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April 10, 2015

ATTN: Document Control Desk, Director
Office of Nuclear Material Safety and Safeguards
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Amendment Request: Increase North Butte Production Flowrate
Cameco Resources Smith Ranch-Highland Uranium Project
Source Materials License SUA-1548

Dear Director:

Power Resources, Inc., doing business as Cameco Resources (Cameco), is requesting an amendment to Source Material License SUA-1548 to increase the production flowrate at the North Butte satellite facility in Campbell County, Wyoming. The approved flowrate is currently 4,000 gpm, and Cameco is requesting an increase of 2,000 gpm for a total satellite production flowrate of 6,000 gpm.

Cameco's production plans include an increase in flowrate at North Butte in August 2015 above the currently approved 4,000 gpm. Source Material License SUA-1548 is currently in renewal, and the renewal application requests a flowrate increase at North Butte. However, Cameco is submitting this separate request for flowrate increase in the event that the entire License Renewal is not approved by August 2015.

Attached to this letter is Cameco's summary review of the potential impacts resulting from this flowrate increase, most of which have been assessed previously by NRC. The impacts and mitigation resulting from the proposed flowrate increase are detailed in the pending License Renewal application

The principal impact from the flowrate increase is expected to be increased radon release at the satellite and wellfields. To estimate the radiation doses to potential and actual members of the public near the facility from the increased flowrate, radiation doses were modeled using the MILDOS-AREA code (version 3.10 as revised February 2012). The modeling report is included as Attachment A to this summary review. The output files from the various MILDOS runs are included as electronic files on an enclosed CD.

NMSS01

Please advise Cameco of any additional information NRC staff may need to complete their review of this request.

Sincerely,

Larry McGonagle

Larry McGonagle
SHEQ Division Manager
Cameco Resources

cc.: Jim Stokey, Cameco Resources w/o Attachments
Brent Berg, Cameco Resources w/o Attachments

Attachments: License Amendment Request with Attachment A
CD with PDFs of the MILDOS Output Files

Enclosures Electronic Copy of the Amendment Request and Attachments

LICENSE AMENDMENT REQUEST
NORTH BUTTE REMOTE SATELLITE FLOW INCREASE
SOURCE AND BYPRODUCT MATERIALS LICENSE SUA-1548

INTRODUCTION

Power Resources Inc., d.b.a. Cameco Resources (Cameco), operates the North Butte Remote Satellite (NBRS) under Source and Byproduct Materials License SUA-1548 (currently under timely renewal). Until the license renewal application (LRA) is approved by NRC Cameco must conduct operations at NBRS in accordance with commitments, representations and statements contained in the NBRS license application (Pathfinder Mines Corp., 1992), which was amended into SUA 1548 by letter (NRC, 2003).

In November 2012, Cameco amended the Operating Plan for the NBRS into license SUA 1548 through the Operations Review Committee / Safety Environmental Review Panel (ORC/SERP) process. This Operating Plan states that the satellite will operate at a planned maximum flow capacity of 4,000 gallons per minute (gpm) and a production capacity of approximately 500,000 to 1,500,000 pounds of uranium per year over an anticipated 20-year operating life. Although the satellite is designed for a maximum operating flow of 6,000 gpm, the Operating Plan states that the flow will be restricted to less than 4,000 gpm until the LRA is approved. When approved, the LRA will authorize Cameco to operate the NBRS facility at 6,000 gpm with an annual uranium production rate ranging from 500,000 to 1,500,000 pounds.

The NBRS commenced production the first half of 2013, and it has become apparent since then that the increased flowrate will be required before the LRA is approved to meet planned uranium production amounts. Cameco requests an amendment to the approved license to increase the NBRS throughput from 4,000 gpm to 6,000 gpm. The additional satellite flow capacity would facilitate the extraction of uranium from approved well fields at a faster rate. Individual well field production will not increase, but more well fields could be in production at the same time, thereby increasing the total uranium production rate at NBRS.

IMPACT ANALYSIS

Cameco has evaluated potential environmental and health and safety impacts that may be increased beyond what has been previously assessed by NRC if the flowrate is increased. The potential impacts to public and occupational health as described in the LRA (detailed in ER Sections 4.12 and 5.12) include the release of Rn-222 from ion exchange (IX) facilities, mine unit wellfields and header houses; fugitive dust from construction activities and vehicle travel; and any potentially adverse impact associated with a spill or accident. The proposed flowrate increase is not expected to affect geology, surface water, endangered or threatened species, socioeconomic, or historic or cultural resources (see ER Sections 3 and 4). The proposed action will not involve additional construction within or outside the existing satellite building, as it is already designed and built to accommodate a maximum flowrate of 6,000 gpm. Cameco does not propose to produce from any new mine units beyond those currently described in the approved license (i.e., Mine Units 1 through 5). Additional personnel will not be needed to accommodate the flow increase.

However, increasing the flowrate from 4,000 gpm to 6,000 gpm (50% increase) may cause additional impacts to air quality, public or occupational exposures, soil or ground water, waste generation, or transportation, as discussed below.

AIR QUALITY AND PUBLIC AND OCCUPATIONAL DOSES

Because the majority of air quality emissions from in situ recovery (ISR) operations are small and occur outdoors, impacts are considered to be minimal and short term (Environmental Assessment Report, ER Section 4.6.1.4). As operations (including restoration activities) at Smith Ranch currently result in minimal air quality emissions, emissions at the NBRS are also expected to be minimal.

Radon-222 and 2014 MILDOS Modeling

Potential radioactive sources for ISR operations include new well drilling, production fluids, ion exchange columns, and restoration fluids. Gaseous radon-222 (Rn-222) is the principle radioactive effluent expected as a result of ISR operations. Rn-222 sources include plant buildings, well fields, and header houses (see Technical Evaluation Report, TR Section 7.3).

Rn-222 is released from IX columns when moving the resin between the IX column and the resin trailer or an elution column. There are minor releases of Rn-222 during the air blow-down prior to resin transfer to the resin trailer. The air blow-down and the gas released during column filling are vented to sumps and then to the atmosphere. The NBRS uses pressurized down-flow IX columns that keep the radon in solution, thereby reducing the radon release and associated doses from these vessels. Section 5.7.1.3 of NUREG 1569 states, in part, that "effective control of radon gas can be achieved by using a pressurized processing tank system that eliminates venting in process buildings..." (NRC, June 2003). Section 7.3.1.2.2 of NUREG 1569 states, in part, that "if a closed processing loop is used, then radon release from processing is expected to be negligible" (NRC, June 2003). The use of pressurized down-flow IX columns minimizes the impacts to air quality and public and occupational exposures, as compared to unpressurized up-flow IX columns that vent radon while in use (see ER Section **4.6.1.2**.)

Cameco and its predecessors have used MILDOS-AREA, an atmospheric dispersion model approved by the NRC, to estimate radiation doses to potential and actual members of the public near the facility during the operation of the satellite facility. The model input uses both site-specific data input as well as certain assumptions. MILDOS-AREA modeling has been completed several times during the project history, each time to simulate slightly different operational scenarios.

In 2014, Cameco's consultant, Two Lines, Inc., conducted MILDOS-AREA modeling (see Attachment A) to assess doses to the public from the NBRS through the operating year 2031. This model assumed the increase in the NBRS production flowrate to 6,000 gpm. The source terms used to estimate radon releases from the NBRS include three well fields in production, one restoration well field, one new well field in development, and resin transfers at the satellite building. This assessment used site-specific meteorological data and assumed a) a 6,000 gpm throughput, b) the same size and number of mine units as previously assessed, and c) the same size building to house the equipment needed for a 6,000 gpm flowrate.

Estimated maximum annual total effective dose equivalents (TEDE) at individual boundary receptor locations are shown Table 7 and Figure 4 of Attachment A. The maximum annual dose of 5.84E+01 mrem for any boundary location is estimated to occur at boundary location EB (east boundary) in 2020. This is understandable since the east boundary is only 100 meters east of the satellite plant where the purge water releases occur.

