobrara River Sediments

Sediment sampling in RG 4.14 requires samples from each large on-site body of water or off-site surface waters that may be subject to direct surface drainage from potentially contaminated areas that could be affected by a tailings impoundment failure. One sample is to be collected prior to construction and analyzed for natural uranium, radium-226, thorium-230, and lead-210. There are no on-site surface impoundments; therefore, such sampling is not required. Sediment samples will be collected from the Niobrara River, which could receive surface water runoff by means of ephemeral drainages located on the MEA project site (**Figure 3.4-4**). Sediments of the Niobrara River were sampled at designated upstream and downstream sampling locations (sample points N-1 and N-2) (**Figure 3.4-4**). Water samples are also collected at these sampling points. The downstream sampling point is located to assess potential impacts from either of the two ephemeral drainages that drain the MEA.

Niobrara River sediment samples at N-1 and N-2 sampling points were collected on March 20, 2013. The radiological sample analytical results for lead-210, radium-226, thorium-230, and natural uranium are shown in **Table 6.1-33**. The analytical results for lead-210, radium-226, thorium-230, and uranium were the same for each parameter for both sampling sites, with all but radium-226 being at or near the reporting limits, (i.e., lead-210 at 0.3 pCi/g – dry weight [RL 0.2 pCi/g – dry weight], radium-226 at 0.4 pCi/g – dry weight [RL 0.04 mg/kg – dry weight], thorium-230 at 0.2 pCi/g – dry weight [RL 0.2 pCi/g – dry weight], and uranium at 0.4 mg/kg – dry weight [RL 0.3 mg/kg – dry weight] and 0.3 pCi/g – dry weight [RL 0.2 pCi/g – dry weight]).

Ephemeral Drainages

Two major ephemeral drainages traverse across the MEA license area north to south (**Figure 3.4-4**). Six upgradient and downgradient sampling points have been selected on these drainages to measure radiological concentrations in the sediment (MED-1 through MED-6).

The ephemeral drainages and the Niobrara River at designated sampling points will be sampled twice, once following spring runoff and in late summer following period of extended low flow. Samples will be analyzed for natural uranium, radium-226, thorium-230, and lead-210.

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Ephemeral drainage sediment sampling at Marsland was conducted in the fourth quarter of 2011 and the first quarter of 2013. The proposed PPMP and operational monitoring program is shown in **Tables 6.1-35 and 6.1-36**.

The 2012 and 2013 radionuclide measurements are shown in **Table 6.1-34**. A summary of the analytical results is as follows:

Analyte	Units	Minimum	Maximum	Reporting Limit
Lead-210	pCi/g-dry	≤0.2	1.5	0.2
Radium-226	pCi/g-dry	0.2	0.8	0.02 to 0.04
Thorium-230	pCi/g-dry	< 0.2	0.5	0.2
Uranium Activity	pCi/g-dry	≤0.2	0.7	0.2
Uranium (metal)	mg/kg-dry	≤0.3	1.0	0.3

Sediment samples were collected in accordance with the SHEQMS Volume VI Environmental Manual (CBR 2010).

6.1.6.1 Quality of Sediment Measurements

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

The private laboratory employed by CBR (ELI) reported the lower limits of detection for sediment sample analyses as MDC/LLD values. ELI stated in a letter dated April 23, 2012 (ELI 2012, **Appendix Q**) that the reported MDC/LLD values for the MEA samples were in compliance with RG 4.14, Section 5 "LLD".

Radionuclide	MDC/LLD for Sediment (dry)	
	µCi/g	pCi/g
Natural Uranium	2 x 10^{-7}	0.2
Thorium-230	2 x 10^{-7}	0.2
Radium-226	2 x 10^{-7}	0.2
Polonium-210	No guidance	No guidance
Lead-210	2 x 10^{-7}	0.2

Source: ELI 2012 (Appendix Q)

Note: For analytes reported in two significant figures. MDC/LLD values rounded off to only one significant figure (e.g., 1.3 pCi/g = 1 pCi/g).

ELI met the criteria of the guidance suggested by the NRC when reasonably achievable by available conventional laboratory methodology. If for some reason the MDC/LLD was not met on the original analysis, the samples were recounted or re-analyzed until RG 4.14 MDC/LLDs were achieved. See **Appendix Q** for additional discussions by ELI of MDC/LLD reporting.

MDC levels for surface and groundwater radiological analytes are presented in the respective data tables of this document as well as in the individual Analytical Summary Reports of **Appendix J**.

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6.1.7 Baseline Direct Radiation Monitoring

6.1.7.1 Survey Intervals

RG 4.14 recommends that direct radiation measurements be collected at 150-meter intervals to a distance of 4,921.26 feet (1,500 meters) in each of eight directions from the center point of the milling area or at a point equidistant from the milling area and tailings disposal area. The direct gamma radiation sampling at MEA will be designed to meet this guidance. Because there is no milling or tailings disposal area, CBR will use the satellite facility as the center point. In addition, gamma readings will be made at 150-meter intervals along established transects through the center portion of each proposed mine unit. The sampling locations will be consistent with the soil sampling locations as discussed in Section 6.1.5.

Samples are to be collected once prior to construction and repeated for areas disturbed by site preparation or construction. The timeline for completion of this sampling is the third quarter of 2013 (**Figure 6.1-1**). Gamma exposure rate is to be derived using passive integrating device such as an optically stimulated luminescence dosimeter (OSLD), pressurized ionization chamber, or a properly calibrated portable survey instrument.

Gamma will be measured using an environmental OSLD. The OSLDs are the most advanced technology available for measuring radiation exposure, including being accurate within ±1 mRem, while in contrast, thermoluminescent dosimeter (TLD) and film badges require 10 mRem to begin reporting (Landauer 2010).

6.1.7.2 Survey Measurements at Air Particulate Monitoring Stations

The PPMP includes routine monitoring of direct radiation levels at the air monitoring stations.

Monitoring has been conducted by placing the OSLDs provided by Landauer, Inc. quarterly at the air particulate monitoring sites (**Figure 6.1-2**). The monitors were located approximately 1 meter above ground level. They were exchanged with new monitors quarterly, 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 PPMP and operational monitoring plan has been designed to meet the criteria outlined in RG 4.14 (NRC 1980). As with air particulate and radon-220 monitoring, gamma monitoring began in the fourth quarter of 2011 and was completed in the fourth quarter of 2012 (five quarters of data). The PPMP and operational monitoring program are shown in **Tables 6.1-36 and 6.1-37**.

The results of gamma measurements conducted at the air particulate monitoring stations (MAR-1 through MAR-5) for the fourth quarter of 2011 through the fourth quarter of 2012 are presented in **Table 6.1-35**. The gross and net measurements for all sampling locations over the entire sampling period ranged from 19.9 to 40.9 (average of 33.3 and 4.5 to 14.5 (average of 8.0) mRems ambient dose equivalent, respectively. The range of the gross and net measurements for MAR-1 through MAR-4 was 19.9 through 40.9 (average of 33.8) and 4.6 to 14.5 (average of 8.5) mRems ambient dose equivalent, respectively, compared to MAR-5, with a range of 20.9 through 38.1 (average of 31.8) and 4.5 to 7.7 (average of 6.2) mRems ambient dose equivalent, respectively.

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The average background gamma level in the Western Great Plains have been reported to be 0.014 milli-Roentgens per hour (mR/hr) (NRC 1979).

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NRC RG 4.14 guidance recommends a combination of direct gamma radiation measurements and exposure measurements made with integrating devices (i.e., OSLDs) during the PPMP. 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 RG 4.14, CBR will perform preoperational/preconstruction gamma radiation measurements at 150-meter intervals as discussed above. Note that some alternate sampling locations may be employed as discussed in Section 6.1.5. These measurements will be made once prior to construction and will be repeated for areas disturbed by site preparation or construction. The type of survey instrument and procedures would be as described below for measurements previously conducted at the proposed satellite facility.

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The preoperational/preconstruction direct gamma radiation program will be designed to meet the guidance provided in RG 4.14.

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6.1.8 Preoperational Baseline Monitoring Program Summary

The MEA PPMP discussed in this section is summarized in **Table 6.1-36**, and the remaining monitoring tasks and completion timelines are presented on **Figure 6.1-1.**

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6.2 Operational Environmental Monitoring Program

The operational baseline monitoring program is presented in **Table 6.1-37**.

6.2.1 Airborne Effluent and Environmental Monitoring Program

6.2.1.1 Air Particulate Monitoring

Composite airborne particulate samples for natural uranium, radium-226, lead-210, and thorium-230 will be obtained quarterly from air monitoring locations MAR-1 through MAR-5. The quality of sample collection and analysis shall be maintained by adhering to QC procedures discussed in Section 6.2.4 and LLC concentration limits discussed in Section 6.1.1.4.

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The air particulate samplers described in Section 6.1.1 will continue to be used for the operational monitoring program.

6.2.1.2 Radon

The radon gas effluent released to the environment from satellite facility will be monitored at the same air monitoring locations (MAR-1 through MAR-5) used for baseline determination of radon concentrations as described in Section 6.1.1. Sampling locations are shown on **Figure 6.1-2**. Monitoring will be performed using Track-Etch radon cups. The cups will be exchanged semiannually to achieve the required LLD. SHEQMS Volume IV, Health Physics Manual currently provides the instructions for environmental radon gas monitoring. In addition to the manufacturer's QA program, CBR will expose one duplicate radon Track Etch cup per monitoring period. The quality of sample collection and analysis shall be maintained by adhering to QC procedures discussed in Section 6.2.4 and LLC concentration limits discussed in Section 6.1.1.4.

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Monitoring of radon gas releases from the satellite facility building and ventilation discharge points is not deemed to be practicable. Section 3.3 of RG 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 TEDE to the individual likely to receive the highest dose from licensed operations does not exceed the annual dose limit of 100 mRem.

The satellite facility would use pressurized downflow IX 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 staying in solution and not being released from the columns. Radon may be released from occasional venting of process vessels and tanks, small leaks in IX equipment, and maintenance of equipment. Therefore, releases via the vent stacks would not have a consistent concentration of radon or flowrate, making it impracticable to try to use such data for public exposure estimates.

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CBR has used MILDOS-AREA to model the dose from facility operations resulting from releases of radon gas (Savignac 2011a). MILDOS-AREA outputs are presented in **Appendix M-1** and discussed in Section 4.12.2.3. In determining the source term for MILDOS-AREA for the satellite facility, radon gas release was estimated at 25 percent of the radon-222 in the production fluid from the wellfields and an additional 10 percent in the IX circuit in the satellite building. The release of radon-222 at this concentration did not result in a significant public dose.

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.

6.2.1.3 Surface Soil

Surface soil will be sampled as described in Section 6.1.5. Surface soil samples will be taken annually at the monitoring locations (MAR-1 through MAR-5) during operations. Following conclusion of operations, samples will be collected and compared to the results of the PPMP. Samples shall be analyzed for natural uranium, radium-226, thorium-230, and lead-210.

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Surface soil will also be sampled at the satellite plant location as described in Section 6.1.5. Surface soil samples will be taken following conclusion of operations and compared to the results of the PPMP. The quality of sample collection and analysis shall be maintained by adhering to QC procedures and LLC concentration limits discussed in Section 6.1.5.