This calculated dose results exclusively from exposure to radon decay products, since there are no particulate releases from the facility. For each receptor point, dose from inhalation contributes over 99% of the total modeled dose. Doses from submersion in a plume and exposure to contaminated ground surface represent less than 1% of the dose. Further, because doses result only from releases of radon with consequent decay products, the 40 CFR 190 annual dose commitments, which exclude radon exposure, are zero in all cases.

The graph of estimated doses through time (Attachment A, Fig. 4) reflects both the staging of different processes and locations of the various mine units relative to the receptor locations. It is important to note that there are no actual receptors at the boundary locations, but it is presumed that an actual receptor could reside at or near that location.

The nearest residence to the facility was located about a kilometer to the southeast of the facility with a predicted dose of less than one mrem in any year of the project. Town locations modeled for this project include Casper, Douglas, Glenrock, Gillette, Wright and Sussex. The maximum modeled dose in those towns was 1.78E-02 mrem/yr for residents of Wright.

Fugitive Dust

The primary source of emissions is fugitive dust from vehicular traffic on un-paved regional access and local well field roads. The construction of new roads in additional mine units and an overall increase in mine unit and resin transport traffic will increase the amount of fugitive dust produced. Similar to the construction phase, fugitive dust is the primary source of air quality emissions during operations. Emissions such as NOx are also possible from ISR operations and although small, are discussed below.

ER Section 3.6.6 presents fugitive dust estimates calculated according to the EPA AP-42 methodology. Fugitive dust emissions from the NBRS are estimated at 97 tonnes (107 tons) per year The flowrate increase should result in only a marginal increase in the fugitive dust emissions because most of the sources of fugitive dust (employee travel and construction) will remain unchanged as a result of the increased flowrate. To mitigate the potential release of fugitive dust, mitigation measures such as watering the roads or applying chemical treatments will be implemented as needed as stated in ER Section 5.6 and TR Sections 3.8.5, 7.1.1, and 7.2.1.

Exhaust from drilling equipment and vehicular traffic causes some emissions such as NOx and would increase as a result of increased drilling to install new well fields to increase production. However, these emissions are small and do not have any significant impacts. TR Section 7.2 presents additional information about NOx.

SOIL AND GROUND WATER

Increasing the flow capacity of the NBRS will allow more mine unit well fields to operate simultaneously, thereby slightly increasing the potential for releases to the environment via leaks or ruptures of piping or injection/recovery well casing failures. Such releases could result in the contamination of soil and/or ground water that would then require remediation. However, increased releases would not change the proposed mitigation measures already approved to deal with potential releases to soil and groundwater.

Soil

Soil may be affected by a spill resulting from a piping or casing failure or a release of uranium-laden resin from a transportation accident involving a transport truck and tanker trailer. The impacts from these releases have been evaluated by NRC. In the case of a resin spill, the uranium is ionically bonded to the resin, and the resin is wet during shipment, thereby minimizing the potential radiological and environmental impacts of a spill. The radiological and environmental impact of a similar accident with barren, eluted resin would be less significant. The primary environmental impact associated with spills or inadvertent releases would be the removal of soils impacted in the area of the spill and the subsequent damage to the topsoil and vegetation. Areas impacted by the removal of soil would be refilled, graded and revegetated.

Groundwater

As detailed in ER Section 4.4.1.2, potential impacts to groundwater as a result of ISR operations may include the following:

- Movement of lixiviant outside the mine unit monitor well ring or within aquifers above or below the production zone (excursions);
- Inadequate groundwater restoration after ISR operations are complete;

- Adverse effects on groundwater in shallow aquifers, if present, from casing or pipeline leaks, surface spills from wells or header houses, and leakage from lined ponds or land application facilities; and
- Consumptive use (water removed from available supplies without return to a water resource system, i.e. water that is not returned to a stream, river, or water treatment plant) of the ore zone aquifer caused by lowering the water table/potentiometric surface via "bleed" during operations and groundwater restoration.

Groundwater Excursions

The simultaneous production of additional mine unit well fields may increase the potential for excursions. Although excursions may be caused by a number of operational and geologic/hydrologic abnormalities, the most common excursion is a horizontal excursion which manifests itself at the perimeter monitor well ring. This type of excursion is typically caused by an imbalance between injection and recovery well flows in a portion of a mine unit well field.

To date there have been excursions at the NBRS and there have been no excursions at Smith Ranch-Highland for over a year. Historical excursion events at the Smith Ranch-Highland operation have been controlled and determined by NRC to pose no threat to human health or the environment. The proposed flowrate change at the NBRS would not change this risk determination.

As detailed in ER Section 4.4.1.2, an excursion of production fluid beyond the monitor well ring or to an overlying or underlying aquifer could occur due to:

- An injection well casing failure;
- Failure to control well field pressures and/or flows;
- Uncontrolled movement of production fluids through an unidentified improperly abandoned drill hole; or
- Inadequate groundwater restoration after ISR operations are completed.

Any of these short-term, local impacts are possible over the life of an ISR operation, regardless of flowrate.

Regulations require control of the ISR fluids and groundwater restoration. Cameco is required by license condition to perform mechanical integrity testing of all Class III injection wells to ensure that the wells are constructed properly. During operations, production fluid is removed from the aquifer at a slightly greater rate than the re-injection rate ("bleed"), thereby maintaining an inward flow direction. Monitoring wells are sited to provide identification of an excursion before the excursion can migrate beyond the production zone or exempted aquifer.

Past recoveries of excursions show that excursions are limited in aerial extent and to the volume of water that must be removed to restore the groundwater quality. The excursion would be short-term and controlled. In conclusion, long-term impacts on groundwater quality are not anticipated. Excursion prevention and control measures are described in TR Section **3**.

Restoration of affected groundwater to baseline quality is required by both WDEQ and NRC regulations using best practicable technology (BPT), which will also negate potential impacts to groundwater caused by ISR operations (see TR Section 6).

Groundwater Consumptive Use

The affected groundwater aquifers at the NBRS are described in ER Section 3.4. Based on the available data and operational experience, drawdown impacts from operations at NBRS are expected to be minimal.

Aqui-Ver Inc. conservatively modeled consumptive use to assess hydrologic impacts from the NBRS (see ER Section 4.4.1.2.2). This modeling indicates that ISR operations will have minimal impact on regional groundwater resources. Drawdown of the shallow water-table aquifer is expected to be negligible at the NBRS.

At NBRS, the greatest drawdowns are predicted in deeper domestic and stock watering wells. Modeling indicates that domestic and stock wells completed in the deeper production (B-Sand) zone will be most affected with a maximum drawdown of 6 meters (22 feet) predicted to occur at the Pfister Ranch southeast of the satellite. Wells completed in the overlying C-Sand and underlying A-Sand at the NBRS are predicted to show maximum drawdowns of approximately 3 meters (10 feet). Although these drawdowns may seem substantial, the modeling study includes NBRS operations, the cumulative impacts of three additional operating and/or planned nearby ISR facilities (Willow Creek, Nichols Ranch, and the Hank facility), and coal-bed methane (CBM) operations located near the NBRS.

Domestic and stock wells are typically low-yield wells which will not suffer loss of production given the relatively small demand. In the event the predicted small drawdowns do cause a significant impact on any domestic well yield within 2 kilometers (1 mile) of the license boundary, Cameco would provide an alternative or supplemental water supply for the well owner.

Since the approval of the last SUA-1548 LRA in May 2001, there has been no apparent reduction of groundwater resources to local area water users within and surrounding Smith Ranch. Groundwater modeling of the production zones at the NBRS indicates that consumptive use of groundwater will have negligible impact on area use of groundwater resources.

TRANSPORTATION

Increasing the flowrate at the NBRS will increase the number of resin shipments between NBRS and the Smith Ranch Highland Central Processing Plant (SRH CPP), which may increase noise, fugitive dust, and the risk of transport related accidents. Cameco is currently averaging approximately one truck round-trip every two days for hauling resin between NBRS and CPP. It is anticipated that increasing the flowrate to 6000 gpm would increase, at a maximum, the round trips of resin transport to approximately one truck round trip every 1.5 days. It is not expected that this increase will create additional impacts beyond those already evaluated by NRC.

Noise

Noise created by the NBRS is expected to increase slightly with increased uranium recovery and processing activity. Noise levels should not be significantly higher for those individuals living near the NBRS area, such as at the Pfister Ranch located approximately 1 kilometer (0.5 mile) south of the site boundary. According to the tests conducted by Cameco and assuming the worst case noise generator (PVC chipper), the calculated noise level at a location 3 kilometers (2 miles) from the noise source would be 77 dBA (ER Section 4.7.1).

Fugitive Dust

Fugitive dust created by vehicular traffic on un-paved regional access and local well field roads is discussed above under Air Quality.

Spills/Accidents

Over the life of the project, there will be no increase in solid byproduct material produced as a result of the flowrate increase and, therefore, no increase in trips to a licensed disposal facility in addition to what is already occurring under the current operating plan. Transportation of byproduct material is conducted in accordance with DOT and NRC regulations, which minimize the chance for, and impacts of, a potential transportation accident and spill. The environmental impacts related to the transportation of source and byproduct materials are expected to remain within the scope of previously analyzed impacts.

IX resin is transported to the CPP in 15 cubic meter (4,000 gal) capacity tanker trailers (ER Section 4.2.2.1). The resin trucks travel on a combination of private, county, and state roads. For shipments of IX resin from NBRS to the CPP, NRC determined that the probability of an accident involving such a truck was 0.009 in any year (NRC, 2009). The flowrate increase will result in a 50% increase in resin shipments per year but over the life of the facility the number of shipments will remain the same since there is no increase in the total production at NBRS.

WASTE GENERATION

The increase in the plant flow will correspond to an additional volume of waste water, primarily process bleed, of approximately 20 gpm more than is currently being generated. In effect, the same volume of waste will be generated over a shorter period of time and, consequently, will not create impacts that have not already been assessed and evaluated. The waste disposal well has the capacity to increase the disposal rate by 20 gpm without adverse effect on the well. Overall, the quantity of liquid and solid 11e(2) materials generated due to increasing the flowrate to 6,000 gpm will be similar to that generated at 4,000 gpm, as no mine units or processing steps (e.g., precipitation or drying) are being added.

Liquid Waste

11e(2) liquid wastes produced at ISR operations include liquid process wastes from the production and restoration processes; water collected from well field releases, header house releases, satellite sumps, and from the UIC Class I disposal well sumps. ER Section 5.13.1-5 and TR Section 4.2 contain specific information regarding the handling of 11e(2) liquid wastes.

Liquid wastes at the NBRS Project are disposed of into a permitted UIC Class I disposal well. As more mine units commence production, and older units are switched to restoration, the volume of waste water will continue to increase. The water balance analysis predicts when additional disposal wells will be needed to accommodate the increasing waste water volume. The flowrate increase is not expected to change the schedule for bringing new disposal wells on line, nor will it overload the current well disposal capacity. Although the currently permitted and operating disposal well is capable of handling the extra waste water flow, Cameco is in the process of permitting additional site disposal wells.

Solid Waste

The project site solid waste generation rate will increase proportionally to the increase in flow. However, over the life of the project, it is expected that the total quantity of solid waste generated will remain the same. Solid byproduct materials generated at the site must be disposed at a licensed disposal facility in accordance with License Condition 9.6 of SUA-1548.

11e (2) solid wastes (i.e., byproduct materials) may include tanks, vessels, IX resin, filter media, process piping and equipment, evaporation and surge pond solid residues, or any other material or equipment that cannot be decontaminated to meet the unrestricted release criteria. All 11e(2) solid waste materials are transported to and disposed at a NRC-licensed disposal facility (see TR Section 4.2).

Production of 11e(2) byproduct materials is minimized primarily through process design, decontamination, and volume reduction. For example, filter media for production and restoration equipment is selected based on filtration efficiency so that fewer replacements are needed. Whenever possible, equipment and buildings are decontaminated so that they can be released for unrestricted use. Volume reduction is accomplished by crushing piping and other materials using a grinder or chipper. Methods for decontamination and release of contaminated equipment and materials are discussed in further detail in TR Sections 5, 6.2 and 6.3.

Non-11e(2) solid wastes may include office wastes, domestic trash, construction debris, empty reagent containers, and uncontaminated or decontaminated non-repairable equipment. These materials are typically disposed of in a municipal landfill. Cameco employs waste minimization and recycling to reduce the quantity of solid waste generated. TR Section 4.2 provides additional information related to the handling and disposal of non-11e(2) waste materials. Additional details associated with waste management mitigation measures are in TR Sections 4, 6.3 and 6.4.

CONCLUSIONS

Approval of the increased flowrate request would enable Cameco to increase the uranium production rate from NBRS, benefitting the economy of surrounding communities through increased state and local taxes and royalty payments, as detailed in ER Section 7. Cameco has analyzed the environmental impacts that may be associated with increasing the NBRS flowrate from 4,000 gpm to 6,000 gpm. Based on this analysis, Cameco concludes that increasing the flowrate will not result in additional environmental impacts beyond those that have already been assessed by NRC in previous EAs, SERs, TERs, and other environmental assessments performed for SUA-1548.

REFERENCES

Cameco, November 2012. North Butte Satellite Operational Plan, 2013, Safety and Environmental Review Panel (SERP), Smith Ranch-Highland Operation.

NRC, December 1990. Environmental Assessment (EA) for Uranerz U.S.A., Inc. Ruth and NBRS Projects.

NRC, July 1991. Approval of Combining the Ruth Project (SUA-1539) with the NBRS Project (SUA-1540). NRC, May 1992. Approval of Amendment No.8 to SUA-1540-NRC Accession No. 9206030288.

NRC, April 2001. Safety Evaluation Report for Renewal of Source Material License No. SUA-1548.

NRC, November 2001. SUA-1540 Amendment No. 5 – Change of Control for Pathfinder's NBRS and Ruth Projects.

NRC, 18 August 2003. Combination of Smith Ranch-Highland Uranium Project (SR-HUP), Ruth, and NBRS Licenses, License Amendment 5 to the Smith Ranch Source Materials License SUA-1548.

NRC, June 2003. Standard Review Plan for In-Situ Leach Uranium Extraction License Applications—Final Report (NUREG-1569). Washington, D.C.

NRC, January 2004. Review of Request to Operate the Gas Hills Project In Situ Leach Uranium Recovery Facility, Amendment 6 to Source Materials License SUA-1548 (TAC L51702).

NRC, September 2009. Review of Request for Third-Party Ion Exchange Resin Processing, Amendment 15 to Source Materials License SUA-1548 (TAC J00565).

NRC, 2009 (updated 13 March 2011). Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities (NUREG-1910). Washington, D.C.

NRC, January 2013. Supplemental Environmental Assessment License Renewal Application, Source Materials License SUA-1341.

Pathfinder Mines Corp. (PMC), April 1992. Request for Amendment, NBRS and Ruth ISL Projects – License SUA-1540. Mills, Wyoming.

Two Lines, Inc. (Grand Junction, CO), November 2014. Estimated Radiation Doses to Members of the Public from the Proposed North Butte Project, Campbell County, Wyoming. Prepared for Power Resources, Inc., d.b.a. Cameco Resources, Casper, WY.

Uranerz, March 1989. NRC License Application, Volume 1, p. 16-6 through 16-7.