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6.2.1.4 Subsurface Soil

Subsurface soil will be sampled at the facility location as described in Section 6.1.5. Subsurface soil samples will be taken following conclusion of operations and compared to the results of the PPMP. The quality of samples shall be maintained by following QC procedures discussed in Section 6.2.4 and adhering to the LLC concentration limits discussed in Section 6.1.5.1.

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6.2.1.5 Vegetation

There are currently no plans to sample vegetation for radiological analyses during operations. In accordance with the provisions of RG 4.14, Footnote (o) to Table 2 states the following: *Vegetation and forage sampling need to be carried out only if dose calculations indicate that the ingestion pathway from grazing animals is a potentially significant exposure pathway (an* *exposure pathway should be considered important if the predicted dose to an individual would exceed 5 % of the applicable radiation protection standard.* The applicable radiation standard in 10 CFR 20 is 100 mRem/yr. Five percent of 100 mRem/yr is 5 mRem/yr.

This pathway was evaluated by CBR's radiological consultant (Savignac 2011b, **Appendix M-2**). MILDOS calculated the radiation dose to individuals within 50 miles (80 km) of the MEA site from vegetables, meat, and milk as population doses in units of person-Rem/yr. Dividing those doses by the population with 50 miles (80 km) and converting the doses to mRem/yr gives the doses in **Table 6.2-1.** The total dose in **Table 6.2-1** is the average dose to humans living within 50 miles (80 km) of the MEA uranium recovery operation that results from the consumption of vegetables, meat, and/or milk that might have been impacted by the release of radon and its decay products on vegetation or forage from ISR extraction operations.

Based on the results of the analysis, as presented in **Appendix M-2,** vegetation or forage sampling at the MEA ISR operations should not be required because the radiation dose calculated for those operations is not considered "important" (NRC terminology in RG 4.14). The average radiation dose to people living with 50 miles (80 km) of the MEA from the vegetation pathway was 0.05 mRem/yr. The maximum radiation dose to the nearby residents from the vegetation pathway was 1.5 mRem/yr. RG 4.14 considers doses less than 5 percent of the applicable radiation standard (5 percent of 100 mRem = 5 mRem/yr) as not "important" as a vegetation pathway.

6.2.1.6 Food

Livestock, Crops, and Vegetable Gardens

RG 4.14 recommends that crops, livestock, and other farm products raised within ~1.86 miles (3 km) of the mill site be sampled at the time of harvest or slaughter. Grab samples should be analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. Livestock should include a variety of animals present in the area, including cattle, sheep, pigs, fowl, and other farm animals.

There are currently no plans to sample food items (e.g., crops, livestock) for radiological analyses during operations. The basis for not collecting such samples is the results of the dose calculations for the food pathway for Marsland in Section 6.1.4.2. The maximum radiation dose to nearby residents from the vegetation pathway was 1.5 mRem/yr, which is significantly lower than the applicable radiation standard of 5 mRem/yr discussed above. Based on these results, it is highly unlikely that livestock, crops, or vegetable gardens, as part of the food pathway, would accumulate unacceptable levels of radioactive constituents. However, the PPMP provides for a survey of a ~1.86-mile (3 km) area around the center point of the satellite facility to assess the availability of crops, livestock, fowl, and other applicable sources for sampling. This would determine the types of crops grown in the area, number and types of livestock, availability of gardens, and other applicable data. For available specimens, sampling and analysis of these resources will be conducted as per RG 4.14, which will allow for collection of baseline data.

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6.2.1.7 Fish

RG 4.14 requires that fish be collected, if available, from lakes and streams in the project site area that may be subject to seepage or direct surface runoff from potentially contaminated areas or that could be affected by a tailings impoundment failure. Fish should be collected, sampled, and analyzed semiannually for natural uranium, radium-226, thorium-230, lead-210, and polonium-210.

There are currently no plans to collect fish for tissue analysis of radiological constituents. The results of the MILDOS analysis for vegetation uptake discussed in Section 6.2.1.5 indicate that the potential for fish uptake of radiological constituents as part of the food pathway would be highly unlikely. Due to the arid nature of the area in which the MEA is located, the ephemeral drainages that traverse to MEA license boundary do not support sufficient water flow to support a fish population. The two major ephemeral drainages eventually connect to the Niobrara River, which is the nearest stream with permanent water. The river is located south of the license boundary, flowing west to east. The Box Butte Reservoir is located on the Niobrara River approximately 3.5 miles (5.6 km) from the southeastern corner of the MEA license boundary. The Marsland operations will not discharge any liquids to the ephemeral drainages or to any other areas of the proposed operations. Any spills that could occur would be contained per the site spill control plans, and it is highly unlikely that any liquid spills would ever reach the Niobrara River. Therefore, operational sampling of fish is not deemed to be of value.

As discussed in Section 6.1.4.3, the CBR PPMP will provide for collection of fish samples from the Niobrara River as per RG 4.14. This sampling and analysis plan will allow for documentation of a baseline of radioactive constituent concentrations in fish tissues for the area of the river south of the MEA site.

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6.2.1.8 Direct Radiation

Environmental gamma radiation levels will be monitored continuously at the air monitoring stations (MAR-1 through MAR-5) during operations. Gamma radiation will be monitored using environmental dosimeters obtained from a National Voluntary Laboratory Accreditation Program (NVLAP)-certified vendor. Dosimeters will be exchanged quarterly.

6.2.1.9 Sediment

Upstream and downstream sediment samples will be collected annually at the sample locations described in Section 6.1.6 and shown on **Figure 3.4-4**. Samples will be collected as described in Section 6.1.6 and analyzed for natural uranium, radium-226, thorium-230, and lead-210. The quality of sample collection and analysis shall be maintained by adhering to QC procedures as discussed in Section 6.2.4 and LLC concentration limits discussed in Section 6.1.6.1.

6.2.2 Groundwater/Surface Water Monitoring Program

6.2.2.1 Program Description

During operations at the satellite facility, a detailed water sampling program will be conducted to identify any potential impacts to water resources of the area. The CBR operational water monitoring program includes the regional evaluation of groundwater, groundwater within the permit or licensed area, and surface water on a regional and site-specific basis. The quality of sample collection and analysis shall be maintained by adhering to QC procedures discussed in Section 6.2.4 and LLC concentration limits discussed in Section 6.1.2.4. 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 approximately 1,500 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

During operations, all active, operational and accessible private wells located within the MEA license boundary and within 0.62 mile (1 km) of the MEA license boundary will be monitored quarterly (**Figures 3.4-6 and 3.4-7**). Groundwater samples are taken in accordance with the instructions contained in SHEQMS Volume VI, Environmental Manual, and are analyzed for natural uranium and radium-226. Water well samples will be collected and analyzed as described in Section 6.1.2.1.

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- Monitor Well Baseline Water Quality

After delineation of the production unit boundaries, monitor wells are installed no farther than 300 feet from the wellfield boundary and no further than 400 feet apart or as required by the NDEQ. After completion, wells are washed out and developed (by air flushing or pumping) until 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 data. 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 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 UCLs for excursion detection. Wells are developed and sampled in accordance with the instructions contained in SHEQMS 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, UCLs are set for chemical constituents that would indicate 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 IX process (uranium is exchanged for chloride on the IX 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. UCLs are set at 20 percent 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 five standard deviations or 15 mg/L to the baseline average for the indicator.

Operational monitoring consists of sampling the monitor wells biweekly 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 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 5 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 nor third sample results exceeded the UCLs, the results from the first sample are 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 NRC Project Manager is notified by telephone or email within 48 hours and notified in writing within 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.
- 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 1-week samples.

A sufficient number of monitoring wells will be installed in the Brule Formation between the permit boundary and the Niobrara River to monitor water quality in the event of failure of an injection well or production well, and to prevent potential communication of mining fluids with surface water. Installation of such monitoring wells is required under the Class III injection well permit. Alluvial deposits along the margins of the Niobrara River may offer limited groundwater storage depending on river levels. Beyond the MEA permit boundary, the magnitude of regional groundwater flow will not be meaningfully affected by operations at the MEA and will resume to regional flow conditions within a few hundred feet outside the permit boundary.

6.2.2.2 Surface Water Monitoring

If available, surface water samples will be collected as described in Section 6.1.3. Samples will be collected quarterly and analyzed for dissolved and suspended natural uranium, radium-226, thorium-230, lead-210, and polonium-210. Sample locations are shown on **Figure 3.4-4.** The quality of sample collection and analysis shall be maintained by adhering to QC procedures discussed in Section 6.2.4 and LLC concentration limits discussed in Section 6.1.3.5.

Surface water samples will be taken in accordance with the instructions contained in SHEQMS Volume VI, Environmental Manual. Upstream and downstream samples from all locations will be obtained quarterly. Surface water samples are analyzed for the parameters identified in Section 6.1.3. Surface monitoring results are submitted in the semi-annual environmental and effluent reports submitted to NRC.

6.2.3 Ecological Monitoring

CBR does not perform any ecological monitoring at the current licensed operation. CBR will follow a swift fox survey protocol during drilling of boreholes and "project development" activities at the MEA. The swift fox is listed as endangered under the Nebraska Nongame and Endangered Species Conservation Act.

Satellite "project development" activities include construction of satellite facilities (process building and associated storage structures), wellfield development (surface preparation, monitor and injection/recovery wells, wellhouses, and trunklines/piping), well workover, boreholes outside of wellfields, and project roadways. Project development activities apply to initial construction/wellfield development, operations, and decommissioning. Decommissioning includes decontaminating, dismantling, and removing satellite facilities and associated wellfield buildings/equipment/wells, and site reclamation and groundwater restoration. The swift fox protocol is presented in **Appendix O**.

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6.2.4 Quality Assurance Program

A QA 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.

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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;
- QC for on-site analytical instrumentation and sampling. 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.

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The SHEQMS developed by CBR is a critical step to ensuring that QA objectives are met. Current procedures exist for a variety of areas, including but not limited to:

1. Environmental monitoring
2. Testing
3. Exposure
4. Equipment operation and maintenance
5. Employee health and safety
6. Incident responses

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Table 6.1-1 Locations of Environmental Sampling Stations, SAT Facility and MET Station at the Marsland Expansion Area Site

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Table 6.1-2 Airborne Particulate Concentrations for Marsland Expansion Area

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Table 6.1-3 Ambient Atmospheric Radon-222 Concentration for Marsland Expansion Area

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Table 6.1-4 Summary of Water Quality for the MEA and Vicinity (2011)

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Table 6.1-5 Radiological Analyses for Private Water Supply Wells in Marsland Area of Review

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Table 6.1-6 Non-Radiological Analyses for Private Water Supply Wells in Marsland Area of Review

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Table 6.1-7 Water Levels - Brule Formation and Basal Sandstone of Chadron Formation

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Table 6.1-8 **Marsland Expansion Area Groundwater Radiological Analytical Results for Brule Wells**

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Table 6.1-9 Marsland Expansion Area Groundwater Non-Radiological Analytical Results for Brule Wells

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Table 6.1-10 Marsland Expansion Area Groundwater Radiological Analytical Results for Chadron Wells

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Table 6.1-11 Marsland Expansion Area Groundwater Non-Radiological Analytical Results for Chadron Wells