ATTACHMENT A:

Estimated Radiation Doses to Members of the Public
from the Proposed North Butte Project, Campbell County, Wyoming
November 2014
Prepared by: Two Lines, Inc., Grand Junction, CO

Estimated Radiation Doses To Members of the Public from the Proposed North Butte Project, Campbell County, Wyoming

Prepared for:

Power Resources, Inc.
DBA Cameco Resources
550 N. Poplar St., Suite 100
Casper, Wyoming 82601

Prepared by:

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November, 2014

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1.0 INTRODUCTION

Cameco Resources has initiated production at a satellite facility at its North Butte Project to mine uranium from *in situ* recovery (ISR) mine units. Figure 1 is a map showing the location of the project within Wyoming.

Four mine units are proposed within the project area. Each well borehole will be surrounded by a drill pit measuring approximately 10 feet by three feet by eight feet. Disturbance in the form of brush removal will also occur around monitor well rings which will surround each of the 30 to 40 acre production areas. A satellite facility has been constructed that includes a concrete pad less than one quarter of an acre in size. Figure 2 shows the location of the satellite plant, the permit boundary, boundary receptors, and mine units.

Initial permitting of the North Butte Satellite included modeling of a satellite facility with a maximum flowrate of 4,000 gpm. The license renewal of Cameco's SUA-1548 seeks approval to increase the North Butte Satellite flowrate to a maximum of 6,000 gpm. To estimate the potential radiation doses to potential and actual members of the public near the facility from the increased flowrate, radiation doses were modeled using the MILDOS-AREA code, version 3.10 as revised February 2012. A more recent version is in development by Argonne National Laboratory, but has not yet been released.

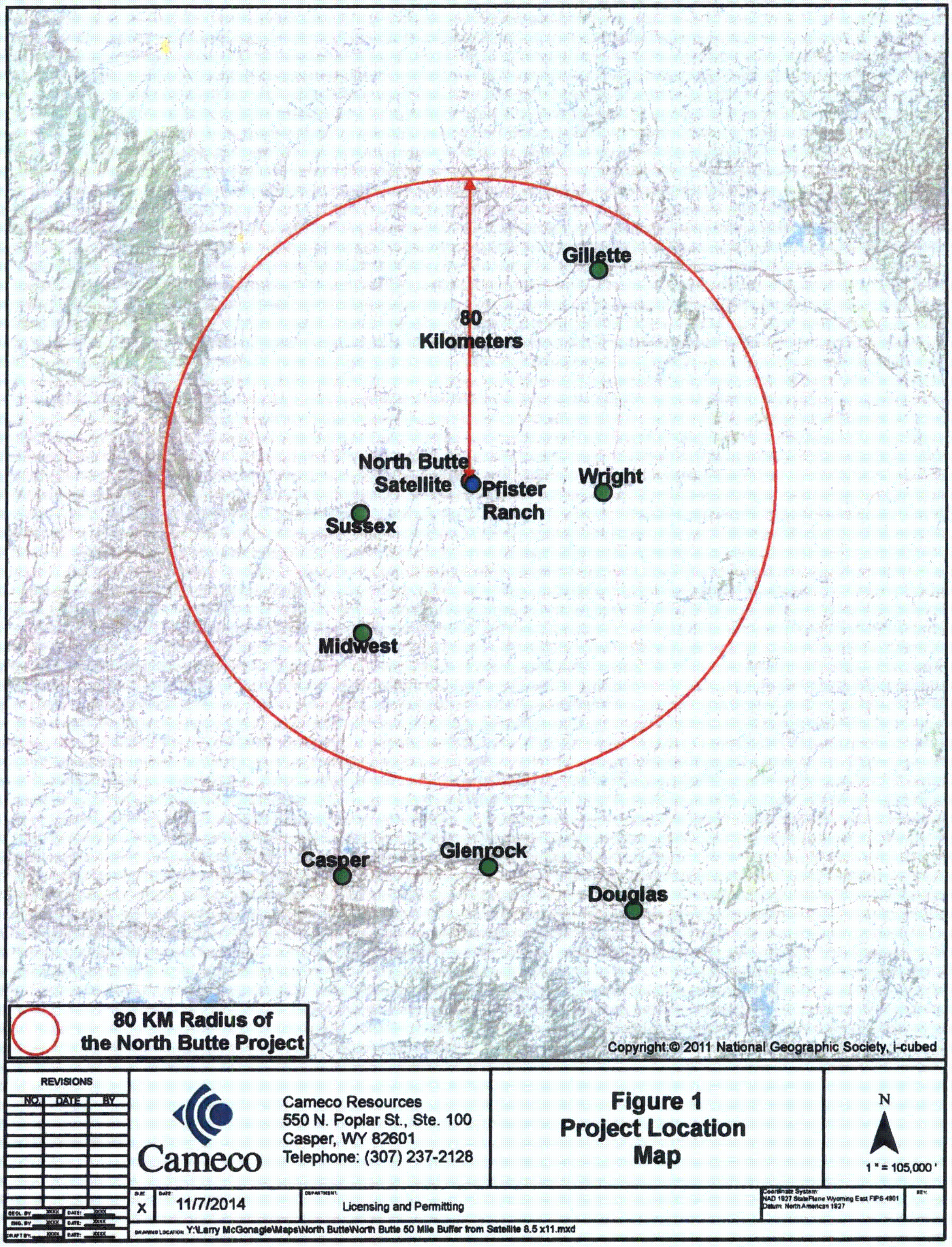

Figure 1. Map of project location.

2.0 PROJECT DESCRIPTION

The processing facility at the North Butte project will consist of an ion exchange recovery plant (IX facility) and associated structures, and well fields, known as mine units. Further processing of loaded resins produced at the IX facility will occur off site at the central processing facility.

Mine units and processes are staged as shown in Fig. 3. Drilling and new well installation for mine unit #1 (MU-1) is completed and production is underway. Production in MU-1 will continue until the first quarter of 2019. Restoration of MU-1 will begin in 2020. The whole numbers in the drilling bars indicate the number of holes of each type, delineation hole or cased well, that is to be installed in each year for each mine unit. Delineation of MU-2 is complete and 300 cased wells are to be installed in 2014. The decimal numbers under production for each mine unit indicate the portion of the year that production will occur in that mine unit. So, MU-2 will be 90% active during 2015 and completely in production in 2016 – 2019.