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Table 6.1-12 Stream Gaging Stations on Niobrara River in Vicinity of Headwaters of Niobrara River

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Table 6.1-13 Summary of Niobrara River Flow Measurements 1999 - 2010

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Table 6.1-14 Water Flow Measurements for Upper Reaches of Niobrara River – 1999 to 2010

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Table 6.1-15 NDEQ Water Quality Data for Niobrara River Above Box Butte Reservoir (SNI4NIOBR402) - 2003

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Table 6.1-16 NDEQ Water Quality Data for Niobrara River Above Box Butte Reservoir (SNI4NIOBR402) - 2004

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Table 6.1-17 NDEQ Water Quality Data for Niobrara River Above Box Butte Reservoir (SNI4NIOBR402) - 2005

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Table 6.1-18 NDEQ Water Quality Data for Niobrara River Above Box Butte Reservoir (SNI4NIOBR402) - 2006

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Table 6.1-19 NDEQ Water Quality Data for Niobrara River Above Box Butte Reservoir (SNI4NIOBR402) - 2007

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Table 6.1-20 NDEQ Water Quality Data for Niobrara River Above Box Butte Reservoir - 2008

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Table 6.1-21 NDEQ Water Quality Data for the Niobrara River Above Box Butte Reservoir - 2009

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Table 6.1-22 Summary of NDEQ Water Quality Data for Niobrara River Above Box Butte Reservoir 2003 - 2009

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Table 6.1-23 NDEQ Water Quality Data for Niobrara River Below Box Butte Reservoir - 2008

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Table 6.1-24 NDEQ Water Quality for Niobrara River Below Box Butte Reservoir 2008 (Range Values)

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Table 6.1-25 Daily Contents in Acre-Feet of Water for Box Butte Reservoir (USGS 06455000)– 2003 to 2010

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Table 6.1-26 Box Butte Reservoir Water Contents (Range Values)

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Table 6.1-27 Niobrara River Dissolved Radiological Water Quality Baseline Data Collected by Marsland

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Table 6.1-28 Niobrara River Suspended Radiological Water Quality Baseline Data Collected by Marsland 2011

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Table 6.1-29 Summary of CBR Radiological Baseline Data for Niobrara River Near MEA

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Table 6.1-30 Niobrara River Non-Radiological Water Quality Baseline Data 2011

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Table 6.1-31 Summary of Non-Radiological Baseline Data for Niobrara River Near Marsland Expansion Area Collected by Crow Butte

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Table 6.1-32 Total Radionuclides and Metals in Tissue of Northern Pike Collected from Inlet of Box Butte Reservoir

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Table 6.1-33 Radionuclide and Metal Analyses for Marsland Ephemeral Drainage (MED) Sample Locations

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Table 6.1-34 Marsland Expansion Area Gamma Exposure Results

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Table 6.1-35 Marsland Expansion Area Preoperational/Preconstruction Monitoring Program

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Table 6.1-36 Marsland Expansion Area Operational Effluent and Environmental Monitoring Plan

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Table 6.2-1 Radiation Doses from Vegetation Pathway to Man Within 80 Kilometers of the Marsland In-Situ Uranium Recovery Operation

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Figure 6.1-1 Marsland Preoperational/Preconstruction Monitoring Timeline

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Figure 6.1-2 Location of Environmental Air Sampling Stations at Marsland Expansion Area

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Figure 6.1-3 Marsland Expansion Area Potentiometric Surface Brule Formation (2/22/11)

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Figure 6.1-4 Marsland Expansion Area Potentiometric Surface Basal Chadron Sandstone (2/22/11)

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Figure 6.1-5 Mean Stream Flow (cfs) for Niobrara River Stream Gaging Stations in Upper Area in Niobrara River

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Figure 6.1-6 USGS/NDNR Stream Gaging Stations and NDEQ Sampling Locations for Niobrara River

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7 COST-BENEFIT ANALYSIS

7.1 General

The general need for production of uranium is assumed to be an integral part of the nuclear fuel cycle with the ultimate objective being the operation of nuclear power reactors. In reactor licensing evaluations, the benefits of the energy produced are weighed against environmental costs including a prorated share of the environmental costs of the uranium fuel cycle. The incremental impacts of typical mining and milling operation required for the fuel cycle are justified in terms of the benefits of energy generation to society in general. However, the specific site-related benefits and costs of an individual fuel-cycle facility such as the CPF and the proposed satellite facility must be reasonable as compared to that typical operation.

7.2 Economic Impacts

Monetary benefits have accrued to the community from the presence of the CPF, such as local expenditures of operating funds and the federal, state, and local taxes paid by the 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 satellite facility.

7.2.1 Tax Revenues

Table 4.10-1 summarizes the tax revenues from the CPF.

Future tax revenues are dependent on uranium prices, which cannot be accurately forecast; however, these taxes also somewhat depend on the number of pounds of uranium produced by CBR. To the extent that uranium prices remain at current levels (spot market of approximately \$50 per pound U_3O_8 in August 2011 [UxC 2011]), the production from MEA should contribute to higher tax revenues.

The present taxes are based on a relatively consistent production rate of 800,000 pounds per year. The additional production from the MEA facility should be approximately 553,000 pounds per year. The incremental contribution to taxes would be on the order of \$950,000 per year in combined taxes.

7.2.2 Temporary and Permanent Jobs

7.2.2.1 Current Staffing Levels

CBR currently employs approximately 68 employees and two contractors employing 14 people on a full-time basis. Short-term contractors and part-time employees are also employed for specific projects and/or during the summer months. This level of employment is significant to the local economies. Total employment in Dawes County in 2010 was 5,691 (BEA 2011). Based on these statistics, CBR currently provides approximately 1.5 percent of all employment in Dawes County. In 2009, the CBR total payroll was \$4,155,000. Of the total Dawes County wage and salary payments of \$106,652,000 in 2009, the CBR payroll represented about 4 percent.