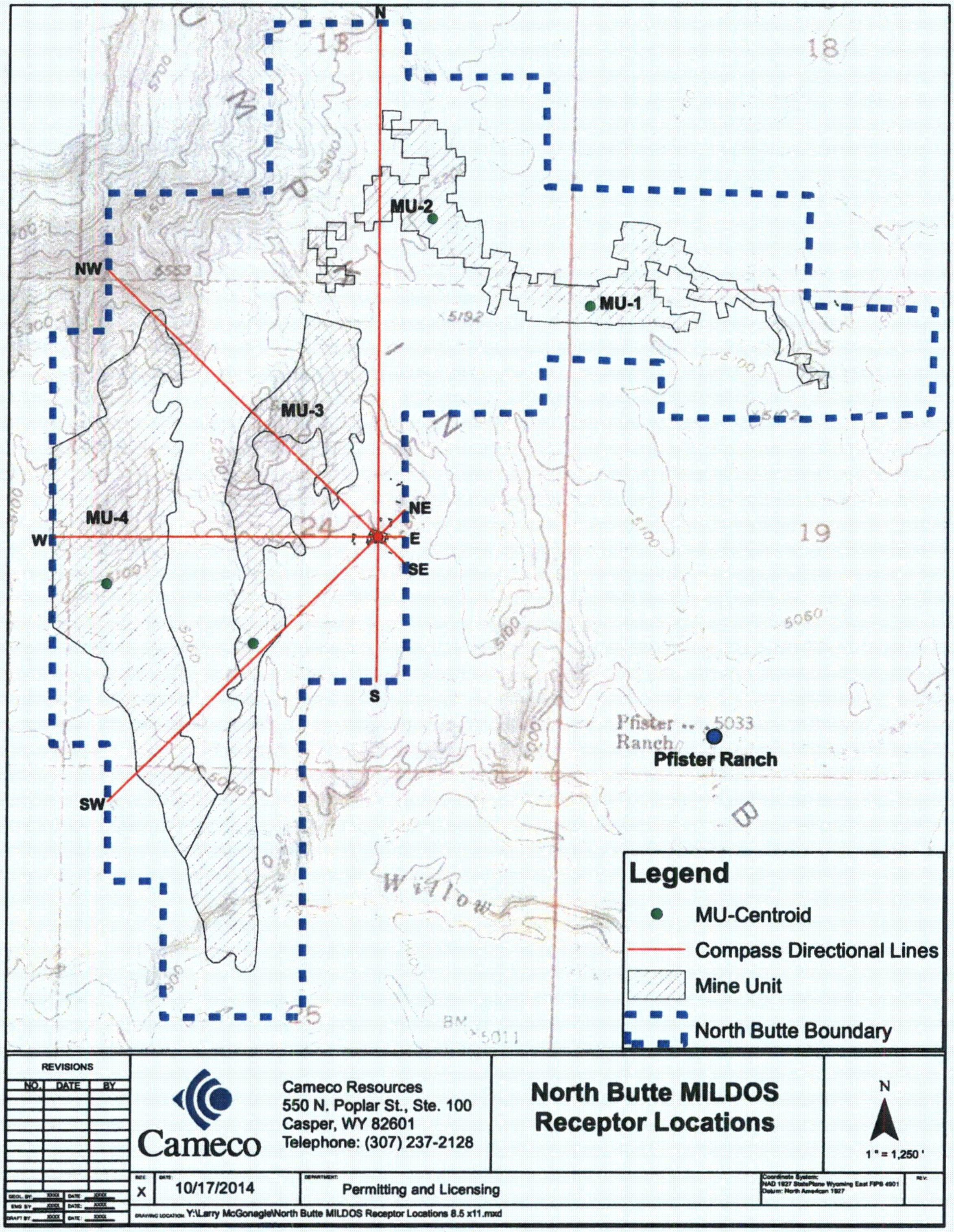

Figure 2. Boundary receptor locations, resource area centroids and processing plant.

Year	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Drilling																		
MU-1																		
MU-2	300																	
MU-3	200	250	250															
MU-4	50	200	150	250	250													
Production																		
MU-1	1.00	1.00	1.00	1.00	1.00	0.20												
MU-2	0.20	0.90	1.00	1.00	1.00	1.00	0.50	0.05										
MU-3			0.20	0.80	1.00	1.00	1.00	0.90	0.50	0.05								
MU-4					0.30	1.00	1.00	1.00	1.00	0.90	0.50	0.05						
Restoration																		
MU-1							1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00			
MU-2									1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
MU-3											1.00	1.00	1.00	1.00	1.00	1.00	1.00	
MU-4													1.00	1.00	1.00	1.00	1.00	1.00
	Delineation holes			Cased wells														

Figure 3. Staging of development, production and restoration by mine unit.

3.0 POTENTIAL RADIOACTIVE EFFLUENTS

Uranium-238 (^{238}U) in the ore body ultimately decays to radium-226 (^{226}Ra) and then radon-222 (^{222}Rn). Uranium (including ^{238}U, ^{234}U, and ^{235}U and radon are soluble in the leach solution and may be released during operations. MILDOS-AREA version 3.10 was used to estimate potential doses to members of the public. The users manual for MILDOS was published in 1989 by Argonne National Laboratory (ANL 1989) and has not been updated since that time. Doses to members of the public may arise from radioactive material released during the following operations:

- ***New wells:*** When drilling new wells into the ore body, drill cuttings, including ore, are transported to the surface in drilling mud. Cuttings are stored in mud pits where ^{222}Rn may be released to the atmosphere.
- ***Production:*** Radon dissolved in the lixiviant may be released in two ways, either from purge water or from gas venting at the wellhead.
- ***Ion Exchange columns:*** Radon gas may be released from the columns as a function of the volume of the columns, the porosity of the resin and the unloading rate of the column.
- ***Restoration activities:*** During the restoration of the mine units, water is circulated within and discharged from the wells in release rates similar to those from producing mine units.

Equations used by MILDOS to estimate releases are those detailed in NUREG-1569, Appendix D as shown below.

New Well Installation

Releases from installation of new wells in a resource area are given by the following equation:

$$Rn_{new} = 10^{-12} * E * L * [Ra] * T * M * N,$$

where Rn_{new} = ^{222}Rn release rate from new mine unit (Ci/yr),

10^{-12} = Ci/pCi,

E = Rn emanation fraction (0.25),

L = ^{222}Rn decay constant (0.181/day),

[Ra] = concentration of ^{226}Ra in ore (pCi/g),

T = storage time in mudpit (d),

M = average mass of ore material in pit (g), and

N = number of mudpits generated per year.

Radon Source Term

The radon source term, S in pCi/d, can be expressed as:

$$S = 10^{6} * E * L * [Ra] * A * D * \rho,$$

where $10^{6} = cm^3/m^3$,

E = Rn emanation fraction (0.25),

L = ^{222}Rn decay constant (0.181/day),

[Ra] = concentration of ^{226}Ra in ore (pCi/g),

A = active area of ore zone (m^2),

D = average thickness of ore zone (m), and

ρ = bulk density of ore material (g/cm^3).

Radon in Production Water

The ^{222}Rn concentration in process water at equilibrium, C_{Rn} (pCi/L), is described by:

$$C_{Rn} = (10^6 * [Ra] * A * D * \rho * E * L * f) / [(L + v) * V + F_p + F_i],$$

where $10^6 = cm^3/m^3$,

[Ra] = concentration of ^{226}Ra in ore (pCi/g),

A = active area of ore zone (m^2),

D = average thickness of ore zone (m),

ρ = bulk density of ore material (g/cm^3),

E = Rn emanation fraction (0.25),

L = ^{222}Rn decay constant (0.181/day),

f = fraction of radon source carried by circulating water (unitless),

v = rate of radon venting during circulation (per day),

V= volume of water in circulation (L),

F_p = purge rate of water (L/d), and

F_i = water discharge rate from ion exchange column resin unloading (L/d).

The rate of ^{222}Rn release from purge water, Rn_w (Ci/y), is given by:

$$Rn_w = 3.65E\text{-}10 * C_{Rn} * F_{p,},$$

where 3.65E-10 = day-Ci/pCi-yr,

C_{Rn} = concentration of radon in process water (pCi/L), and

F_p = purge rate of water (L/d),

Likewise, the rate of ^{222}Rn release from venting, Rn_v (Ci/y), is given by:

$$Rn_v = 3.65E\text{-}10 * v * C_{Rn} * V,$$

where 3.65E-10 = day-Ci/pCi-yr,

v = rate of radon venting during circulation (per day),

C_{Rn} = concentration of radon in process water (pCi/L), and

V= volume of water in circulation (L).

Ion Exchange Columns

The water discharge rate from ion exchange column resin unloading, F_i (L/day), is calculated by:

$$F_i = N_i * V_i * P_i,$$

where

N_i = number of ion exchange column unloadings per day

V_i = Volume of ion exchange column (L) and

P_i = porosity of resin material (unitless).

The annual ^{222}Rn discharge from unloading of ion exchange columns, Rn_x, Ci/y, is given by:

$$Rn_x = 3.65E\text{-}10 * F_i * C_{Rn},$$

where

3.65E-10 = day-Ci/pCi-yr,

F_i = water discharge rate from ion exchange column resin unloading (L/d) and

C_{Rn} = concentration of radon in process water (pCi/L).