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Total CBR payroll for the past 5 years was:

2006	$2,543,000
2007	$3,822,000
2008	$3,941,000
2009	$4,155,000
2010	$4,200,000

The average annual wage for all workers in Dawes County was $27,347 in 2009. By comparison, the average wage for CBR was approximately $58,821. Entry-level workers for CBR earn a minimum of $16.15 per hour or $33,600 per year, not including overtime, bonus, or benefits.

7.2.2.2 Projected Short-Term and Long-Term Staffing Levels

CBR expects that construction of the MEA will provide approximately 10 to 15 temporary construction jobs for up to 1 year. 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 members (less than 5 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. The annual unemployment rate in Dawes County in 2010 was 4.5 percent, equating to 216 individuals (BLS 2011). 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 10 to 12 full-time CBR employees. These new employees will be needed for facility operators and wellfield operator and maintenance positions. Contractor employees (e.g., drilling rig operators) 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 approximately $40,000 per month, or $400,000 to $480,000 per year.

7.2.3 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 available in the local area.

Total CBR payments made to Nebraska businesses for the past 4 years were:

2006	$4,396,000
2007	$5,167,000
2008	$7.685,000
2009	$7,838,700
2010	$4,330,900

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

This level of business is expected to continue dependent upon CBR project activities in any given year. As production at the CPF mine site ceases due to depleted ore reserves, expansion areas will be brought on stream. These expansion areas will be sequenced (brought on line) in a manner that will continue CPF production consistent with current production rates. CPF project activities should increase somewhat with the addition of expanded production from the proposed MEA and from restoration activities, although not in strict proportion to production. While there are some savings due to some fixed costs, there are additional expenses that are expected to be higher (wellfield development). Therefore, it can be assumed that the overall effect on local purchases will be relatively proportional to the number of pounds produced. In addition, mineral royalty payments accrue to local landowners. This should translate to additional purchases of $3,650,000 to $4,350,000 per year.

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7.2.4 Economic Impact Summary

As discussed in this section, CBR currently provides a significant economic impact to the local Dawes County economy. Approval of the proposed project would have a positive impact on the local economy as summarized in **Table 4.10-2**.

7.2.5 Estimated Value of Marsland Resource

CBR continues to develop the reserve estimates for the MEA. Based on the current recoverable resource estimate of 5,667,926 pounds of U_3O_8 and the current market price of uranium ($50 per pound in August 2011 [UxC 2011]), the total estimated value of the energy resources at MEA is approximately $283,396,300. This value will fluctuate as the market price and realized price vary.

7.2.6 Short-Term External Costs

7.2.6.1 Housing Impacts

The available housing resources should be adequate to support short-term needs during facility construction. In 2010, a total of 568 housing units were vacant in Dawes County out of a total housing base of 4,252 units (USCB 2011). Of the vacant units, 168 were available for rent. In addition to this availability of rental housing units, there are two small hotels in the City of Crawford that generally have vacancies and routinely provide units for itinerant workers such as railroad crews. Temporary housing resources have experienced little change in the past two decades.

Recent data for the City of Crawford indicate that, in 2010, there were a total of 567 houses in the City, with 470 occupied (334 by owners and 136 by renters; USCB 2011). This indicates that 97

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housing units were available for purchase or rent. In 2008, the housing density was 467 houses/condos per square mile. The median rent being asked for vacant rental units in 2008 was $337/month. The median purchase price for a home was $51,856 (Advameg 2010).

7.2.6.2 Noise and Congestion

CBR projects an increase in the noise and congestion in the immediate area of the satellite facility during initial construction of the facility. This will include heavy truck and equipment traffic and access to the job site by construction workers. These impacts will be most noticeable to residents in the immediate vicinity of the facility and will be temporary in nature. The increase in noise should be considered in light of the project location, which is two minor rural roads (Hollibaugh and River Roads) used primarily for access.

A BNSF rail line is located east of SH 2/71 and is approximately 1.1 miles (17.7 km) from the MEA boundary at the closest point. Noise from the trains on the BNSF rail line would be intermittently audible to receptors within and in close proximity to the MEA. Dust from construction activities will be controlled using standard dust suppression techniques used in the construction industry.

7.2.6.3 Local Services

As previously noted, CBR actively recruits and trains local residents for positions at the mine. CBR expects that the majority of permanent positions at the MEA will be filled with local hires. As a result of employing the local workforce, the impact on local services should be minimal. In many cases, these services (e.g., schools) are underused due to population trends in the area.

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7.2.7 Long-Term External Costs

7.2.7.1 Housing and Services

Because of the small number of people who have needed to move into the area to support CBR activities in the past, the impact on the community in terms of expanded services has been minimal. CBR expects that the types of long-term positions that will be created by the MEA project 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. As stated earlier, CBR expects that the new positions at the satellite facility will be filled from the local pool of available labor.

7.2.7.2 Noise and Congestion

CBR projects a minor increase in the long-term noise and traffic congestion in the immediate area of the satellite facility. Most of this will consist of increased traffic from employees commuting to and from the work site and performing work in the wellfield. Some increase in heavy truck traffic will occur due to deliveries of process chemicals such as O_2 and the shipment of IX resin from the satellite facility to the CPF. Delivery and IX shipments should average two per day. These impacts will be most noticeable to residents in the immediate vicinity of the facility.