4.0 MODELING

The computer code MILDOS-AREA was used to estimate potential radiation doses from planned North Butte ISR operations. MILDOS (ANL, 1989) was originally developed to estimate doses from conventional uranium milling operations, including large area releases such as ore storage pads and tailings beaches. Inputs to the dose are limited to uranium decay chain radionuclides. MILDOS was subsequently updated in 1998 to address potential impacts of uranium *in situ* leaching operations. In situ leach specific types of source terms, such as production wells and restoration wells are included in the updated version. Modeling parameters and assumptions are addressed below.

Meteorology

Meteorological conditions greatly influence dispersion of radionuclides from estimated releases during the year. The onsite meteorology data are summarized in Table 1. Winds from the north and north-northeast account for over 20% of the total, while winds from the southwest and west-southwest account for over 34%.

Table 1. Percentage of wind from each direction.

Direction from	Percent
N	9.38
NNE	10.83
NE	5.29
ENE	2.44
E	1.68
ESE	1.68
SE	2.09
SSE	2.3
S	3.21
SSW	6.38
SW	16.93
WSW	17.89
W	8.92
WNW	3.81
NW	2.45
NNW	4.74
Total	100

Receptor Locations

There are few permanent receptors in the vicinity of the North Butte project. The nearest town is more than 20 miles away. The nearest permanent residence is approximately 1 km to the southeast of the satellite plan.

Table 2. Location of modeled receptors.

Distance relative to IX plant*			
Name	X (km)	Y (km)	Z (m)
NB	0	1.7	61
NEB	.10	.10	2
EB	.1	0	9
SEB	.1	-.1	14
SB	0	-0.5	-9
SWB	-0.9	-0.9	-40
WB	-1.1	0	0
NWB	-0.9	0.9	111
Casper	-31	-92	17
Douglas	-38	-1.6	-32
Glenrock	-17	-92	-25
Midwest	-34	-36	-32
Gillette	34	56	-32
Wright	38	0	0
Pfister Ranch	1	-0.7	-21
Sussex	-29	-14	-32

Population Distribution

As shown by the data in Table 3, fewer than 33,000 people are estimated to live within 80 km of the proposed processing plant. The 80-km radius encompasses parts of 4 different counties. Doses were modeled to specific towns including Casper, Douglas, Glenrock and Gillette.

Table 3. Population distribution surrounding the North Butte site.

Distance from site (km)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
1.0- 2.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.0- 3.0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
3.0- 4.0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0
4.0- 5.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5.0-10.0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0
10.0-20.0	3	6	11	0	0	3	0	0	0	0	0	0	0	0	0	0
20.0-30.0	6	11	20	3	0	3	0	0	0	0	71	0	2	9	0	0
30.0-40.0	0	6	6	0	1602	6	3	0	0	0	0	38	0	0	0	0
40.0-50.0	6	70	17	56	22	3	0	3	0	176	431	0	0	0	0	0
50.0-60.0	0	53	53	0	3	0	3	5	8	0	0	5	295	0	0	0
60.0-70.0	0	7393	7393	0	0	0	3	0	0	0	0	2	2	2	19	9
70.0-80.0	0	7393	7393	11	2	3	0	0	0	0	0	0	2	2	59	17
1.0-80.0	15	14932	14893	70	1629	18	15	8	8	176	502	45	304	13	78	26

Input Parameters for MILDOS Model

Parameters that apply to the entire project are shown in Table 4. Parameters specific to a resource area are listed in Table 5.

Table 4. Important Input Parameters.

All sources	Thickness of ore body	6.1 m
	Density of ore body	1.89 g/cm^3
	Porosity of ore body	0.29
	% U_3O_8	0.087%
	Emanation fraction	0.25
	Fraction of radon in solution	0.80
New Well sources	Number of mud pits/yr	550 max
	Ore material added to mudpit	Varies with number of delineation holes and cased wells
	Duration of storage in mudpit	10 days
	Area of active drilling	4.12E+05 m^2 max
Production Mine Unit sources	Rate of radon venting	0.01/day
	Volume in circulation	Varies with size of unit
	Treated water purge rate	3.27E+05 L/day max
Ion Exchange columns	Column volume	2.65E+04 L
	Column unloading rate	0.50/day
	Porosity of resin	0.40
Restoration Mine Unit sources	Volume in circulation	Varies with size of unit
	Operating days	365/yr
	Treated water purge rate	1.01E+06 L/day max

Table 5. Resource Area-Specific Parameters.

Production Area	Location of centroid (relative to CPP)			Active wellfield area (m^2)	Volume in circulation during production (L)
	X (km)	Y (km)	Z (m)		
MU-1	0.7	0.8	9.1	1.66E+05	2.94E+08
MU-2	0.2	1.0	31	1.58E+05	2.79E+08
MU-3	-0.4	-0.3	-17	1.44E+05	2.54E+08
MU-4	-0.9	-0.2	4.8	1.23E+05	2.18E+08

Modeling Assumptions

Sources were modeled according to the staging shown in Figure 3. Sources were modeled using the MILDOS-prescribed format and inputs for that type of source. Sources of potential release include new production area development, releases from radon in purge water and from venting during both production and restoration, and Rn releases during ion exchange column unloading. Radon releases from production and restoration purge water was assumed to occur at the location of the satellite. Radon releases from venting was assumed to be at the centroid of the mine unit in question. No particulates are released, so, all calculated doses come solely from radon releases.

Inhalation, direct exposure from material deposited on the surface (ground) and submersion in contaminated air (cloud) were calculated for all receptors. Food pathways were included for vegetables and cattle grown in the area. It was assumed that all cattle feed was from pasture grass, not hay or other feed. The milk pathway was turned off for all receptors because there is no commercial dairy in the vicinity. Doses were calculated for an 8760-hr year, a conservative assumption meaning that, unless otherwise noted, the receptor is present at that location 100% of the time.

Source Strength Adjustment

The QAJUST factor in MILDOS was used to adjust the timing and fraction of a year that various sources operate in keeping with the staging shown in Figure 3. The annual rate of release from a specific resource was varied depending timing of the release. In all cases, the modeling time step was set to 1 year. For example, during 2015, MU-2 is in production for 90% of the time, so QAJUST is set at 0.90 to account for that diminished output on a yearly basis. By varying QAJUST in this way, it was possible to calculate the dose as the project progresses.

Model Runs

Dose modeling was conducted in several MILDOS Code runs as follows:

- Drilling for new resource development was modeled in run New14-18 run that encompassed all mine units starting in 2014 and continuing through 2018. Different amounts of ore material in drilling mud were used for delineation holes and cased wells as calculated using the number of wells shown in Fig. 3.
- MILDOS will allow up to ten sources at a time, so production purge and releases from the IX columns were represented by the runs named PP14-23 and PP24-25, for years 2014 – 2023 and 2024-2025, respectively. Releases of radon from purge water is assumed to occur at the satellite plant.
- Radon releases from unloading of the IX columns was modeled in runs, IX14-23 and IX24-25. Releases were prorated based on the portion of the maximum flow rate at which the facility is operated in a given year.
- Restoration purge was modeled in runs RP20-29 and RP30-31 for years 2020 – 2029 and 2030-2031, respectively. As with production purge, releases of radon from purge water is assumed to occur at the satellite plant.
- Production and restoration venting are modeled using PV14-23, PV24-25, RV20-29 and RV30-31. Venting of radon releases is assumed to occur at the centroid of the mine unit undergoing either production or restoration. Timing for production and restoration venting follow the same pattern as purge water releases.

5.0 MODEL RESULTS

This section presents the results of the MILDOS modeling.

Radon Release Rates

Maximum potential annual radon release rates calculated by MILDOS from input parameters during the project from the various sources are listed in Table 6. The actual radon release rate varies with the sources that are active during all or part of a given year and are determined using the QAJUST parameter described above.

Table 6. Maximum annual radon quantities potentially released by source.

Source	Ci
New well development	7.05E-03
Production purge	3.82E+01
Production venting	3.42E+02
IX columns	1.24E+00
Restoration purge	9.11E+01
Restoration venting	1.12E+02

Dose to Individual Receptor Locations

Estimated maximum annual total effective dose equivalents (TEDE) at individual boundary receptor locations are shown below in Table 7 and Figure 4. The maximum dose of 5.84E+01 mrem for any boundary location is estimated to occur at boundary location EB in 2020. This is understandable since the east boundary is only 100 m due east of the satellite plant and the purge water releases that occur there.

This calculated dose results exclusively from exposure to radon decay products, since there are no particulate releases from the facility. For each receptor point, dose from inhalation contributes over 99% of the total modeled dose. Doses from submersion in a plume, direct and exposure to contaminated ground surface represent less than 1% of the dose. Further, because doses result only from releases of radon with consequent decay products, the 40 CFR 190 annual dose commitments, which are exclusive of radon exposure, are zero in all cases.

The shape of estimated doses through time (Fig. 4) reflects both the staging of different processes and locations of the various mine units relative to the receptor locations. It is important to note that there are no actual receptors at the boundary locations, but it is presumed that an actual receptor could reside at or near that location.

The nearest residence to the facility was located about a km to the southeast of the facility with a predicted dose of less than a mrem in any year of the project. Town locations modeled for this project include Casper, Douglas, Glenrock, Gillette, Wright and Sussex. The maximum modeled dose in those towns was 1.78E-02 mrem/yr for residents of Wright.

Table 7. Maximum total effective dose equivalent (TEDE, mrem/yr)) at various receptor locations.

Receptor	2014	2015	2016	2017	2018	2019	2020	2021	2022
NB	3.71E-01	5.52E-01	5.94E-01	5.77E-01	5.77E-01	5.42E-01	6.78E-01	5.57E-01	4.95E-01
NEB	9.01E+00	1.06E+01	1.14E+01	1.15E+01	1.24E+01	1.42E+01	2.50E+01	2.17E+01	1.88E+01
EB	1.14E+01	1.35E+01	1.45E+01	1.47E+01	1.59E+01	1.81E+01	5.84E+01	5.42E+01	5.05E+01
SEB	2.62E+00	2.94E+00	3.93E+00	5.81E+00	6.39E+00	6.64E+00	1.41E+01	1.19E+01	1.01E+01
SB	7.69E-01	7.84E-01	1.06E+00	1.61E+00	1.76E+00	1.72E+00	2.77E+00	2.17E+00	1.64E+00
SWB	9.92E-02	1.09E-01	1.76E-01	3.18E-01	3.60E-01	3.76E-01	5.29E-01	3.88E-01	2.86E-01
WB	1.94E-01	2.21E-01	2.61E-01	3.20E-01	5.65E-01	1.05E+00	1.43E+00	1.08E+00	1.03E+00
NWB	1.84E-01	2.62E-01	2.93E-01	3.15E-01	3.49E-01	3.91E-01	5.44E-01	4.36E-01	3.89E-01
Casper	2.67E-03	3.02E-03	3.31E-03	3.54E-03	3.68E-03	3.34E-03	5.46E-03	4.55E-03	3.69E-03
Douglas	2.17E-03	2.41E-03	2.67E-03	2.87E-03	3.00E-03	2.73E-03	4.47E-03	3.72E-03	3.01E-03
Glenrock	2.43E-03	2.71E-03	2.99E-03	3.22E-03	3.36E-03	3.04E-03	4.99E-03	4.16E-03	3.37E-03
Midwest	3.90E-03	4.32E-03	4.79E-03	5.23E-03	5.50E-03	5.06E-03	8.28E-03	6.87E-03	5.55E-03
Gillette	4.51E-03	5.01E-03	5.53E-03	5.95E-03	6.22E-03	5.64E-03	9.22E-03	7.68E-03	6.20E-03
Wright	8.74E-03	9.69E-03	1.07E-02	1.14E-02	1.19E-02	1.07E-02	1.78E-02	1.49E-02	1.20E-02
Pfister Ranch	1.98E-01	1.77E-01	2.26E-01	3.23E-01	3.53E-01	3.24E-01	5.25E-01	4.11E-01	2.95E-01
Sussex	4.00E-03	4.39E-03	4.88E-03	5.36E-03	5.64E-03	5.17E-03	8.47E-03	7.02E-03	5.65E-03
Receptor	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
NB	4.43E-01	3.47E-01	3.57E-01	3.02E-01	3.02E-01	2.30E-01	2.30E-01	2.53E-01	2.53E-01
NEB	1.73E+01	1.60E+01	1.47E+01	1.40E+01	1.40E+01	1.46E+01	1.46E+01	1.38E+01	1.38E+01
EB	4.85E+01	4.70E+01	4.53E+01	4.45E+01	4.45E+01	4.52E+01	4.52E+01	4.39E+01	4.39E+01
SEB	8.40E+00	9.12E+00	8.92E+00	8.56E+00	8.56E+00	9.42E+00	9.42E+00	7.57E+00	7.57E+00
SB	1.16E+00	1.36E+00	1.34E+00	1.21E+00	1.21E+00	1.45E+00	1.45E+00	9.47E-01	9.47E-01
SWB	1.70E-01	2.24E-01	2.31E-01	2.08E-01	2.08E-01	2.72E-01	2.72E-01	1.70E-01	1.70E-01
WB	8.83E-01	5.77E-01	6.74E-01	6.03E-01	6.03E-01	8.19E-01	8.19E-01	1.36E+00	1.36E+00
NWB	3.34E-01	2.73E-01	2.86E-01	2.55E-01	2.55E-01	2.60E-01	2.60E-01	3.08E-01	3.08E-01
Casper	3.17E-03	2.75E-03	2.81E-03	2.32E-03	2.32E-03	2.34E-03	2.34E-03	2.34E-03	2.34E-03
Douglas	2.57E-03	2.24E-03	2.29E-03	1.90E-03	1.90E-03	1.94E-03	1.94E-03	1.92E-03	1.92E-03
Glenrock	2.88E-03	2.51E-03	2.56E-03	2.11E-03	2.11E-03	2.16E-03	2.16E-03	2.14E-03	2.14E-03
Midwest	4.70E-03	4.13E-03	4.23E-03	3.50E-03	3.50E-03	3.64E-03	3.64E-03	3.60E-03	3.60E-03
Gillette	5.30E-03	4.62E-03	4.73E-03	3.89E-03	3.89E-03	3.98E-03	3.98E-03	3.95E-03	3.95E-03
Wright	1.03E-02	9.01E-03	9.19E-03	7.58E-03	7.58E-03	7.71E-03	7.71E-03	7.69E-03	7.69E-03
Pfister Ranch	2.04E-01	2.26E-01	2.31E-01	1.89E-01	1.89E-01	2.41E-01	2.41E-01	1.71E-01	1.71E-01
Sussex	4.78E-03	4.21E-03	4.31E-03	3.56E-03	3.56E-03	3.72E-03	3.72E-03	3.67E-03	3.67E-03