The 2008 average daily traffic counts for a segment of SH 2/71 near Marsland at the southern end of the MEA was 675 total vehicles, including 90 heavy commercial vehicles. Traffic levels on SH 2/71 increase to 695 total vehicles, including 90 heavy commercial vehicles in the vicinity of East Belmont Road (NDOR 2010). Secondary and private roads connect with East Belmont

Road, River Road, Hollibaugh Road, and Squaw Mound Road to provide access to residences and agricultural lands within the MEA. The limited additional traffic related to the MEA operation will not significantly affect these routes.

7.2.7.3 Aesthetic Impacts

The primary visible surface structures proposed for the MEA include wellhead covers, wellhouses, electrical distribution lines, and DDW building, and one satellite processing building. The project will use existing and new roads to access each mine unit and wellhouse, DDW building, and the satellite processing building. Project development would alter the physical setting and visual quality of portions of the landscape, which would affect the overall landscape to some degree. The proposed facilities would introduce new elements into the landscape and would alter the existing form, line, color, and texture that characterize the existing landscape. The project would primarily affect agricultural land.

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In foreground-middleground views, the satellite processing building, wellhouses, DDW building, and associated access road clearings would be the most obvious features of development. Clearings and access roads would be visible as light tan exposed soils in geometrically shaped areas with straight, linear edges that provide some textural and color contrasts with the surrounding cropland. The satellite facility processing building, wellhouses, wellhead covers, and DDW building would be painted to harmonize with the surrounding soil and vegetation cover. These facilities would be visible from Squaw Mound Road and the residence within the license boundary, but would be subordinate in scale to the rural landscape.

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The electric distribution line poles would be an estimated 20 feet tall, and would be located throughout the project area to connect wellhouses with existing lines. The distribution lines are similar in appearance to those typical of the rural landscape, but would occur at a higher density than on adjacent lands. The lines would be obvious to viewers at the viewing areas, but would not change the rural character of the existing landscape.

Wellhead covers would be difficult to discern in the landscape from any sensitive viewing area. The form and textural contrast would be very weak because the relatively low profile (3 feet high) and small size of these would disappear into the surrounding textures of soil and vegetation. Generally, color contrasts are most likely to be visible in foreground-middleground distance zone. However, the wellhead covers would be painted a tan color that would harmonize with the surrounding vegetation and soil colors. Therefore, contrast of line, form, texture, and color would be low. The facilities would not be noticeable to the casual observer. Wellhead covers would be visually subordinate to the landscape in foreground-middleground distance zone.

7.2.7.4 Land Access Restrictions

Property owners of land located within the immediate wellfield and facility boundaries will lose access and free use of these areas during mining and reclamation. The areas impacted are all used for agricultural purposes, and the owners will lose the ability to use the areas for production purposes. Offsetting these land use restrictions are the surface lease and mineral royalty payments to the landowners.

7.2.8 Most Affected Population

The expected impacts from the proposed MEA can be characterized as an incremental increase in the impacts from current CBR operations. For the most part, the impact from operation of the current Crow Butte Uranium Project has been positive. CBR has provided much needed well compensated employment opportunities for the local population. Additionally, the policy of purchasing goods and services locally to the extent possible has had a positive economic impact on an area facing economic challenges. Tax expenditures, particularly the recent increases in local property taxes paid due to the increase in the price of uranium, have had a positive economic impact on local government-provided services.

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Offsetting these positive impacts to the local population are increases in noise, traffic congestion, and aesthetic impacts for residents in and adjacent to the proposed satellite facility. Most residents located in the proposed license area are landowners who have mineral and/or surface leases with CBR and will benefit economically from the presence of the facility.

7.2.9 Satellite Facility Decommissioning Costs

Approval of the proposed satellite facility will result in CBR incurring additional decommissioning liabilities for the installed facilities. The actual estimated decommissioning costs will be included in the annual surety update required by SUA-1534 submitted to the NDEQ and the NRC for approval prior to construction activities.

This section presents a written estimate of the costs for "environmental protection" deemed to be necessary during and after the cessation of operations. These cost estimates focus on costs associated with the restoration and reclamation (decommissioning) of the MEA in order to ensure that adequate funds are available for permanent closure of the project. The cost estimates address the above-referenced "measures" of concern. The estimated decommissioning costs will be included in the annual surety update required by SUA-1534 submitted to the NDEQ and the NRC for approval prior to construction activities.

The NRC requires a financial surety arrangement consistent with 10 CFR 40, Appendix A, Criterion 9 to cover costs of reclamation activities. Evidence of financial responsibility in the form of a letter of credit or other form satisfactory to the NDEQ in accordance with Title 122, Chapter 13, shall be provided to the NDEQ in an amount equal to or greater than the total costs indicated in the Surety Cost Estimate as required, along with an audit statement from an independent professional auditing firm. CBR will review the cost estimate annually and update in order to ensure adequacy of the dollar amount. The purpose is to ensure that there are sufficient funds available for decontamination, decommissioning, and reclamation of the facility in the event CBR is incapable of performing the tasks. NRC License SUA-1534 requires that CBR continuously maintain an approved surety instrument for Crow Butte Resources, Inc., in favor of the State of Nebraska. CBR is required to ensure that the financial assurance instrument, when authorized by the State of Nebraska, identifies the NRC-related portion of the instrument and covers the aboveground decommissioning and decontamination, the cost of off-site disposal of solid byproduct material, soil and water sample analyses, and groundwater restoration associated with the site. The basis for the cost estimate is the NRC-approved site closure plan or the NRC-approved revisions to the plan. Reclamation or decommissioning plan cost estimates and annual updates will follow the outline in Appendix C to RG-1569, entitled "Recommended Outline for Site-Specific In-Situ Leach Facility Reclamation and Stabilization Cost Estimates."