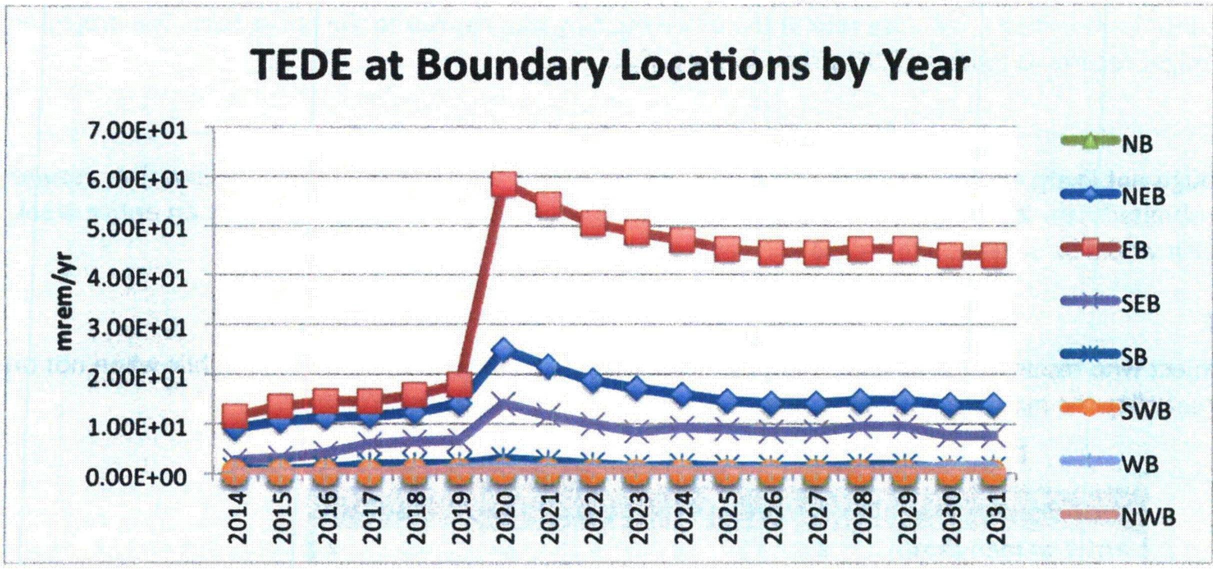

Figure 4. Maximum TEDE (mrem/yr) at each receptor.

Dose to Members of the Public

The above doses are to locations and represent a maximum potential dose due to the 100% occupancy assumption. In reality, various members of the public may potentially be exposed under a variety of different situations. Several common exposure scenarios include a courier or delivery person, a visitor at the mine site, and a person camping nearby. There will also be a man camp situated within the permit boundary. During off-duty hours, residents at the man camp would be considered members of the public. Potential doses to each of these scenarios were calculated and the results are shown in Table 8 and discussed below. Dose rates from 2020, which are the highest during the project, were used to make these calculations.

Table 8. Potential Classes of Exposure to Members of the Public.

Class	Annual Hours Exposed	MILDOS Dose Rate in 2020 (modeled location)	Estimated Annual Dose
Delivery person	2.5 hr/wk * 50 wks/yr = 125 hr/yr	61.1 mrem/yr (office, 40 m N and E of satellite)	(125 hr/yr * 61.1 mrem/yr) / 8760 hr/yr = 0.87 mrem/yr
Tour group	8 hr/yr	61.1 mrem/yr (office, 40 m N and E of satellite)	(8 hr/yr * 61.1 mrem/yr) / 8760 hr/yr = 0.06 mrem/yr
Camper	1 wk/yr = 168 hr/yr	58.4 mrem/yr (location EB in 2020	(168 hr/yr * 58.4 mrem/yr) / 8760 hr/yr = 1.12 mrem/yr
Man camp resident	1813 hrs.	34.1 mrem/yr (mancamp, 90 m E and 50 m N of satellite)	(1813 hr/yr * 34.1 mrem/yr) / 8760 = 7.1 mrem/yr

Delivery Person or Courier

It is reasonable to assume that a courier or delivery person might spend as much as 30 minutes per weekday on average for a total of 125 hrs per year at the project office building, which is 40 m east and south of the satellite plant. Dose for that location was modeled as amounting to 61.1 mrem/yr. Prorating that rate for the 125 hr exposure equates to an annual dose of 0.87mrem.

Tour Group Member

Public tours of the project would likely spend some time being briefed at the office building and then be transported to various locations around the project. A likely maximum exposure time of 8 hrs seems reasonable. To account for various dose rates at multiple locations, the dose rate at the office building was applied to the entire tour. The projected tour group member might receive as much as 0.06 mrem during a visit.

Camper

It is conceivable, though not likely, that someone might decide to camp near the project. To be conservative, assume that the campsite is situated near location EB, just outside the permit boundary. A camper spending an entire week, 168 hrs, at that location would be subjected to a dose for that week of 1.1 mrem.

Man Camp Resident

Employees of the project who reside at the nearby man camp would be considered members of the public when not on duty. Assumptions regarding the man camp residents are as follows for each 7 day week:

Table 9. Assumptions about man camp residents.

Daily activity	1	2	3	4	5	6	7	Total hrs
Arrive at man camp	2							2
Work shift	12	12	12	4				40
Off shift at man camp	10	12	12					34
Prep to go home				1				1
Off shift at home				19	24	24	24	91
Total								168

Over a 49-wk year, this amounts to 1813 hours as a member of the public at the man camp.

The modeled dose rate for the mancamp location, 90 m E and 50 m north of the satellite, is 34.1 mrem/yr. Prorating this rate over 1813 hr leads to an estimated dose for the resident worker of 7.1 mrem in addition to their occupational dose.

Population Doses

Using the population distribution shown in Table 3, population doses (person-rem/yr) from site releases were calculated for both total effective dose equivalent (TEDE) and the dose to the bronchial epithelium of receptors. Population dose results are summarized in Table 10. Maximum population TEDE is calculated to be slightly above 0.05 person-rem. The maximum bronchial dose is estimated to be 4.1 person-rem to the population.

While there is no regulatory limit for population dose, it is interesting to compare results in Table 8 to exposures from natural background. The most recent data indicate that the average American receives approximately 310 mrem from "ubiquitous background" [National Council on Radiation Protection and Measurements [NCRP] 2009]. Ubiquitous background is assumed to include external exposure from cosmic radiation, external exposure from terrestrial radiation, internal exposure from inhalation of background radon (^{222}Rn) and thoron (^{220}Rn) and their progeny and internal exposure from radionuclides in the body. For a population of 32,732 (Table 3), the total background dose is over 9,800 person-rem TEDE. This is nearly 200,000 times greater than the estimated dose to the same population from the North Butte project.

Table 10. Collective dose to population within 80 km.

	Population dose (person-rem)	
Pathway	**Effective**	**Bronchi**
Inhalation	1.40E-02	4.37E+00
External from ground deposition	6.30E-04	6.30E-04
External from submersion in air	3.82E-02	3.82E-02
Total	**5.28E-02**	**4.41E+00**

Uncertainties in Dose Estimates

MILDOS is not designed to calculate uncertainty associated with estimates of doses. Use of the Gaussian Plume Dispersion coefficients and the uncertainty in the dose conversion factors themselves introduce an unknown amount of uncertainty into estimated doses at receptor locations. Doses calculated by the code represent an entire year of occupancy at the specified receptor location. For any actual resident, this represents a large overestimate of the actual dose that would be received. Residents in the vicinity would leave their place of residence for work or recreation and the model dose not accounts for those absences.

6.0 SUMMARY

Potential releases from the North Butte were modeled using MILDOS-AREA, version 3.10. Releases from drilling of new production areas was assumed to occur at the centroid of each production area, as was radon release from venting. Radon releases from the ion exchange columns and purge water during production and restoration were assumed to occur at the location of the satellite. Because there are no particulate releases from the facility, calculated doses result only from exposure to radon and its decay products.

Results of MILDOS modeling indicate that no boundary location is likely to receive greater than the 10 CFR 20 limit of 100 mrem/yr TEDE. The maximum modeled dose at any boundary location, 58.4 mrem, occurs at the East Boundary (EB), located only 100 m east of the satellite in the year 2020. This dose rate assumes 100% occupancy at the modeled location. Potential scenarios of various members of the public indicate that workers who are resident at the company mancamp northeast of the satellite would receive less than 15 mrem/yr. Other exposure scenarios result in far lower doses.

Collective dose, expressed in person-rem/yr to residents surrounding the project, is very small relative to natural background radiation. The average background radiation to a person in the United States is 310 mrem. Collective dose from the North Butte project to the 32,000+ residents within 80 km is approximately 180,000 times lower than the dose to the same population from ubiquitous natural background radiation

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