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Groundwater and surface reclamation and restoration methods to be used for the MEA are discussed in Section 5. A decommissioning plan shall be based on factors such as the mine plan, baseline environmental information, and any other factors that will assure the long-term physical, geotechnical, and geochemical stability of the site. Restoration of a specific MU can start as soon as mining is completed, hence the importance of integrating the mine plan and the decommissioning plan. Restoration of a specific MU can occur while uranium recovery operations continue at other MUs. Once groundwater restoration has been completed in the final MU and approved by the NDEQ, decommissioning of the satellite processing plant, remaining CPF evaporation ponds, and other structures can be initiated.

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The cost estimates presented in this section are based on the cost per year to restore one MU and reclaim one MU (surface and subsurface features). The CBR mine plan calls for sequential restoration and reclamation, and CBR will have approximately two to three MUs in restoration, mining, or reclamation at any one time. The surety cost estimates will be adjusted as necessary when additional MUs are to be brought on line and the proposed operations are better defined. A current and updated surety is required at least 90 days prior to commencement of construction of a new MU or significant expansion.

Cost information is presented in the following tables located in **Appendix P**:

Table P.1-1	Primary Assumptions Serving as the Basis for Surety Cost Estimates Associated with Restoration and Reclamation of One (1) Mine Unit	
Table P.1-2	Marsland Total Restoration and Reclamation – 2013 Surety Estimate	Deleted: 1
Table P.1-3	Marsland Groundwater Restoration – 2013 Surety Estimate	Deleted: 1
Table P.1-4	Marsland Wellfield Reclamation – 2013 Surety Estimate	Deleted: 1
Table P.1-5	Marsland Well Abandonment Unit – 2013 Surety Estimate	Deleted: 1
Table P.1-6	Marsland Satellite Facility Equipment Decommissioning – 2013 Surety Estimate	
Table P.1-7	Marsland Building Demolition Cost – 2013 Surety Estimate	Deleted: 1
Table P.1-8	Marsland Miscellaneous Site Reclamation – 2013 Surety Estimate	Deleted: 1
Table P.1-9	Marsland Deep Disposal Well Reclamation – 2013 Surety Estimate	Deleted: 1
Table P.1-10	Marsland Groundwater IX Treatment (GIX) Restoration 9Unit Cost]	
Table P.1-11	Marsland Groundwater Reverse Osmosis (RO) Treatment [Unit Cost] – 2013 Surety Estimate	Deleted: 1
Table P.1-12	Marsland Groundwater Recirculation [Unit Cost] – 2013 Surety Estimate	Deleted: 1
Table P.1-13	Marsland Well Abandonment [Unit Cost] – 2013 Surety Estimate	Deleted: 1
Table P.1-14	Five Year Mechanical Integrity Tests (MIT) – 2013 Surety Estimate	Deleted: 1
Table P.1-15	Marsland Master Cost Basis – 2013 Surety Estimate	Deleted: 1

Table P.1-1 presents the primary assumptions that serve as the basis for the surety cost estimates associated with restoration and reclamation of one MU (as of June 11, 2013). **Table P.1-2** provides a summary of the total estimated costs for projected restoration and reclamation activities for MU 1 ($2,286,647), which includes a contract administration and contingency fees of 10 and 15 percent, respectively. The remaining tables further refine the cost estimates and the basis for the tasks and cost estimates. The DDW will operate under a separate UIC permit, but

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the reclamation cost estimates for this well have been provided as part of the total surety estimate for the MEA.

7.3 The Benefit Cost Summary

The benefit-cost summary for a fuel-cycle facility such as the CPF involves comparing the societal benefit of a constant U_3O_8 supply (ultimately providing energy) against possible local environmental costs for which there is no directly related compensation. For this project, there are basically three of these potentially uncompensated environmental costs:

- Groundwater impact
- Radiological impact
- Disturbance of the land

The groundwater impact is considered to be temporary in nature, as restoration activities will restore the groundwater to a pre-mining quality. The successful restoration of groundwater at the CPF during the R&D project and the commercial restoration of MU 1 have demonstrated that the restoration process can meet this criterion successfully.

The radiological impacts of the current and proposed project are small, with all radioactive wastes being transported and disposed of offsite. Radiological impacts to air and water are also minimal. Extensive ongoing environmental monitoring of air, water, and vegetation has shown no appreciable impact to the environment from the CPF.

The disturbance of the land for a satellite facility and related activities is quite small, especially when compared with conventional surface mining techniques. All of the disturbed land will be reclaimed after the project is decommissioned and will become available for previous uses.

7.4 Summary

In considering the energy value of the U_3O_8 produced to U.S. energy needs, the economic benefit to the local communities, the minimal radiological impacts, minimal disturbance of land, and mitigable nature of all other impacts, it is believed that the overall benefit-cost balance for the proposed MEA is favorable, and that amending SUA-1534 is the appropriate regulatory action.

8 SUMMARY OF ENVIRONMENTAL CONSEQUENCES

This ER has characterized the existing baseline environment of the MEA and the surrounding area in Section 3. The potential environmental impacts (adverse and positive) of the proposed action were discussed in detail in Section 4. In this impact analysis, CBR identified unavoidable impacts of the proposed action. Alternatives for mitigation were discussed in Section 5.

This section summarizes the environmental impacts that cannot be avoided. Where available, means of mitigation is summarized.

Table 8.1-1 summarizes the unavoidable environmental impacts of the proposed construction, operation, and decommissioning of the MEA. Each impact is quantified (where possible). All impacts are short-term (i.e., the predicted impact will exist during the construction, operation, and decommissioning of the MEA). No significant long-term impacts have been identified that would extend beyond the duration of the project. For each impact, mitigative measures are summarized.

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Table 8.1-1 Unavoidable Environmental Impacts

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